The Role of Mindfulness in Physical Activity

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Declaration

While registered as a candidate for the above degree, I have not been registered for any other research award. The results and conclusions embodied in this thesis are the work of the named candidate and have not been submitted for any other academic award.

Publications and communications

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Glossary

AAQ	Acceptance and Action Questionnaire
ABBT	Acceptance-based behaviour therapy
ACT	Acceptance and commitment therapy
AMOS	Analysis of a moment structures (statistical software package)
ANOVA	Analysis of variance
BMI	Body mass index (weight in kilograms divided by the squared height in meters)
BREQ	Behavioural Regulation in Exercise Questionnaire
CAMM	Child and Adolescent Mindfulness Measure
CBT	Cognitive behavioural therapy
CCT	Controlled clinical trial
CFA	Confirmatory factor analysis
COH	Cohort study
CS	Cross-sectional study
DBT	Dialectical behaviour therapy
DM	Dispositional mindfulness
FFMQ	Five Facet Mindfulness Questionnaire
FMI	Frieberg Mindfulness Inventory
HEPA	Health-enhancing physical activity
IPAQ	International Physical Activity Questionnaire
Kcal	Kilocalorie (a unit of energy of 1000 calories, equal to one large calorie)
KIMS	Kentucky Inventory of Mindfulness Skills
LGT	Longitudinal study
LJMU	Liverpool John Moores University
MAAS	Mindful Attention and Awareness Scale
MBCT	Mindfulness-based cognitive therapy
MB-EAT	Mindfulness-based eating awareness training
MB-EAT-D	Mindfulness-based eating awareness training for diabetes
MBI	Mindfulness-based intervention
MBSP	Mindfulness-based strengths practice
MBSR	Mindfulness-based stress reduction
MfPA	Mindfulness for Physical Activity intervention (outlined in study three, chapter four)
ML	Maximum likelihood estimation in AMOS
MMT	Mindfulness meditation training
MPA	Moderate intensity physical activity
MRC	Medical Research Council
MVPA	Moderate to vigorous intensity physical activity

NHS	National Health Service (United Kingdom)
PA	Physical activity
PAAAQ	Physical Activity Acceptance and Action Questionnaire
PAAQ	Physical Activity Acceptance Questionnaire
PHLMS	Philadelphia Mindfulness Scale
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCT	Randomised controlled trial
SDT	Deci and Ryan's Self-Determination Theory of human behaviour
SEM	Structural equation modelling
SPSS	Statistical Package for the Social Sciences (statistical software package)
Study one	Systematic review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (chapter two)
Study two	Online prospective cohort study over two weeks (chapter three)
Study three	Pre-post pilot study of a six-week mindfulness intervention for physical activity following the Medical Research Council guidelines for developing and evaluating interventions (chapter four)
TAU	Treatment as usual
UK	United Kingdom
VPA	Vigorous intensity physical activity
WHO	World Health Organisation

Thesis Abstract

Despite public health campaigns to promote physical activity (PA), physical inactivity affects 60% of the world population and continues to pose a risk of overweight and obesity, type 2 diabetes, and related cancers. Current interventions show small to moderate changes in PA and limited long-term effects, possibly because they fail to prepare individuals for PA behaviour change. Mindfulness has the potential to address psychological barriers of change and foster greater acceptance of PA. However, little is currently known about the mindfulness-PA relationship and the potential of mindfulness-based interventions (MBIs) for PA. This PhD examined two main research questions: 1) what is the effect of mindfulness on PA outcomes, and 2) what is the relationship between mindfulness and psychological factors related to PA? *Study one* provided the first systematic review on the role of mindfulness for PA. Evidence showed a positive relationship between DM and psychological factors related to PA and beneficial between-subjects effects of MBIs on PA outcomes. Interventions were more likely to be successful if they were PA-specific and targeted psychological factors related to PA. *Study two* explored the relationship between DM and PA outcomes using a prospective cohort design. Statistical modelling techniques of cross-sectional and longitudinal data showed that DM predicted autonomous exercise motivation and PA acceptance, which in turn predicted baseline PA, but no effect was found for change in PA over time. *Study three* examined the effectiveness and feasibility of a novel MBI for PA (MfPA) in a sample of underactive participants. One-way, repeated-measures ANOVAs revealed improvements in PA acceptance and autonomous exercise motivation, but no change in DM, self-control, or PA. Thematic analysis of qualitative data suggested that the MfPA intervention was successful at improving participants' relationship with PA. Taken together, these studies provide a unique insight into the beneficial effect of mindfulness on psychological factors related to sustained PA and its potential for increasing autonomous exercise motivation and PA acceptance in novice exercisers. Future research is required to evaluate the effectiveness of the MfPA intervention using a randomised controlled trial, by employing an active matched control group without a mindfulness component.

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And finally to my wonderful nieces, Mia and Evie. I dedicate this thesis (and beyond) to you. Thank you for reminding me that family always comes first.

Chapter One – General Introduction

1.1. Overview of mindfulness

In the last two decades, there has been an increase in interest and research around the concept and application of meditation and mindfulness (Chiesa, 2013; Chiesa & Serretti, 2014; Gu, Strauss, Bond, & Cavanagh, 2015; Hilton et al., 2017; Hofmann, Sawyer, Witt, & Oh, 2010; Kabat-Zinn, 2003; Malinowski, 2017; Piet & Hougaard, 2011; Sedlmeier et al., 2012; Sedlmeier, Loße, & Quasten, 2018; Van Dam et al., 2018b). An increasing number of studies are being conducted to establish the effect of mindfulness within a wide range of contexts, such as eating behaviour (Katterman, Kleinman, Hood, Nackers, & Corsica, 2014b; Wanden-Berghe, Sanz-Valero, & Wanden-Berghe, 2010), education (Bush, 2011; de Bruin, Meppelink, & Bögels, 2015; Helber, Zook, & Immergut, 2012; Meiklejohn et al., 2012), workplace well-being (Good et al., 2016; Van Gordon, Shonin, Zangeneh, & Griffiths, 2014), and the military (Jha et al., 2015; Stanley, Schaldach, Kiyonaga, & Jha, 2011). The majority of reviews have found promising evidence for the beneficial effect of meditation and mindfulness on psychological (Bohlmeijer, Prenger, Taal, & Cuijpers, 2010; Keng, Smoski, & Robins, 2011; Sedlmeier et al., 2018; Spijkerman, Pots, & Bohlmeijer, 2016; Zainal, Booth, & Huppert, 2013) and physical health (Carlson, 2012; Chiesa & Serretti, 2011b; Gotink et al., 2015; Toivonen, Zernicke, & Carlson, 2017). Benefits of mindfulness have been proposed for a variety of populations, ranging from clinical populations, such as individuals with cancer (Bower et al., 2015) and individuals with stress, anxiety, or depression (Sundquist et al., 2015), to the general population (Kerrigan et al., 2017; Khoury,

Sharma, Rush, & Fournier, 2015; Sharma & Rush, 2014). Despite such promising results, several issues need to be addressed in meditation and mindfulness research, including problems regarding how mindfulness is currently defined and measured. Additionally, many published studies have used small and homogenous samples and few studies include comparison conditions that adequately control for the direct and indirect effects of meditation and mindfulness. As such, more research is required to investigate the potential benefits and applications of mindfulness.

The following chapter introduces the overall thesis and contains four main parts. Firstly, it provides an overview of mindfulness, including how it is currently defined, operationalised, and applied in intervention research (section 1.1). Secondly, it discusses mindfulness in the context of health behaviours, specifically with regards to physical activity (section 1.2). Thirdly, it outlines the structure and content of this thesis and highlights the original contributions of this PhD to the wider literature (section 1.3). Finally, it provides a justification for the first study of the PhD programme of research (section 1.4).

1.1.1. The conceptualisation of mindfulness

One of the main limitations of current mindfulness research lies in the difficulty of defining it (Brown & Ryan, 2004). The term “mindfulness”, as it is used in the area of contemplative science, stems from Eastern introspective psychological practices, specifically Buddhist meditative traditions, which referred to it over 2500 years ago (Black, 2011; Malinowski, 2017). Although it is beyond the scope of this thesis to describe mindfulness through a Buddhist conceptualisation in

detail, some elements of the classical literature should be considered (Kabat-Zinn, 2011). Early conceptualisations of mindfulness can be found in Buddhist scriptures such as the *Abhidhamma* (Kiyota, 1978) and *Visuddhimagga* (Buddhaghosa, 2010). The modern meaning of the term mindfulness was first translated in 1881 (Davids, 1881; Gethin, 2011) and originated from the Pāli term *sati*, its Sanskrit counterpart *smṛti*, and the Tibetan *dran pa*. These terms have been translated both as remembrance or memory, possibly in terms of remembering to maintain awareness (Batchelor, 1998; Gethin, 2011), and as a lucid awareness of what is occurring within our phenomenological field (Bodhi, 2012). Other scholars argue that definitions of mindfulness often entail attention, awareness, memory/retention, and discernment (Bodhi, 2011; Davids, 1899, 1910; Davidson & Kaszniak, 2015; Dreyfus, 2011; Dunne, 2011; Gethin, 2011).

While there appears to exist some overlap between *sati/smṛti/dran pa* and the "contemporary" construct of mindfulness as it is used today (Grossman, 2010; Malinowski, 2017), there are important differences between Buddhist and secular interpretations. Firstly, within Buddhist contexts, mindfulness is embedded within a complete spiritual system, which includes teachings and meditation practice, while secular mindfulness is typically applied as a stand-alone approach. From a Buddhist perspective, mindfulness is considered to be an active, investigative practice or process that inherently involves cognitive, attitudinal, affective, social, and ethical dimensions (Grossman, 2010; Grossman & Van Dam, 2011). Moreover, it is regarded as one of several important qualities that should be developed through meditation (Gethin, 2011). Secondly, traditional mindfulness practices aim to remove the root of human dissatisfaction and promote equanimity, acceptance,

compassion, loving-kindness, and joy (Dorjee, 2016). Modern mindfulness-based approaches, on the other hand, tend to follow the Western medical model, which has the aim of alleviating clinical and other conditions (Malinowski, 2017; Monteiro, Musten, & Compson, 2015). However, other modern mindfulness programmes exist with different aims, such as boosting self-compassion or resilience (see section 1.1.4).

Over the last decade, a number of psychologists have attempted to define and measure mindfulness. Today, the term mindfulness has a plethora of meanings and is used somewhat like an umbrella term (Van Dam et al., 2018b) taken to encompass a large number of practices, processes, and characteristics (Crane et al., 2016). Grossman (2011) suggests that most definitions reflect mindfulness "as deliberate, open-minded awareness of moment-to-moment perceptible experience that ordinarily requires gradual refinement by means of systematic practice; …characterised by a nondiscursive, nonanalytic investigation of ongoing experience; …fundamentally sustained by such attitudes as kindness, tolerance, patience, and courage; and … markedly different from everyday modes of awareness" (page 1035).

In the scientific literature, the most commonly used definition of mindfulness was proposed by Jon Kabat-Zinn (, 2004) and describes it as a state of paying attention on purpose to unfolding moment-by-moment experience with an open, non-judging, and accepting attitude. However, at present, there is no universally accepted technical definition of mindfulness (Bodhi, 2011; Dreyfus, 2011; Dunne, 2011; Gethin, 2011; Grossman & Van Dam, 2011; Van Dam et al., 2018b). Modern definitions of mindfulness have been formulated in a particular

way and with specific constructs that are most readily available to Western audiences (Kabat-Zinn, 2011) and therefore may not necessarily represent the original construct of mindfulness as discussed and practiced within Buddhist meditative traditions. Furthermore, it has been argued that removing mindfulness from its larger philosophical context and practices may have decontextualised the original construct by neglecting the experience of developing mindfulness through gradual practice (Grossman, 2008, 2010, 2011; Grossman & Van Dam, 2011; Malinowski, 2017; Monteiro et al., 2015; Rau & Williams, 2016; Sharf, 2015).

Another commonly used definition was proposed by Bishop et al. (2004), which advocates that mindfulness comprises self-regulation of attention directed to the present moment and a particular orientation toward one's experience of the present moment that is characterised by curiosity, openness, and acceptance. Other definitions view mindfulness as: 1) an open and receptive attention to and awareness of what is occurring in the present moment (Brown & Ryan, 2004), 2) an awareness that arises through intentionally attending in an open, accepting, and discerning way to whatever is arising in the present moment (Shapiro & Carlson, 2009), and 3) a process of bringing one's complete attention to the present experience on a moment-to-moment basis (Marlatt & Kristeller, 1999). Thus, mindfulness is often conceptualised as a form of attention, characterised by a range of distinct, yet overlapping attributes, such as acceptance, non-judgement, and non-reactivity (Bergomi, Tschacher, & Kupper, 2013a).

Mindfulness within Western psychology is generally assumed to reflect the Buddhist *sati* (Grossman, 2011; Grossman & Van Dam, 2011), but it has been suggested that *sati* may be best translated as "to be mindful", implying an action or

a practice (Bodhi, 2000; Nanamoli & Bodhi, 1995). This is in direct opposition to the fixed trait-like connotation of the noun “mindfulness” (Grossman & Van Dam, 2011). This is particularly important, considering that the majority of current questionnaires (see section 1.1.3) attempt to measure mindfulness as a fixed trait or a mental function (Grossman & Van Dam, 2011). Consequently, a cycle is often created where simplified definitions of mindfulness define the scales that are being used and, in turn, the scales used in mindfulness research define and reify the construct of mindfulness in the literature (Grossman & Van Dam, 2011). It therefore seems apparent that mindfulness is not a unitary construct (Van Dam et al., 2018b) and studies examining mindfulness need to consider and justify how they define and measure it.

1.1.2. Models and mechanisms of mindfulness

Current efforts to investigate mindfulness are increasingly focusing on the mechanisms through which mindfulness exerts positive influences on mental and physical well-being (Coffey & Hartman, 2008; Crane, Barnhofer, Hargus, Amarasinghe, & Winder, 2010; Schöne, Gruber, Graetz, Bernhof, & Malinowski, 2018; Shapiro, Carlson, Astin, & Freedman, 2006; Williams, McManus, Muse, & Williams, 2011). According to several proposed models of mindfulness, there are distinct mental processes through which mindfulness meditation training (MMT) may illicit change (Van Dam et al., 2018b). These include psychological distancing or reperceiving (Shapiro et al., 2006), decentering (Segal, Williams, & Teasdale, 2002), inhibitory control (Vago & Silbersweig, 2012), non-conceptual discriminatory awareness (Brown, Ryan, & Creswell, 2007), acceptance and reintegration (Hayes,

Strosahl, & Wilson, 1999), and sustaining and shifting attention, decentering, and meta-awareness (Lutz, Jha, Dunne, & Saron, 2015). Additionally, researchers have suggested other potential mechanisms of action involved in mindfulness processes (Baer, 2010; Carmody, Baer, Lykins, & Olendzki, 2009), such as acceptance, psychological flexibility, relaxation, emotion regulation, self-management, cognitive change, and self-compassion.

Several researchers have also proposed intention as an important criterion for meditation practice (Shapiro & Schwartz, 2000). Research shows that intentions of meditation practice correlate with outcomes of practice (Shapiro, 1992). Moreover, through continued practice, meditators' intentions shift from self-regulation, to self-exploration, and finally to self-liberation. Based on this, several models were developed that emphasise the role of intention (i.e., the purpose of practicing mindfulness meditation) as a core element of mindfulness. For example, the Intention-Attention-Attitude model (Shapiro et al., 2006) depicts intention, attention, and attitude as axioms, or fundamental building blocks, of mindfulness. When we attend intentionally with an open and non-judging attitude, we experience a shift in perspective (reperceiving). This perspective in turn promotes non-identification with our experience, allowing us to observe our experiences as something external to us, rather than something that is fundamental to our sense of self (see Figure 1.1).

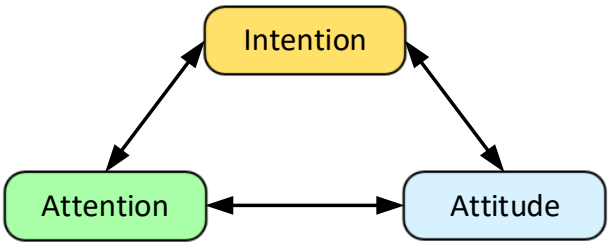

Figure 1.1. The Intention-Attention-Attitude model of mindfulness (reproduced with permission from Shapiro et al., 2006).

Similarly, the Liverpool Mindfulness Model (Malinowski, 2013) proposes that motivational factors, including intention, are required to engage in mindfulness practice, which in turn cultivates non-judging awareness through several core processes (see Figure 1.2). Both models therefore emphasise the importance of intention in conceptualising the benefits of MMT (Malinowski, 2017).

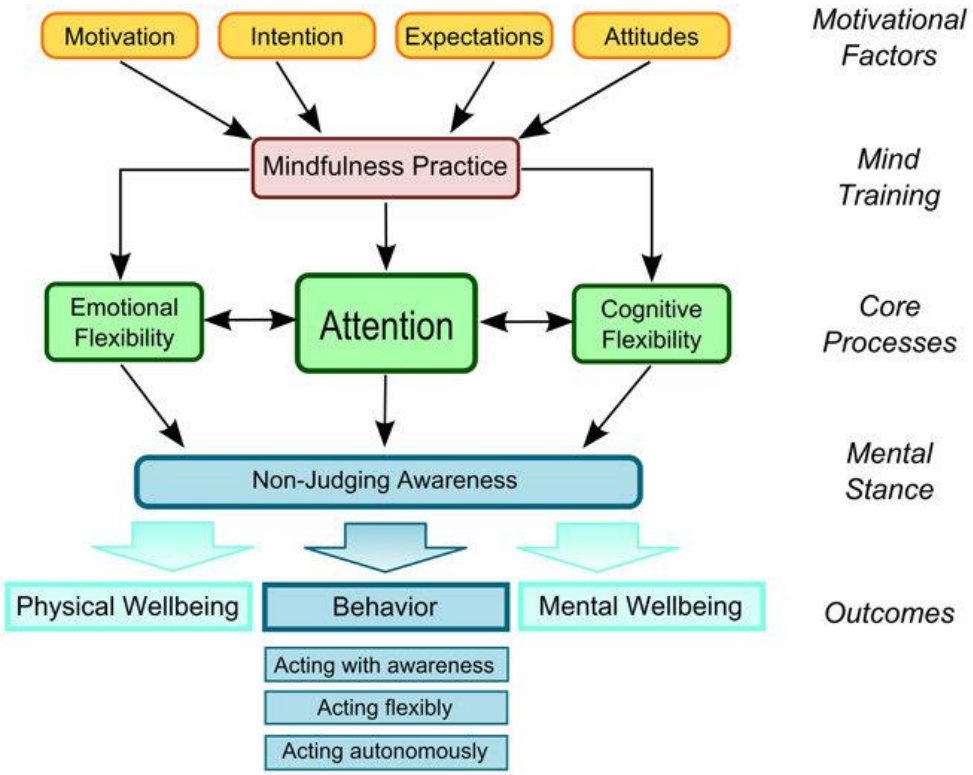

Figure 1.2. The Liverpool Mindfulness Model (reproduced with permission from Malinowski, 2013).

Others (see, for example, Hölzel et al., 2011) have suggested that body awareness (e.g., during breath awareness or body scan meditation) is an important mechanism in emotion regulation processes (Mirams, Poliakoff, Brown, & Lloyd, 2013), through which MMT may elicit positive change. Several researchers have proposed that mindfulness meditation sits within the broader context of mental training and may thus exert its benefits through cognitive or neural processes (Malinowski, 2013; Slagter, Davidson, & Lutz, 2011; Tang, Hölzel, & Posner, 2015; Tang & Posner, 2014).

It should be noted, however, that not all meditative traditions consider our thoughts and experiences as something external to us (Malinowski, 2017), but rather aim for non-dual meditative states without the subject-object divide (Dunne, 2011). Put differently, such states of awareness are devoid of the usual separation between the subject, or the experiencer (i.e., the meditator), and the object, or the experienced (e.g., one's thoughts). This can be seen in the intentions of practicing meditators (Shapiro, 1992), where experienced meditators tend to set their intentions of practice on self-liberation (i.e., becoming free from the sense of being a separate "self"), while novice meditators often practice with self-regulation of behaviour as their main intention. In this sense, the mindfulness meditation commonly practiced as part of mindfulness-based interventions (MBIs), where participants are encouraged to view their thoughts as external events, differs markedly from some Buddhist meditative traditions, such as the *Mahāmudrā* (the "Great Seal" tradition), where non-duality is the aim (Dunne, 2011; Malinowski, 2017). Furthermore, the typical eight-week structure of MBIs is unlikely to allow participants to move along the continuum towards self-liberation, which may limit

the full potential of mindfulness meditation and the programmes that utilise it (Malinowski, 2017).

Current definitions of mindfulness and the proposed mechanisms through which mindfulness operates present a complex depiction of what mindfulness is and how it may work. Additionally, several of the proposed mechanisms may not be unique to mindfulness meditation (e.g., relaxation, attention, and self-compassion). Therefore, more research is still required to distinguish between the unique effects of mindfulness meditation, compared to different types of meditation, relaxation techniques, and other forms of mental training. Specifically, future studies should consider the mechanisms through which MMT induces benefits or changes in measured outcomes (Shapiro et al., 2006), to gain a more comprehensive understanding of *how* mindfulness practice elicits such changes.

1.1.3. Operationalising mindfulness

Given the outlined difficulties and deficiencies in how mindfulness is defined and described in current research, measuring mindfulness is similarly challenging (Grossman & Van Dam, 2011; Quaglia, Brown, Lindsay, Creswell, & Goodman, 2015; Van Dam et al., 2018b). Within existing research, mindfulness has been used to imply an inherent human capacity (Kabat-Zinn, 2003), a stable trait or disposition (Brown & Ryan, 2003), a state that can be induced, usually through meditation practice (Brown & Ryan, 2003), and a skill that can be cultivated or improved through consistent MMT (Lykins & Baer, 2009). This is an important consideration as the way in which mindfulness is defined within studies will have direct consequences on what measures are (or should be) used (Van Dam et al., 2018b).

Typically, research distinguishes between "dispositional mindfulness" and "cultivated mindfulness" (Rau & Williams, 2016). Dispositional mindfulness (also known as trait mindfulness) has been described as an inherent human quality that we all possess to varying extents (Black, 2011) and it is often measured using self-report questionnaires in cross-sectional and other study designs (Grossman, 2008). Cultivated mindfulness, on the other hand, is usually defined as the outcome of MMT (Kabat-Zinn, 2005). Accordingly, it may be appropriate to suggest that several *forms* of mindfulness exist and should therefore be measured using different tools (Grossman, 2008; Rau & Williams, 2016).

1.1.3.1. Dispositional and state mindfulness

Historical context is important in understanding definitions of dispositional mindfulness (DM; Rau & Williams, 2016), which are based in Eastern religion and discussed within the Buddhist doctrine, as outlined in the *Abhidhamma* (Bodhi, 2012). The fourth text of the *Abhidhamma*, the *Puggalapannatti* ("Descriptions of Individuals"; Gaur & Pathak, 2000) acknowledges the innate individual differences in DM, suggesting that mindfulness is both an innate individual trait and a set of skills that require training and practice (Rau & Williams, 2016). Several questionnaires have been developed that aim to measure DM, including the Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003), the Kentucky Inventory of Mindfulness Skills (KIMS; Baer, Smith, & Allen, 2004), the revised Cognitive and Affective Mindfulness Scale (CAMS-R; Feldman, Hayes, Kumar, Greeson, & Laurenceau, 2006), the Five Facet Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006), the Freiburg Mindfulness

Inventory (FMI; Buchheld, Grossman, & Walach, 2001; Walach, Buchheld, Buttenmüller, Kleinknecht, & Schmidt, 2006), the Southampton Mindfulness Questionnaire (SMQ; Chadwick et al., 2008), the Philadelphia Mindfulness Scale (PHLMS; Cardaciotto, Herbert, Forman, Moitra, & Farrow, 2008), the Comprehensive Inventory of Mindfulness Experiences-beta (CHIME-β; Bergomi, Tschacher, & Kupper, 2013b), and the trait version of the Toronto Mindfulness Scale (TMS-t; Davis, Lau, & Cairns, 2009).

Additionally, researchers distinguish between trait mindfulness (i.e., DM) and state mindfulness (i.e., a transient state of mindful awareness during a particular task or at a certain time; Medvedev, Krägeloh, Narayanan, & Siegert, 2017; Thompson & Waltz, 2007). Several questionnaires have been developed to measure state mindfulness, including the State Mindfulness Scale (SMS; Tanay & Bernstein, 2013) and the state version of the Toronto Mindfulness Scale (TMS-s; Lau et al., 2006). There is currently little evidence showing that DM and state mindfulness are correlated (Thompson & Waltz, 2007) or linked to actual mindfulness practice (see section 1.1.3.2 below), suggesting that they are indeed separate constructs. However, some research has shown that increased state mindfulness over repeated meditation sessions may contribute to increased DM (Kiken, Garland, Bluth, Palsson, & Gaylord, 2015).

Although widely used in mindfulness research, there are several limitations of using self-report questionnaires to assess mindfulness. These include the general limitations of assessing psychological constructs using self-report tools, such as the introduction of the Hawthorne effect, the overconfidence effect, social desirability bias, and cognitive dissonance (Grossman, 2008; Grossman & Van Dam, 2011).

Substantial evidence shows that perceptions of one's behaviour (or perceptions of one's cognitive processes, as may be the case with regards to mindfulness) often differ from actual behaviour (Baumeister, Vohs, & Funder, 2007a). Additionally, there are several limitations that are unique to self-report measures of mindfulness specifically.

Firstly, it has been argued that to report on one's own mental state fundamentally requires a certain degree of mindfulness (Grossman, 2008; Grossman & Van Dam, 2011; Malinowski & Shalamanova, 2017). Secondly, it is very likely that the same mindfulness questionnaire is interpreted inconsistently by different individuals (Belzer et al., 2013; Grossman, 2011; Smallwood, McSpadden, & Schooler, 2007). Research shows that questionnaire items may have different meanings for novice practitioners and experienced meditators (Grossman, 2008, 2011; Schöne et al., 2018) and for individuals with and without prior knowledge about mindfulness (Baer et al., 2008; Christopher, Charoensuk, Gilbert, Neary, & Pearce, 2009; Leigh, Bowen, & Marlatt, 2005). This may lead to lower "mindfulness" scores in an experienced meditator who is more aware of his or her emotional states and is thus more likely to notice mind wandering or be more inclined to provide modest and realistic responses to the questionnaire items (Baer et al., 2008; Rau & Williams, 2016).

Conversely, individuals experienced in mindfulness courses or meditation may know the "correct" response to self-report measures of mindfulness and thus be more likely to select those responses, leading to a higher estimated level of mindfulness (Grossman, 2008, 2011; Van Dam, Earleywine, & Danoff-Burg, 2009). It is therefore important to distinguish between different populations when choosing

an appropriate mindfulness measure (Bergomi et al., 2013a; Grossman, 2011). For instance, the FMI (Buchheld et al., 2001; Walach et al., 2006) may be better suited for populations familiar with meditation, the FFMQ (Baer et al., 2006) may be best suited for the general population and for individuals not familiar with meditation, and the CAMS-R (Feldman et al., 2006) and the SMQ (Chadwick et al., 2008) may be most appropriate for clinical populations (Bergomi et al., 2013a).

Thirdly, as of yet, there is no agreement regarding what aspects of mindfulness should be captured in a mindfulness questionnaire. Existing measures attempt to capture a wide variety of constructs (Bergomi et al., 2013a), including: 1) observing or attending to experiences, 2) acting with awareness, 3) non-judgement or experiential acceptance, 4) self-acceptance, 5) willingness and readiness to expose oneself to experiences or non-avoidance, 6) non-reactivity to experiences, 7) non-identification with experiences, 8) insightful understanding, and 9) labelling or describing. There is no single self-report measure of mindfulness that assesses all the above aspects (Bergomi et al., 2013a). For instance, despite being one of the most widely used measures of DM, the MAAS consists entirely of reverse-scored items measuring the absence of awareness and attention (Brown & Ryan, 2003), thus focusing on the absence of *mindlessness*, rather than the presence of mindfulness. Several researchers have postulated that mindfulness is more than the mere absence of mindlessness (Ritchie & Bryant, 2012) and involves an *intentional* or *active* element of being mindful (Van Dam, Earleywine, & Borders, 2010). There is currently limited evidence regarding relationships between the subscales of mindfulness questionnaires (Bergomi et al., 2013a) and between mindfulness questionnaires more generally (Sauer et al., 2013).

Finally, due to the wide variety of DM measures used in research, comparison between studies becomes challenging, making it difficult to draw firm conclusions about the construct and its impact (Brown et al., 2007; Malinowski, 2008). There are currently debates in the mindfulness literature with arguments to completely abandon self-report measures of DM (e.g., Grossman, 2008, 2011) versus arguments that DM can indeed be measured using self-report questionnaires, but current measures are insufficient and suffer from various limitations (e.g., Bergomi et al., 2013a). Future research may benefit from developing new mindfulness scales (see, for example, Van Dam, Bilgrami, & Eisenlohr-Moul, 2018a) that: 1) are theory-based and take into account previous operationalisations of mindfulness, 2) consider measuring constructs that are closely related to mindfulness, such as non-attachment (Sahdra, Shaver, & Brown, 2010), self-compassion (Neff, 2003), and awareness (Shields, Mallory, & Simon, 1989), and 3) have been cross-validated with mindfulness measures that do not rely on self-report, such as experimental tasks, interview data (Frewen, Lundberg, MacKinley, & Wrath, 2011; Grossman, 2008; Teasdale et al., 2002), or actual meditation practice (Bergomi et al., 2013a). Other researchers have proposed behavioural measures of mindfulness, such as breath counting (Levinson, Stoll, Kindy, Merry, & Davidson, 2014), which may complement questionnaire use.

Another suggestion has been to refer to “mindfulness-based skills” in relation to outcomes of mindfulness practice. This approach views aspects of mindfulness as a set of skills, rather than as defining properties of mindfulness as a construct (Van Dam et al., 2018a). There are few questionnaires that consider measuring mindfulness as a set of skills (see, for example, Solloway & Fisher, 2007

and Baer et al., 2004). Recently, Van Dam et al. (2018a) developed the Balanced Inventory of Mindfulness-Related Skills (BIMS)[1], attempting to improve upon the validity of previous questionnaires, such as the FFMQ (Baer et al., 2006). Other authors have suggested renaming existing mindfulness questionnaires to reflect the skills or constructs that they actually measure (e.g., lapses in attention or psychological qualities; Grossman & Van Dam, 2011) and then investigating the effect of MBIs and MMT on these skills specifically (Grossman, 2011). Alternatively, it may be desirable to focus on putative outcomes of mindfulness practice (Grossman, 2008), such as enhancements in an individual's well-being (Grossman, Niemann, Schmidt, & Walach, 2004) and/or positive effects on others (Singh et al., 2004). Consequently, much research has been conducted to investigate the effect of mindfulness practice on intervention outcomes.

1.1.3.2. Mindfulness meditation practice

Mindfulness practice differs from DM (i.e., mindfulness as an inherent trait or disposition) as it involves intention to attend to the present moment (Wheeler, Arnkoff, & Glass, 2016) and is aimed at cultivating mindfulness skills (Rau & Williams, 2016). It is often seen as an integral part of MBIs, which typically comprise educational advice and MMT, the latter adapted for a Western secular context from Eastern traditions of meditative practices. Accordingly, numerous studies measure meditation, rather than DM (i.e., time or frequency spent engaging in mindfulness meditation practice; Black, 2011). Meditation is a general term describing a large

[1] Data collection for this thesis was completed prior to the publication of this paper.

variety of practices, and as such, a unified definition of meditation is perhaps as challenging as a unified definition of mindfulness (Malinowski, 2017). In a recent attempt, meditation has been defined as a "a form of mental training that aims to improve an individual's core psychological capacities, such as attentional and emotional self-regulation" (Tang et al., 2015, page 213). It is important to distinguish between mindfulness and meditation (Thompson & Waltz, 2007), as they are complementary, but ultimately different constructs (Van Gordon, Shonin, Griffiths, & Singh, 2015b). Evidence from several studies further shows a low association between DM, as measured by self-report questionnaires, and actual meditation practice (Manuel, Somohano, & Bowen, 2017; Van Dam et al., 2018b). A recent meta-analysis (Quaglia, Braun, Freeman, McDaniel, & Brown, 2016) only found small to moderate effect sizes in the mean change in scale dimensions of self-reported DM following MMT, although the data showed that DM may positively moderate the effect of MBIs on beneficial outcomes.

Similarly, more research is required to compare the benefits of different types of meditation practices (e.g., focused attention or open monitoring practices) and between different meditative traditions (e.g., Vipassana meditation and Zen meditation). There is currently no objective or gold-standard measure of mindfulness (Grossman, 2011; Grossman & Van Dam, 2011), so measuring actual meditation practice may be an important step towards objectivity. This is also in line with original meditative traditions, which acknowledge that mindfulness is best understood through experience (Grossman, 2010) and is an extremely gradual developmental process (Grossman & Van Dam, 2011), thus going beyond an inherent disposition. It is therefore important to distinguish between different kinds

of mindfulness (Dorjee, 2010) to ensure effective comparison between studies and the ability to draw firmer conclusions about the influence of DM and mindfulness practice on health outcomes. Additionally, both DM and mindfulness practice are arguably important to investigate, as research has suggested that DM may be protective against psychological distress, even for individuals without formal MMT (Brown & Ryan, 2003). More research is required to investigate the unique effects of DM and intentional mindfulness practice, which could facilitate new treatments aimed at improving well-being through DM for individuals who are unwilling (or unable) to engage in formal meditation practice (Wheeler et al., 2016).

1.1.4. Mindfulness-based interventions

As previously mentioned, mindfulness is primarily known in the context of Buddhist meditative traditions (Gunaratana & Gunaratana, 2011; Thera, 2005), but has recently been applied in Western contexts as a means to cope with and treat various physical and psychological disorders (Chiesa & Serretti, 2009; Keng et al., 2011). Mindfulness practice and MBIs have been investigated as treatment approaches for a variety of mental and physical health concerns (Gethin, 2011), such as depression, anxiety, stress, and chronic pain. It is perhaps because of this integration and adaptation of mindfulness within the Western medical model (Grossman, 2010; Malinowski, 2017; Shapiro & Carlson, 2009) and its secularity (Van Gordon, Shonin, & Griffiths, 2015a) that it has seen such a rise in popularity in research and mainstream media (Dimidjian & Segal, 2015).

Mindfulness practices were popularised in the West by Jon Kabat-Zinn, who integrated Eastern meditative practices within the mindfulness-based stress

reduction programme (MBSR; Kabat-Zinn, 1982), the most widely used, taught, and studied MBI today (Crane et al., 2016). MBSR was primarily developed to help individuals cope with chronic pain and has shown to be effective in improving mental health outcomes in individuals with chronic physical health conditions (Bohlmeijer et al., 2010). The formal practices of MBSR are: 1) mindful movement (e.g., gentle hatha yoga and walking), 2) the body scan (a practice designed to systematically bring the practitioner's attention and awareness to various body regions), and 3) sitting meditation (e.g., awareness of breath; Cullen, 2011). Despite the relatively well-defined and systematic format of MBSR (Kabat-Zinn, 2007), it retains flexibility in how it can be structured and delivered (Dobkin, Hickman, & Monshat, 2014). Following on from the success of MBSR, Segal and colleagues developed mindfulness-based cognitive therapy (MBCT), aimed at individuals with recurring depression (Segal et al., 2002). MBCT has demonstrated effectiveness as a treatment for relapse prevention for those with recurrent depression, particularly for individuals with more pronounced residual symptoms (Kuyken et al., 2016) and individuals with three or more depressive episodes (Teasdale et al., 2000). This is potentially because acute episodes of depression are likely to be caused by major external life events, while recurring depression is more likely to be characterised by internal events and rumination, which is where mindfulness exerts its benefits (Segal et al., 2002).

Newer programmes that are based on the traditional structure of MBSR and MBCT have followed, such as mindfulness-based strengths practice (MBSP; Niemiec & Lissing, 2016), which combines mindfulness and character strengths training (Peterson & Seligman, 2004). Other mindfulness-based programmes have been

developed, with particular aims across a broad range of settings (Crane et al., 2016). Among others, mindfulness has been applied to addiction and relapse prevention, e.g., mindfulness-based smoking cessation (Singh et al., 2011), mindfulness-based relapse prevention (Bowen et al., 2014), and mindfulness-oriented recovery enhancement (Garland, 2013); healthcare and education, e.g., mindfulness-based elder care (McBee, 2008, 2009) and mindfulness-based childbirth and parenting education (Duncan & Bardacke, 2010); interpersonal relationships, e.g., mindfulness-based relationship enhancement (Carson, Carson, Gil, & Baucom, 2004); eating behaviour and weight-loss, e.g., mindfulness-based eating awareness training (Kristeller, Wolever, & Sheets, 2014; Kristeller & Wolever, 2010) and enhancing mindfulness for the prevention of weight regain (Caldwell, Baime, & Wolever, 2012); and other contexts, e.g., mindfulness-based art therapy (Peterson, 2014), mindfulness-based positive behaviour support (Singh et al., 2014), and mindfulness-based mind fit training (Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010).

Advances in positive psychology (Seligman & Csikszentmihalyi, 2000), as well as medicine, healthcare, and education, have led to the development of other therapeutic approaches (Crane et al., 2016), such as acceptance and commitment therapy (ACT; Hayes et al., 1999), compassion focused therapy (Gilbert & Irons, 2015), mindful self-compassion (Germer, 2009; Neff & Davidson, 2016; Neff & Germer, 2013), and dialectical behaviour therapy (Robins & Rosenthal, 2011). These therapeutic approaches are often referred to as MBIs as they include training in mindfulness skills (e.g., through exercises and education) and resemble the non-judging and accepting mental stance cultivated in traditional MBIs (Malinowski,

2017), but they do not necessarily include formal MMT (Chiesa & Malinowski, 2011), which some have maintained is a foundation of a true mindfulness-based programme (Crane et al., 2016). ACT, for instance, is structured to increase the psychological flexibility of participants through various core processes (Hayes et al., 1999), but does not include formal meditation practice.

Furthermore, researchers have argued that true MBIs cannot be fully secular, as mindfulness is ultimately one single construct as taught by the Buddha (Van Gordon et al., 2015b). In response to this critique, a second generation of MBIs has emerged (Crane et al., 2016; Van Gordon et al., 2015a) that emphasize spirituality and ethics as inherent programme elements, such as meditation awareness training, mindfulness-integrated cognitive behaviour therapy, and the M4 programme (Cayoun, 2011; Monteiro & Musten, 2013; Monteiro, Nuttall, & Musten, 2010; Shonin & Van Gordon, 2015). Second generation MBIs teach mindfulness in conjunction with other principles of meditation (Van Gordon et al., 2015b), such as ethical awareness, impermanence, loving-kindness, compassion, non-self/emptiness, and others (Gunaratana & Gunaratana, 2011; Nanamoli & Bodhi, 1995; Thera, 2005).

The programmes outlined above have many factors in common, such as general structure (8 – 12 weeks), format (i.e., group sessions), and content (e.g., inquiry and practice). Generally, both first and second generation MBIs include three main components (see Figure 1.3). The first component (contemplative practice) is composed of various contemplative practices, such as formal and informal meditation and mindfulness practices. The second component (Buddhist philosophy) is the understanding of how we experience the flow of events in our

body and mind. The third component (psychological process) addresses the intention of the treatment process (Monteiro et al., 2015).

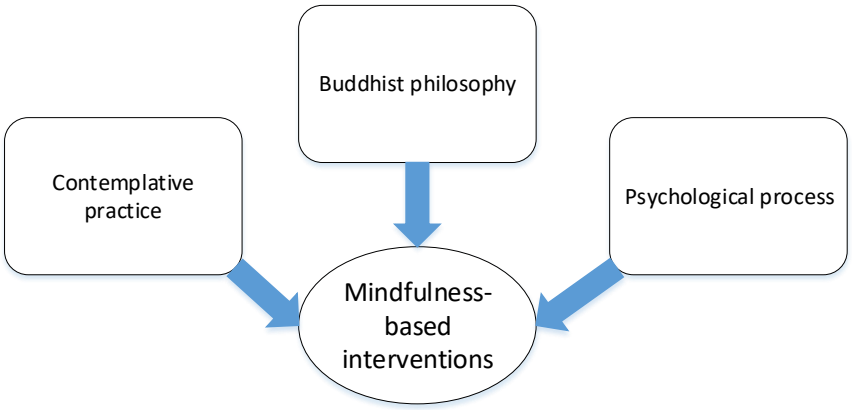

Figure 1.3. Components of mindfulness-based interventions (reproduced with permission from Monteiro et al., 2015).

However, MBIs sometimes have marked differences in session length, curriculum, delivery method, and purpose (Malinowski, 2017), depending on the specific intent of the programme (e.g., relapse prevention, self-compassion, etc.) and the target population (Monteiro et al., 2015). Even traditional meditation-based MBIs often include additional components, such as yoga, psychoeducation, stretching, group discussions, and different types of meditation exercises (Schöne et al., 2018). Moreover, MBIs differ in intensity and duration of the programme (Van Dam et al., 2018b), with several newer interventions deviating from the typical eight-week structure (e.g., Demarzo et al., 2017) and opting for shorter-duration programmes.

At present, the majority of published reviews and meta-analyses tend to find promising evidence for the effectiveness of MBIs on various mental and physical health outcomes (Bohlmeijer et al., 2010; Carlson, 2012; Chiesa & Serretti,

2011b; Gotink et al., 2015; Keng et al., 2011; Sedlmeier et al., 2018; Shonin, Van Gordon, & Griffiths, 2014; Singh et al., 2014; Spijkerman et al., 2016; Toivonen et al., 2017; Zainal et al., 2013). However, perhaps due to the relative infancy of mindfulness research, evidence is currently mixed and limited and the majority of research suffers from small sample sizes and uncontrolled study designs. As such, several of these meta-analyses raise concerns about the quality of the research. Additionally, few studies investigate non-standard MBIs that differ in important ways from MBSR and MBCT. Variation in MBIs has led to vague and incongruent definitions of mindfulness elements (Chiesa & Malinowski, 2011; Crane et al., 2016), which makes it difficult to identify the active ingredient(s) of such interventions (Dorjee, 2016; Gotink et al., 2015; Malinowski & Shalamanova, 2017). Nonetheless, mindfulness provides the potential for exciting and innovative research opportunities, which address limitations of previous studies.

1.1.5. Considerations for this PhD

For the purposes of this PhD, DM was defined in line with previously established definitions of mindfulness in the existing literature (Kabat-Zinn, 2004) and special care was taken to distinguish between DM and mindfulness practice. Moreover, it was acknowledged that no unified definition of mindfulness currently exists. Throughout this thesis, the term “DM” was used when referring to trait mindfulness measured using self-report questionnaires and the term “mindfulness practice” was used when referring to MMT or mindfulness skills and exercises as taught within the context of MBIs. The FFMQ (Baer et al., 2006) was chosen as a measure of DM in the experimental studies of this PhD (study two, chapter three

and study three, chapter four), in line with recommendations by Bergomi et al. (2013a), suggesting that the FFMQ is appropriate for the general population with no or limited previous meditation experience. Moreover, both DM and mindfulness practice were assessed in the final study of this PhD, to gain a more complete understanding of the influence of different *forms* of mindfulness on physical activity outcomes (see study three, chapter four). In terms of MBIs, this PhD distinguished between traditional mindfulness-based approaches that include MMT and acceptance-based/other approaches that teach mindfulness skills without explicit meditation training (see study one, chapter two).

1.2. Overview of physical activity

1.2.1. Mindfulness and health

In recent years, mindfulness has become a rapidly expanding phenomenon in the secular domains of health and well-being (Monteiro et al., 2015). In fact, researchers argue that perhaps one of the greatest opportunities for MBIs is its potential to contribute to healthcare (Cullen, 2011). Along with extensive evidence showing beneficial outcomes of mindfulness practice on psychological health (Keng et al., 2011), several studies show that mindfulness can be used as an effective approach for physical health (Carmody, Reed, Kristeller, & Merriam, 2008). In recent years, mindfulness has been linked to several health behaviours, such as sleep quality (Black, O'Reilly, Olmstead, Breen, & Irwin, 2015; Howell, Digdon, & Buro, 2010), healthy eating (e.g., consuming more fruits and vegetables; Gilbert & Waltz, 2010), and avoidance of second hand smoke (Gao & Shi, 2015), as well as

reduced smoking (Brewer et al., 2011; Singh et al., 2011), alcohol consumption (Murphy & MacKillop, 2012), and intake of foods high in salt, fat, and sugar (Gilbert & Waltz, 2010; Mantzios, Egan, Hussain, Keyte, & Bahia, 2018; Saxe et al., 2001). However, the evidence base is still weak and more research is required to establish the potential benefits of mindfulness on health behaviours. Mindfulness practice has been advocated for use with performance athletes (Salmon, Hanneman, & Harwood, 2010) and could readily be adapted for those embarking on physical activity-based lifestyle change.

1.2.2. Physical activity guidelines

Physical activity (PA) refers to any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen, Powell, & Christenson, 1985). It is often used interchangeably with exercise, but exercise refers specifically to a subset of PA that is planned, structured, and repetitive and that has as an objective to improve or maintain physical fitness (Caspersen et al., 1985). PA therefore broadly encompasses exercise, sports, and activities done as part of daily living, occupation, leisure, and active transportation (Garber et al., 2011). Department of Health advice for the United Kingdom (UK) recommends adults (19 – 64 years) to engage in ≥ 150 minutes of moderate intensity PA (MPA) or 75 minutes of vigorous intensity PA (VPA), or an equivalent combination of MPA and VPA weekly (Department of Health, 2011). In addition to this, adults are recommended to do at least two days of strength exercises weekly, for each of the major muscle groups (National Health Services, 2016b). It is suggested that a programme of regular exercise that includes cardiorespiratory (aerobic), resistance (strength),

flexibility, and neuromotor exercises, beyond activities done as part of daily living, is essential for most adults to maintain physical fitness and health (Garber et al., 2011).

Substantial research has been conducted to investigate how much PA is needed and at what intensity to improve health markers, such as cardiorespiratory fitness (Garber et al., 2011). The available data support a dose-response relationship between PA and health outcomes, such that the more PA one engages in, the better (Garber et al., 2011; Warburton, Nicol, & Bredin, 2006). However, the specific shape of the dose-response curve is likely to depend on several factors, such as the health outcomes measured and the individual's baseline PA and fitness levels (Haskell et al., 2007). Some studies have demonstrated that an energy expenditure of 1000 kilocalories (kcal) per week through MPA, or about 150 minutes of MPA weekly, is likely to be associated with lower rates of cardiovascular disease and premature mortality (Lee, Rexrode, Cook, Manson, & Buring, 2001; Manson et al., 2002). Other studies have found that an energy expenditure of as little as 500 kcal per week, or 10 – 15 minutes of daily MPA, has significant benefits on risk reduction (Lee & Skerrett, 2001; Sesso, Paffenbarger, & Lee, 2000), particularly for individuals with low baseline PA and physical fitness (Church, Earnest, Skinner, & Blair, 2007).

Recent evidence of the dose-response relationship between PA and health outcomes shows that even 600 MET-minutes[2]/week can minimally lower risk for ischemic heart disease and diabetes, while 3000 – 4000 MET-minutes/week provide

[2] MET: the metabolic equivalent of a task, an indicator of metabolic energy expenditure.

the optimal threshold for health benefits and > 4000 MET-minutes/week do not necessarily contribute further to risk reduction (Kyu et al., 2016). Among physically inactive adults, even small improvements in PA can be beneficial for health (Warburton et al., 2006). Therefore, there is scope for PA interventions that support small changes and long-term maintenance (Kangasniemi, Lappalainen, Kankaanpää, Tolvanen, & Tammelin, 2015). Finally, although VPA generally provides greater physiological benefits than MPA (Swain, 2005), total volume of PA along with reduced sedentary time is more important in inducing health benefits and reducing risk factors than intensity or pattern of exercise (Garber et al., 2011).

1.2.3. Benefits of physical activity

It is well-known that PA is a major contributor to mental (Biddle & Asare, 2011; Rosenbaum, Tiedemann, & Ward, 2014; Zschucke, Gaudlitz, & Ströhle, 2013) and physical health (Department of Health, 2011; Donnelly et al., 2009; Leitzmann et al., 2009; National Health Services, 2018; Penedo & Dahn, 2005). Results of studies investigating the benefits of PA continue to support a growing literature demonstrating that PA is beneficial for a variety of physical and mental health outcomes (Ojiambo, 2013; Penedo & Dahn, 2005; Warburton et al., 2006; Zschucke et al., 2013) and reduced risk of all-cause mortality (Blair et al., 1995; Garber et al., 2011; Lee, Hsieh, & Paffenbarger, 1995; Paffenbarger et al., 1993; Paffenbarger et al., 1994). Regular PA reduces the risk of cardiovascular disease (Sesso et al., 2000; Wannamethee & Shaper, 2001), type 2 diabetes (Department of Health, 2011; Hu et al., 2001), certain cancers (e.g., colon and breast cancers; Leitzmann et al., 2009; Monninkhof et al., 2007), osteoporosis (Vuori, 2001), depression (Dinas,

Koutedakis, & Flouris, 2011; Mammen & Faulkner, 2013; Rimer et al., 2012; Teychenne, Ball, & Salmon, 2008), anxiety (Herring, Jacob, Suveg, Dishman, & O'Connor, 2012; Herring, Jacob, Suveg, & O'Connor, 2011; Ströhle, 2009; Wipfli, Rethorst, & Landers, 2008), overweight and obesity (Donnelly et al., 2009), cognitive impairment (Denkinger, Nikolaus, Denkinger, & Lukas, 2012), and fall-related injuries (Gardner, Robertson, & Campbell, 2000). Moreover, PA is beneficial for sleep quality (Kredlow, Capozzoli, Hearon, Calkins, & Otto, 2015), positive affect (Chan et al., 2019), overall well-being (Bartholomew, Morrison, & Ciccolo, 2005), and health-related quality of life (Bize, Johnson, & Plotnikoff, 2007).

However, despite continued public health campaigns to promote the benefits of PA and motivate people to become more active (World Health Organisation, 2018) and less sedentary (Hamilton, Healy, Dunstan, Zderic, & Owen, 2008), physical inactivity affects 60% of the global population (Das & Horton, 2012; Guthold, Stevens, Riley, & Bull, 2018; World Health Organisation, 2010) and continues to pose a risk of overweight and obesity (Donnelly et al., 2009), type 2 diabetes (Department of Health, 2011), and related cancers (Leitzmann et al., 2009). The consequences associated with low PA extend beyond the individual and pose a great financial concern for society (Ding et al., 2016; Kohl et al., 2012). It has been estimated that the direct burden of PA-related ill-health costs the National Health Service (NHS) in the UK over £1 billion annually (Allender, Foster, Scarborough, & Rayner, 2007). If indirect costs are to be considered (e.g., days lost to sickness absence, premature mortality, and other healthcare costs), this figure may be closer to £21 billion (Leal, Luengo-Fernández, Gray, Petersen, & Rayner, 2006).

Physical inactivity tends to be more prevalent in individuals with overweight and obesity (Adams, Der Ananian, DuBose, Kirtland, & Ainsworth, 2003; Tudor-Locke, Brashear, Johnson, & Katzmarzyk, 2010). Furthermore, many individuals drop out within the first six months of commencing a PA programme (Dishman, Heath, & Lee, 2012; Marcus et al., 2000). This is particularly apparent when individuals are prescribed high levels of PA (e.g., 2500 kcal/week) as part of an intervention, which often results in low engagement during the intervention and a lack of adherence to a high level of PA after the intervention (Jakicic, Marcus, Lang, & Janney, 2008; Tate, Jeffery, Sherwood, & Wing, 2007). Due to low levels of adherence to and engagement with many existing PA interventions, novel approaches are required that enhance PA uptake and maintenance.

1.2.4. Correlates and determinants of physical activity

A substantial amount of research has already been conducted on factors that are associated with PA or predict PA behaviour. In line with the social ecological perspective of human health behaviour (Stokols, 1996), the socio-ecological model of PA proposes a range of correlates (i.e., factors associated with PA) and determinants (i.e., factors that predict PA) that influence PA behaviour (Bauman, Sallis, Dzewaltowski, & Owen, 2002). These can be broadly classified on four levels: 1) individual (e.g., age, sex, ethnicity, and socio-economic status), 2) social (e.g., parental and peer support), 3) environmental (e.g., neighbourhood and school characteristics), and 4) policy (e.g., government schemes and health campaigns; Giles-Corti & Donovan, 2002; Spence & Lee, 2003). Alternatively, researchers have categorised factors associated with PA as either a) demographic

and biological, b) psychological, cognitive, and emotional, c) behavioural attributes and skills, d) social and cultural, e) physical environmental, or f) PA characteristics (Dishman, Sallis, & Orenstein, 1985; Trost, Owen, Bauman, Sallis, & Brown, 2002). For the purposes of this PhD, primarily psychological factors of PA behaviour change were considered, as these factors are most likely to be influenced by mindfulness. Moreover, research has consistently highlighted the importance of psychology in influencing PA behaviour (Biddle & Fuchs, 2009). However, it is acknowledged that the various factors and levels within the socio-ecological model of PA interact and influence PA behaviour (Sallis & Owen, 2015; Trost et al., 2002).

Several reviews show that PA interventions tend to be more effective and achieve better exercise maintenance when they are theory-based, target self-regulatory processes (e.g., self-monitoring, feedback, goal setting, etc.), and include continued intervention sessions (Greaves et al., 2011; Michie, Abraham, Whittington, McAteer, & Gupta, 2009; Noar, Benac, & Harris, 2007; Rhodes & Pfaeffli, 2010; Teixeira et al., 2015). Apart from self-regulation, autonomous motivation often emerges as one of the most consistent correlates of PA (Bauman et al., 2012; Teixeira, Carraça, Markland, Silva, & Ryan, 2012; Teixeira et al., 2015; Trost et al., 2002). Additionally, tolerance of PA-related discomfort has been suggested as an important mechanism of sustained PA (Butryn, Forman, Hoffman, Shaw, & Juarascio, 2011). These three constructs (i.e., self-regulation, autonomous exercise motivation, and tolerance of PA-related discomfort) may be important in closing the PA intention-behaviour gap (Rhodes & Dickau, 2012; Rhodes & Pfaeffli, 2010), i.e., the disparity between the intention to engage in PA and actual PA

behaviour. Each construct is discussed further below. Throughout this thesis, these constructs will be broadly referred to as psychological factors related to PA.

1.2.4.1. Self-regulation

Existing evidence is limited, but suggests that sustained PA behaviour is dependent, in part, on enhancing self-regulation skills (Best, Nagamatsu, & Liu-Ambrose, 2014; Teixeira et al., 2015). Self-regulation refers to a psychological function that involves putting effort into changing one's behaviour (Audiffren & André, 2015), as well as maintaining an existing behaviour (e.g., exercise) or refraining from an undesired behaviour (e.g., smoking). The term is often used interchangeably with self-control, which has been described as the ability to regulate one's thoughts, emotions, and actions in order to behave consistently with one's values or goals (Baumeister, Gailliot, DeWall, & Oaten, 2006) and as a process involved in guiding and monitoring behaviour (Carver & Scheier, 2000). Self-control is a mental capacity, or a limited resource, which depletes when individuals engage in behaviours requiring self-regulation (Baumeister, Bratslavsky, Muraven, & Tice, 1998) and is therefore an integral part of effective self-regulation and important in successful behaviour change. As such, self-control can be understood as an operational subset of self-regulation. (However, it should be acknowledged that the strength model of self-control that views self-control as a limited resource is not the only model that exists and recent evidence suggests that self-control may not be subject to depletion (Friese, Loschelder, Gieseler, Frankenbach, & Inzlicht, 2019; Inzlicht, Schmeichel, & Macrae, 2014)).

The relationship between PA and self-regulation appears to be reciprocal; considerable evidence supports a positive effect of PA on executive function (Colcombe & Kramer, 2003; Guiney & Machado, 2013; Verburgh, Konigs, Scherder, & Oosterlaan, 2014), a precursor of effective self-regulation, but much less is known about the influence of executive function on PA (Buckley, Cohen, Kramer, McAuley, & Mullen, 2014). Executive functions comprise a wide set of cognitive processes, such as attentional control, attention shifting, cognitive flexibility, self-monitoring, planning, inhibitory control, and working memory (Tang, Yang, Leve, & Harold, 2012). Some executive functions, for instance inhibitory control and cognitive flexibility, can enable individuals to maintain goals across prolonged periods of time and flexibly adapt behaviour to changing demands. Cross-sectional evidence shows that executive functions play an antecedent role, whereby those with greater self-regulation capacity are more successful at implementing PA intentions (de Bruin et al., 2012b).

Research has shown that dispositional self-regulation (e.g., self-control; Wills, Isasi, Mendoza, & Ainette, 2007) and self-regulation skills (e.g., self-monitoring, feedback, goal setting, action planning) may help decrease the intention-behaviour gap (Sniehotta, Scholz, & Schwarzer, 2005) and enhance PA uptake and maintenance (Michie et al., 2009; Stadler, Oettingen, & Gollwitzer, 2009; Teixeira et al., 2015). Self-control specifically has been applied to a wide range of health-related behaviour domains, such as dietary restraint and eating behaviour, alcohol consumption, smoking cessation, and PA (Hagger, Wood, Stiff, & Chatzisarantis, 2009). It has also been found to associate with PA and fitness in the general population (Kinnunen, Suihko, Hankonen, Absetz, & Jallinoja, 2012).

1.2.4.2. Autonomous exercise motivation

The predominant theory in exercise motivation is the Self-Determination Theory of behaviour (SDT; Deci & Ryan, 1985, 2000, 2011), which has grown considerably in the last 25 years (Ntoumanis, 2012; Teixeira et al., 2012). SDT suggests that human behaviour is dependent on motivation, which in turn is fostered by the three psychological needs of autonomy (i.e., the need to have control over one's own actions), relatedness (i.e., the need to have a social relationship with others), and competence (i.e., the need to develop mastery over tasks one perceives as important). Human motivation is likely to come from a wide range of sources. Historically, the distinction in exercise motivation was made between extrinsic motivation, which arises from external sources and pressures and intrinsic motivation, which arises from internal drives, such as core values, personality, and interests. SDT has moved this thinking forward by acknowledging that extrinsic motivation varies to the extent to which it is internalised, with the important distinction being between autonomous and controlled motivation (Deci & Ryan, 1985). The self-determination continuum (see Table 1.1) distinguishes between five forms of motivation (as well as the lack of motivation, i.e., amotivation): two controlled forms of extrinsic motivation (i.e., external and introjected motivation), two autonomous forms of extrinsic motivation (i.e., identified and integrated motivation), and intrinsic motivation.

External motivation refers to the desire to obtain external rewards or avoid punishments, while introjected motivation represents the desire to obtain intrapersonal rewards (e.g., pride) or to avoid self-inflicted punishments (e.g., guilt or shame). An individual who exercises for reasons of controlled extrinsic

motivation may do so because of peer pressure or for appearance-related concerns. Identified motivation represents the desire to perform a behaviour because it is personally significant and results in desired outcomes, while integrated motivation is represented by an individual's belief that a behaviour is an important part of his or her identity and is consistent with his or her personal values. Individuals who exercise for reasons of autonomous extrinsic motivation may do so because they identify as an athlete or want to gain health benefits of being active. Finally, intrinsic motivation is the motivation to engage in behaviour that derives from internal reasons, such as the enjoyment of being active or an interest in a particular type of exercise (Duncan, Hall, Wilson, & Jenny, 2010). Autonomous motivation therefore combines intrinsic, identified, and integrated motivation. Controlled motivation, on the other hand, is comprised of external motivation and introjected motivation (Ryan & Deci, 2000).

Several studies show that amotivation can partly explain why some individuals do not engage in regular PA, due to low levels of interest in being active among competing demands (e.g., school, work, childcare; Ryan, Williams, Patrick, & Deci, 2009) and/or low levels of perceived confidence in their ability to exercise (Korkiakangas, Alahuhta, & Laitinen, 2009). Controlled forms of extrinsic motivation may motivate short-term behaviour, but are unlikely to encourage behaviour (e.g., PA) maintenance over time (Deci & Ryan, 1985; Teixeira et al., 2012). Autonomous forms of motivation (specifically identified motivation) have been linked to individual intentions to engage in exercise (Wilson & Rodgers, 2004). Findings from recent reviews (Teixeira et al., 2012; Teixeira et al., 2015) further support the importance of autonomous (specifically identified and intrinsic) motivation in

promoting PA among the general population. Notably, findings show that identified motivation is most strongly associated with exercise uptake and short-term adoption of exercise, while intrinsic motivation is most strongly associated with long-term exercise adherence (Teixeira et al., 2012). Intrinsic motivation appears to be most associated with positive and sustained behavioural outcomes in the health domain (Ng et al., 2012).

Table 1.1. The self-determination continuum (modified from Ryan & Deci, 2000).

	Not self-determined					**Self-determined**
Motivation	**Amotivation**	**Extrinsic**				**Intrinsic**
Regulatory styles	Non-regulation	External	Introjected	Identified	Integrated	Intrinsic
Regulatory types	Non-regulation	Controlled	Controlled	Autonomous	Autonomous	Autonomous
Sources of motivation	Impersonal	External	Somewhat external	Somewhat internal	Internal	Internal
Sources of regulation	Non-intentional, non-valuing, incompetence, lack of control	Compliance, external rewards and punishments	Self-control, ego involvement, internal rewards and punishments	Personal, importance, conscious valuing	Congruence, awareness, synthesis with self	Interest, enjoyment, inherent satisfaction

1.2.4.3. Tolerance of physical activity-related discomfort

Tolerance of PA-related discomfort (hereinafter PA acceptance) can be said to lie within the general area of having a positive attitude towards PA (Ajzen, 1991). Individuals who enjoy the experience of PA and tolerate PA-related discomfort (e.g., fatigue or pain) are arguably more likely to maintain PA in the short and long term. Consistent with hedonic theories of behaviour (Cabanac, 1992; Johnston, 2003), existing research suggests that affective valence (e.g., pleasure or displeasure) during exercise predicts future exercise behaviour (Bryan, Hutchison, Seals, & Allen, 2007; Rhodes & Kates, 2015; Williams, 2008). Additionally, researchers have suggested that exercise intensities that are self-selected (i.e., autonomous) may have a direct effect on the affective response to exercise and thus enhance exercise adherence (Ekkekakis & Lind, 2006; Parfitt, Rose, & Burgess, 2006; Rose & Parfitt, 2007; Williams et al., 2016).

However, discomfort and displeasure that may occur during exercise that is new or challenging is sometimes unavoidable (e.g., muscle soreness after trying a new type of activity). Therefore, acceptance of PA-related discomfort may be important in enhancing exercise adherence and maintenance. Research in this area is relatively scarce, but recent research has suggested that acceptance and commitment, which are key skills outlined in behavioural therapies, such as ACT (Hayes, Follette, & Linehan, 2004), may influence health-related behaviour change (Butryn et al., 2015). Such behavioural therapies place less emphasis on controlling internal experiences than traditional behavioural approaches (e.g., cognitive behavioural therapy) and more emphasis on experiential acceptance (i.e., confronting internal experiences, rather than avoiding them). Experiential

acceptance has been successfully applied in a wide range of health behaviours, such as binge eating (Kristeller & Hallett, 1999) and smoking (Gifford et al., 2004). Behavioural commitment (i.e., the willingness to tolerate discomfort to persist in behaviours that are consistent with one's goals) has also been suggested as a predictor of health behaviour (Butryn et al., 2011). Recently, acceptance and commitment-based therapies (Hayes et al., 1999) have gained some preliminary support for enhancing PA outcomes (Katterman, Goldstein, Butryn, Forman, & Lowe, 2014a; Tapper et al., 2009), but more research is currently required to assess the effect of PA acceptance on PA adherence and maintenance.

1.2.5. The potential of mindfulness for physical activity

So far, PA research has focused on providing PA prescriptions and goals with a minimal and/or intermittent focus on psychological constructs or novel strategies to facilitate PA adoption and maintenance (Lillis & Bond, 2019). Understanding what psychological processes are related to PA engagement is crucial for effective PA promotion. Although some individuals describe PA as pleasurable, many individuals frequently report a preference for more sedentary leisure activities and negative perceptions of PA are typically associated with lower PA engagement (Ekkekakis, Parfitt, & Petruzzello, 2011; Rhodes, Fiala, & Conner, 2009; Salmon, Owen, Crawford, Bauman, & Sallis, 2003). Conversely, affective response to PA may predict long-term PA behaviour (Williams, 2008; Williams et al., 2008). One challenge of current lifestyle interventions is to identify how to motivate individuals to translate intentions into actual PA behaviour (Kennedy & Resnick, 2015).

Identification of and subsequent training in self-regulation skills that bridge the PA intention-behaviour gap is required to optimise lifestyle interventions.

A direct and relatively inexpensive method (Strowger, Kiken, & Ramcharran, 2018) that can enhance PA self-regulation (Salmoirago-Blotcher, Hunsinger, Morgan, Fischer, & Carmody, 2013; Vago & Silbersweig, 2012) may be mindfulness practice. The benefits of mindfulness are often conceptualised in terms of self-regulation or self-control (Bowlin & Baer, 2012). Mindfulness has a direct impact on executive functions (Malinowski, 2013; Teper & Inzlicht, 2012), such as cognitive flexibility (Moore & Malinowski, 2009), attentional functions (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007; Lutz, Slagter, Dunne, & Davidson, 2008; MacLean et al., 2010; Schöne et al., 2018; Tang et al., 2007), working memory (Jha et al., 2010; Mrazek, Franklin, Phillips, Baird, & Schooler, 2013), and impulsivity (Lattimore, Fisher, & Malinowski, 2011; Murphy & MacKillop, 2012; Peters, Erisman, Upton, Baer, & Roemer, 2011). MMT arguably promotes more effective self-regulation by enhancing executive functions (Miyake et al., 2000) and reducing emotional reactivity (Teper & Inzlicht, 2012; Teper, Segal, & Inzlicht, 2013). Moreover, previous studies have shown that mindfulness meditation may protect against self-control depletion (Friese, Messner, & Schaffner, 2012).

There are several reasons why mindfulness may be applicable to health behaviours, such as PA. Mindfulness can help increase awareness of urges to skip exercise sessions and to respond more effectively to difficulties that often occur when initiating or attempting to maintain a new exercise programme (Gilbert & Waltz, 2010). Mindfulness practice helps cultivate an open, non-judging, and non-reactive mind, which may help individuals persist with PA (Yang & Conroy, 2019),

despite potentially frustrating or negative thoughts that appear, by not over-identifying with them or responding to them in a habitual way (Bishop et al., 2004). For example, an inactive individual embarking on a lifestyle change may experience thoughts of discouragement or think, “this is too difficult” or “I am not good at this”. A state of mindfulness can help foster a sense of separation between thoughts and actions, and therefore encourage sustained PA, as opposed to quitting due to discouragement.

As such, mindfulness has the potential to target psychological factors related to PA (see section 1.2.4). Studies have shown that DM is positively associated with autonomous exercise motivation (Kang, O'Donnell, Strecher, & Falk, 2017; Ruffault, Bernier, Juge, & Fournier, 2016a) and PA acceptance (Butryn et al., 2015), even when no direct association between DM and PA behaviour was evident. Several possible models have been proposed to suggest the potential mechanisms explaining the effect of mindfulness on PA (Kang et al., 2017; Roberts & Danoff-Burg, 2010; Sagui-Henson, Levens, & Blevins, 2018; Tsafou, De Ridder, Van Ee, & Lacroix, 2016a; Tsafou, Lacroix, van Ee, Vinkers, & De Ridder, 2016b) and showed that stress, PA satisfaction, state mindfulness, psychological flexibility, and negative affect and shame influence the mindfulness-PA relationship (see study one, chapter two). However, prior to this PhD, only one such study employed a longitudinal study design (Kang et al., 2017). Cross-sectional evidence is limited in value and prospective research is required to understand the mechanisms through which mindfulness enhances PA behaviour.

Beyond DM, mindfulness practice has been proposed as a potential approach in interventions aimed at PA promotion (Dutton, 2008), but evidence for

the effect of mindfulness on PA is currently inconsistent (see study one, chapter two). A recent study (Strowger et al., 2018) investigated the relationship between mindfulness (meditation practice over the last year) and PA outcomes (inactivity and whether or not participants met PA recommendations) in a large sample of US adults (N = 34,525). Results showed that adults who reported meditation practice in the past year were less likely to be inactive and more likely to meet PA guidelines, above and beyond other covariates, such as age, gender, race, ethnicity, family education and income level, marital status, and tendency to engage in healthy behaviours (e.g., healthy eating). Moreover, mindfulness meditation showed the strongest associations with PA, compared with mantra meditation and guided imagery (Strowger et al., 2018). However, neither frequency nor specific type of meditation over the past year nor type of PA was investigated in this study, making it difficult to draw definitive conclusions about the relationship between mindfulness and PA outcomes.

Additionally, it is possible that the findings merely reflect a more active, engaged, or "conscious" lifestyle in general (Barrett, Torres, Meyer, Barnet, & Brown, 2019), with no direct causal link between mindfulness and PA. Engagement in various health behaviours often co-occurs through possible shared individual difference factors (Nielsen et al., 2018). Indeed, some studies have shown that aerobic exercise (Mothes, Klaperski, Seelig, Schmidt, & Fuchs, 2014) and movement-based courses, such as Tai Chi, Pilates, and Gyrokinesis (Caldwell, Emery, Harrison, & Greeson, 2011; Caldwell, Harrison, Adams, Quin, & Greeson, 2010), may actually increase DM. It is therefore likely that the relationship between DM and exercise is bidirectional to some extent. Researchers have also suggested

that participants may benefit more from movement-based mindfulness exercises (e.g., mindful walking and yoga) compared to non-movement-based exercises (e.g., body scan or sitting meditation), as it may be easier for novice practitioners to direct mindful attention when engaged in movement (Carmody & Baer, 2008). Similarly, mindfulness combined with PA may induce greater affective benefits when compared to stand-alone PA (Edwards & Loprinzi, 2019). As such, when PA is done in a "mindful way", through deliberate movement and present moment awareness, PA can foster mindfulness and, in turn, benefit mental health (Asztalos et al., 2012).

The complex relationship between mindfulness and PA can further be explained through the fact that both activities impact similar self-regulatory processes, such as the ability to sustain and shift attention and stay cognitively flexible (Barnes, Coombes, Armstrong, Higgins, & Janelle, 2010; Hillman, Erickson, & Kramer, 2008; Ratey & Loehr, 2011; Smith et al., 2010). Indeed, some researchers have suggested that mindfulness can be understood within the context of self-control theory, due to the potentially reciprocal relationship between mindfulness and self-control (Masicampo & Baumeister, 2007). However, while these two concepts share similarities (some of which likely lie within how they are measured), mindfulness is distinct from self-control, particularly through its focus on present moment awareness (Brown et al., 2007), rather than on the pursuit of goals.

Overall, the existing literature suggests a possible relationship between mindfulness and PA, but the directionality and causality of this relationship is still unclear. Moreover, little is known about what other factors may influence this relationship. As such, more research is urgently required to investigate the causal

relationship between mindfulness and PA and the potential mechanisms involved. MMT is different from many intervention strategies, as it is generally inexpensive and can be self-administered frequently once learned (Strowger et al., 2018). Through the evidence outlined above, it is likely that mindfulness has potential as a stand-alone or add-on approach for participants not currently benefitting from existing lifestyle interventions because of its potential to target psychological factors related to PA as well as self-regulatory processes associated with behaviour change. Indeed, several existing MBIs targeted at promoting PA have shown promising, albeit mixed, results (see study one, chapter two). However, little is still known about the potential of mindfulness-based approaches for PA promotion as well as to what extent psychological factors related to PA influence the mindfulness-PA relationship.

1.3. Outline of the PhD

1.3.1. Research questions and thesis plan

This PhD aimed to investigate the role of mindfulness in PA. Two central research questions were addressed through a series of three studies: 1) what is the effect of mindfulness on PA outcomes? and 2) what is the relationship between mindfulness and psychological factors related to PA? The employed process followed updated guidelines by the Medical Research Council (MRC) for developing and evaluating complex interventions (Craig et al., 2008; see Figure 1.4). The development phase was realised in study one (identifying the evidence base and developing the theory) and study two (modelling processes and outcomes). Study

three targeted the feasibility/piloting phase (testing procedures, estimating recruitment/retention, and determining sample size) and, partially, the evaluation phase (assessing preliminary effectiveness). Table 1.2 provides a summary of the content and key outcomes of each study.

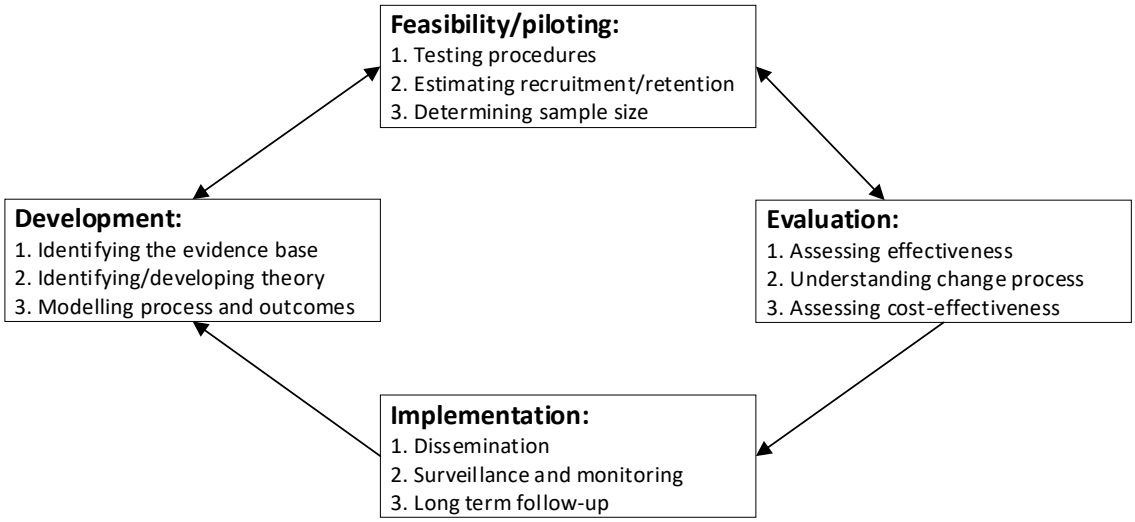

Figure 1.4. Development-evaluation-implementation process from the Medical Research Council guidance on developing and evaluating complex interventions (adapted from Craig et al., 2008).

Study one (chapter two) was a comprehensive systematic review of mindfulness and PA literature published up until 1 June 2018 (Schneider, Malinowski, Watson, & Lattimore, 2018). The purpose of the systematic review was to investigate: 1) the relationship between DM and PA, 2) psychological factors that potentially explain the relationship between DM and PA, and 3) the effect of mindfulness practice on PA outcomes. In line with considerations regarding how mindfulness is defined and measured, the review distinguished between DM and mindfulness skills cultivated through MMT and MBIs (i.e., mindfulness practice). Through the review, several psychological mechanisms were identified for investigation in future studies (studies two and three).

Study two (chapter three) was designed based on knowledge gained from the systematic review and existing health literature and used cross-sectional and longitudinal data following a prospective cohort study to investigate: 1) the relationship between DM and psychological factors related to sustained PA and 2) the direct and indirect effect of DM on PA change over time. Several psychological correlates of PA behaviour change were considered as mediators between DM and PA, including self-control, autonomous exercise motivation, and PA acceptance. Studies one and two provided the basis for the development of a novel MBI specifically targeted to enhance PA motivation and acceptance in underactive participants (study three).

Study three (chapter four) involved the development of a MBI called Mindfulness for Physical Activity (MfPA) and assessed it in terms of feasibility, acceptability, and preliminary efficacy. It aimed to: 1) evaluate the efficacy of the MfPA intervention by exploring changes in self-regulation, DM, and PA outcomes, 2) assess the feasibility and acceptability of the intervention for underactive participants, and 3) gather information from participants to generate a basis for the refinement of the MfPA programme. This study expanded upon findings from study two by investigating the influence of mindfulness practice on PA outcomes and by including an objective measure of PA (i.e., accelerometers).

Finally, **chapter five** offers a general discussion and synthesis of the PhD work contained within this thesis. Overall, this PhD provides a comprehensive attempt at understanding the impact of mindfulness on PA outcomes and contributes evidence for the potential of MBIs to enhance psychological factors related to sustained PA behaviour change.

1.3.2. Original contribution of this PhD

This PhD aimed to fill the following gaps in the literature:

1. Study one (chapter two) was the first comprehensive systematic review conducted to investigate the relationship between DM and PA and to assess the effect of mindfulness practice on PA. The systematic review uniquely distinguished between mindfulness practice and DM and considered both psychological factors related to PA and PA behaviour as target outcomes. It also considered potential mediators of the mindfulness-PA relationship.

2. Building on findings from the systematic review, study two (chapter three) investigated potential mechanisms of the mindfulness-PA relationship through a prospective cohort study design, using structural equation modelling and latent growth curve modelling. As such, it was the first longitudinal study to investigate psychological factors related to PA as mediators of the mindfulness-PA relationship.

3. Finally, building on knowledge gained from studies one and two, study three (chapter four) was a mixed-methods study that outlined the development and testing of a novel mindfulness-based approach for PA promotion in underactive participants, by considering MRC guidance, previous literature and guidance on MBI adaptation and development, and participant feedback and involvement. In line with the central research questions of this PhD, it considered both PA behaviour and psychological factors related to PA as target outcomes. Additionally, the intervention uniquely targeted PA acceptance and autonomous exercise motivation as mechanisms of PA behaviour change.

Table 1.2. Outline of studies conducted as part of this PhD.

Study	Chapter	Title	Participants	Research aims	Methodology	Conclusions
1	2	The role of mindfulness in physical activity: A systematic review	Cross-sectional studies (n = 20) Intervention studies (n = 20)	1) To investigate the relationship between DM and PA; 2) To investigate psychological factors that potentially explain the relationship between DM and PA; 3) To investigate the effect of MBIs on PA outcomes	Systematic review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines	1) DM was positively correlated to psychological factors related to PA (e.g., autonomous exercise motivation); 2) MBIs were more successful at implementing PA behaviour change if they target psychological factors related to PA
2	3	Modelling the relationship between dispositional mindfulness and physical activity outcomes: A prospective cohort study	Male and female participants, aged 19 – 64 years old (N = 196)	1) To investigate the relationship between DM and psychological factors related to sustained PA; 2) To investigate the direct and indirect effect of DM on PA change over time	Online prospective cohort study over two weeks	1) DM directly or indirectly predicted autonomous exercise motivation and PA acceptance at baseline; 2) The relationship between DM and PA was sequentially mediated by autonomous exercise motivation and PA acceptance
3	4	Adapting a mindfulness-based programme to facilitate physical activity uptake in underactive participants: A feasibility study	Male and female underactive participants, aged 19 – 64 years old, who want to improve their relationship with PA (N = 13)	1) To evaluate the efficacy of the MfPA intervention by exploring changes in self-control, DM, and PA outcomes; 2) To assess the feasibility and acceptability of the intervention for underactive participants; 3) To gather information from participants to generate a basis for the refinement of the MfPA programme	Pre-post pilot study of a six-week mindfulness intervention for PA following the Medical Research Council (MRC) guidelines for developing and evaluating interventions	1) PA acceptance and autonomous exercise motivation increased following the intervention, but no change was seen in DM, self-control, or PA; 2) Participants reported an improved relationship with PA following the intervention

Note. DM, dispositional mindfulness; MBI, mindfulness-based intervention; MfPA, Mindfulness for Physical Activity; PA, physical activity.

1.4. Justification for study one

Previous literature reviews have considered the potential of mindfulness-based approaches for eating behaviour (O'Reilly, Cook, Spruijt-Metz, & Black, 2014), athletic performance (Sappington & Longshore, 2015), weight loss (Daubenmier et al., 2016; Olson & Emery, 2015; Ruffault et al., 2016b), depression (Klainin-Yobas, Cho, & Creedy, 2012; Piet & Hougaard, 2011), anxiety disorders (Treanor, 2011), speech pathologies (Boyle, 2011), eating disorders (Godsey, 2013; Katterman et al., 2014b; Wanden-Berghe et al., 2010), substance use disorders (Zgierska et al., 2009), cancer care (Musial, Büssing, Heusser, Choi, & Ostermann, 2011; Ott, Norris, & Bauer-Wu, 2006; Shennan, Payne, & Fenlon, 2011; Smith, Richardson, Hoffman, & Pilkington, 2005), stress reduction (Chiesa & Serretti, 2009; Khoury et al., 2015), psychiatric disorders (Chiesa & Serretti, 2011a), chronic pain (Chiesa & Serretti, 2011b; Zeidan, Grant, Brown, McHaffie, & Coghill, 2012), and general psychological health (Hofmann, Grossman, & Hinton, 2011; Keng et al., 2011). Prior to this PhD, no systematic review has looked exclusively at mindfulness-based approaches for PA and little is currently known about the relationship between DM and PA and the effect of mindfulness practice on PA outcomes. As no previous systematic review has been conducted on mindfulness and PA specifically, it was the first logical step of the full programme of research and served as the backbone of the PhD in that it outlined current knowledge in the field and highlighted gaps in the literature. Findings from the review were subsequently used to inform the design of studies two and three of this PhD.

Chapter Two – The Role of Mindfulness in Physical Activity: A Systematic Review[3]

2.1. Study overview

Despite continued public health campaigns to promote PA, a majority of the population is inactive. In recent years, mindfulness-based approaches have been used in health and lifestyle interventions for PA promotion. A narrative systematic literature review was conducted using the PRISMA guidelines to investigate the evidence for the potential of mindfulness-based approaches for PA. Electronic databases were searched for papers that met eligibility criteria and 40 studies were identified for inclusion. Evidence from cross-sectional studies (n = 20) indicated a positive relationship between DM and PA, particularly with psychological factors related to PA. Five studies found that the DM-PA relationship was mediated by stress, psychological flexibility, negative affect and shame, satisfaction, and state mindfulness. Evidence from MBIs (n = 20) showed positive between-subjects effects on PA in more than half of the studies, but interventions varied in duration, session length, group size, delivery, content, and follow-up period. MBIs were more likely to be successful if they were PA-specific and targeted psychological factors related to PA. The body of research shows a need for more methodologically rigorous studies to establish the effect of mindfulness on PA and to identify potential mechanisms involved in the mindfulness-PA relationship.

[3] Schneider, J., Malinowski, P., Watson, P. M., & Lattimore, P. (2018). The role of mindfulness in physical activity: A systematic review. *Obesity Reviews, 20*(3), 448-463. doi: 10.1111/obr.12795

2.2. Introduction

2.2.1. Background

Current lifestyle interventions have consistently shown modest changes in target behaviours (Conn, Hafdahl, & Mehr, 2011; Lemmens, Oenema, Klepp, Henriksen, & Brug, 2008; Metcalf, Henley, & Wilkin, 2012; Rhodes & Pfaeffli, 2010) and limited long-term effects (Fjeldsoe, Neuhaus, Winkler, & Eakin, 2011; Shaya, Flores, Gbarayor, & Wang, 2008; Wing & Hill, 2001). Moreover, interventions targeting PA specifically have demonstrated small (Johnson, Scott-Sheldon, & Carey, 2010; Michie et al., 2009) to moderate (Foster, Hillsdon, Thorogood, Kaur, & Wedatilake, 2005) effects on PA outcomes. Many PA interventions typically suffer from high drop-out rates and low short- and long-term adherence (Blue & Black, 2005; Dishman et al., 2012). Several psychological factors may contribute to greater PA adherence and maintenance, such as autonomous exercise motivation, self-efficacy, and the use of self-regulation skills (Teixeira et al., 2015). However, more research is needed to identify the mechanisms of successful PA behaviour change. This is particularly important for individuals with overweight and obesity who may experience additional barriers to PA (Kennedy & Blair, 2014; Korkiakangas et al., 2009; McIntosh, Hunter, & Royce, 2016; Teixeira et al., 2015), such as discomfort while exercising (Egan et al., 2013; Leone & Ward, 2013; Piana et al., 2013; Thomas, Hyde, Karunaratne, Kausman, & Komesaroff, 2008; Wiklund, Olsén, & Willén, 2011), feeling too overweight (Atlantis, Barnes, & Ball, 2008; Ball, Crawford, & Owen, 2000; Napolitano, Papandonatos, Borradaile, Whiteley, & Marcus, 2011), feeling embarrassed or insecure (Ball et al., 2000), lacking motivation (Egan et al., 2013;

Napolitano et al., 2011; Peacock, Sloan, & Cripps, 2014; Piana et al., 2013), and reporting less positive attitudes towards PA (Deforche, De Bourdeaudhuij, & Tanghe, 2006; Napolitano et al., 2011; Peacock et al., 2014; Piana et al., 2013). Novel interventions are therefore required that remove such barriers to optimise PA uptake, adherence, and maintenance. In recent years, mindfulness practices have received increasing attention in lifestyle interventions, because of their potential to address psychological barriers to change (Hayes, 2004). The purpose of the current review was therefore to summarise and evaluate evidence for the potential of mindfulness-based approaches for PA promotion and obesity prevention.

Mindfulness training enhances self-regulation abilities, including attentional mechanisms, behaviour flexibility, and emotion regulation (Malinowski, 2013; Shapiro et al., 2006; Tang et al., 2015). Regarding PA, mindful awareness could enhance acceptance of negative or uncomfortable thoughts and sensations that are likely to occur during PA, particularly in novice exercisers or individuals with overweight and obesity (e.g., pain, fatigue, exertion) and thus encourage individuals to sustain PA in the short (Gilbert & Waltz, 2010) and long term (Salmon et al., 2010). Mindfulness-based approaches used as an adjunct to weight-loss interventions have the potential to prepare individuals who have difficulty starting or maintaining an exercise program (Kennedy & Resnick, 2015), by improving their acceptance of PA-related discomfort (Butryn et al., 2015). However, little is currently known about the effect of mindfulness on PA behaviour change.

2.2.2. Review objectives

The current review is the first to summarise existing knowledge on the relationship between DM and PA and to summarise outcomes from MBIs targeting PA. Three objectives were devised to investigate: 1) the relationship between DM and PA, 2) psychological factors that potentially explain the relationship between DM and PA, and 3) the effect of mindfulness practice on PA outcomes.

2.3. Method

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher, Liberati, Tetzlaff, Altman, & The Prisma Group, 2009). Due to the heterogeneity in study design and measurements used in the reviewed studies, a meta-analytic approach could yield misleading results; thus, a narrative systematic review was conducted.

2.3.1. Data sources and search strategies

A systematic literature search was conducted for papers published up to 1 June 2018 using the databases Google Scholar, MEDLINE (PubMed), PsycINFO, PsycARTICLES, and Ovid. Boolean combinations of the following search terms and their abbreviations were used: mindfulness; dispositional mindfulness; cultivated mindfulness; mindfulness meditation training; acceptance and commitment therapy; dialectical behaviour therapy; mindfulness-based stress reduction; mindfulness-based cognitive therapy; mindfulness-based strengths practice; Zen

meditation; Vipassana meditation; physical activity; exercise; fitness; and physical health (see Table 2A.1 in appendix 2A for an example search strategy). The reference sections of the included articles were scanned to identify any additional studies that met the inclusion criteria.

Given the relative infancy of the mindfulness and PA literature, a broad view of "mindfulness" was adopted that encompassed DM, mindfulness skills, and mindfulness meditation. As such, it was important to include all MBIs, even those without MMT, in an effort to investigate the different ways mindfulness is conceptualised within PA intervention research. MBIs were defined as interventions that either involved MMT and/or trained individuals in mindfulness skills through formal or informal exercises. Mindfulness skills were defined as those identified in the mindfulness literature, including observing, describing, acting with awareness, accepting without judgement (Baer et al., 2004), non-reactivity (i.e., refraining from impulsive reactions toward internal experience; Baer et al., 2006), intention (i.e., purpose), attention (i.e., paying attention in the present moment; Shapiro et al., 2006), openness, and curiosity (Kabat-Zinn, 2004). This review examined self-reported and objectively measured PA (e.g., frequency, duration, type) and psychological factors related to PA (e.g., motivation, satisfaction, enjoyment).

2.3.2. Inclusion and exclusion criteria

Papers were included if they: 1) were cross-sectional or longitudinal studies providing a quantitative measure of DM or intervention studies that contained MBIs (with or without a PA component), 2) measured any frequency, type, duration, or intensity of PA using quantitative outcomes, and 3) were published in

English. Where the MBI contained PA, only studies that controlled for the PA component by including a PA-based control group were considered for inclusion. This is because MBIs that contain PA within the intervention do not isolate the effects of the MBI on PA outcomes. Studies were not excluded based on participant characteristics (e.g., age, gender, ethnicity, health condition, weight status) or year of publication. The decision to include or exclude studies was based initially on the title, then on the abstract, and finally on the full text.

2.3.3. Data extraction

JS extracted data from the identified studies and PW checked for accuracy and consistency. The following data were extracted: 1) authors and year of publication, 2) study design, 3) sample size and gender (percentage females), 4) age, 5) body mass index (BMI), 6) measures used, 7) mindfulness and PA outcomes, and 8) study quality. Additional data extracted for intervention studies included information about intervention and control conditions. For studies that described statistically significant outcomes, a p-value < .05 was considered significant.

2.3.4. Quality assessment

Quality was assessed using the Effective Public Health Practice Project (EPHPP) tool. The EPHPP provides good interrater agreement for overall quality grade (Armijo-Olivo, Stiles, Hagen, Biondo, & Cummings, 2012) across a variety of quantitative study designs (Thomas, Ciliska, Dobbins, & Micucci, 2004). Studies were assessed on: 1) selection bias, 2) study design, 3) confounders, 4) blinding, 5)

data collection methods, and 6) withdrawals and dropouts. Components were scored as strong, moderate, or weak. EPHPP guidelines were used to generate a global score such that no weak component ratings = strong, one weak component rating = moderate, and ≥ two weak component ratings = weak. JS assessed all studies and PW assessed a subsample (n = 15). Cohen's kappa (Cohen, 1960) was calculated to determine interrater reliability, showing good agreement (87%) between scores (κ = .752, p = .001). Discrepancies were due to differences in the interpretation of criteria and were discussed with PL until a 100% agreement in coding was reached.

2.4. Results

2.4.1. Paper selection

As of 1 June 2018, the search protocol yielded 2500 papers (see Figure 2.1). After removing duplicates, 1149 papers were reviewed based on the title. Of those, 245 abstracts were retained for review and 60 articles were reviewed based on the full text. One cross-sectional study was excluded because it did not analyse the relationship between mindfulness and PA. One cross-sectional and one longitudinal study were excluded because they did not provide a measure of DM. Ten intervention studies were excluded because they did not provide a measure of PA and seven others were excluded because PA was a component of the MBI with no PA-based control group (see Table 2B.1 in appendix 2B). All full-text articles were independently screened by two reviewers (JS and PW).

2.4.2. Study characteristics

A final sample of 40 papers (from 39 studies) was included in this review (see Table 2.2), consisting of 19 cross-sectional studies, one longitudinal study, five cohort studies (no control group), one non-randomised controlled trial, and 14 randomised controlled trials (RCTs). The majority of the included studies were rated as weak (n = 18) or moderate (n = 21) and one study was rated strong.

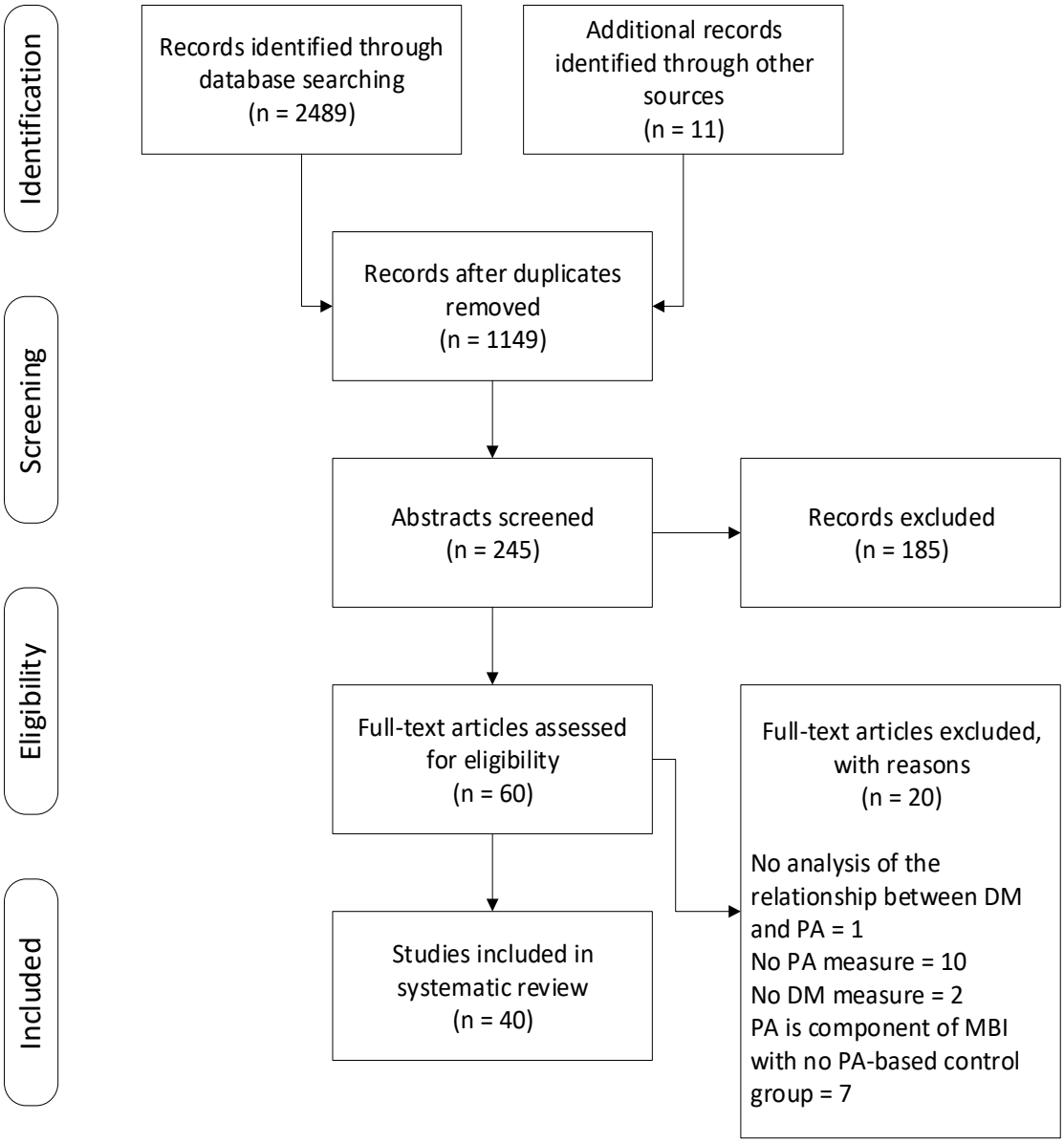

Figure 2.1. PRISMA flowchart of study selection.
Note. DM, dispositional mindfulness; MBI, mindfulness-based intervention; PA, physical activity.

Table 2.2. Characteristics of the reviewed studies.

Author (year)	Design	Participants			Intervention	Control	Measures	Main findings	Study quality
		N (% female)	Mean years (SD)	Mean BMI (SD)					
Caluyong et al. (2015)	CS	74 (39.2)	63.4 (10.2)	-	N/A	N/A	**DM:** FFMQ **PA:** SDSCA **Other:** none	DM not correlated with PA	Weak
Chatzisarantis & Hagger (2007)	CS	**Study 1:** 226 (51.3) **Study 2:** 292 (52.4)	**Study 1:** 19.23 (1.1) **Study 2:** 19.48 (1.2)	-	N/A	N/A	**DM:** MAAS **PA:** intentions**,** behaviour **Other:** SRHI	DM not correlated with PA, but positively correlated with attitude and perceived behavioural control; DM moderated the intention-PA relationship	Weak
Clevenger et al. (2018)	CS	754 (47)	Range 8-13	Percentile 69.2 (29.3)	N/A	N/A	**DM:** CAMM **PA:** PAQ-C **Other:** none	PA not associated with DM	Moderate
Fanning, Osborn, Lagotte, & Mayberry (2018)	CS	148 (60)	55.7 (10.1)	35.5 (6.7)	N/A	N/A	**DM:** MAAS **PA:** SDSCA **Other:** none	DM not associated with exercise	Weak
Gao & Shi (2015)	CS	1354 (62)	18.3 (-)	-	N/A	N/A	**DM:** MAAS **PA:** IPAQ **Other:** none	DM positively associated with PA	Weak
Gilbert & Waltz (2010)	CS	269 (68.8)	20.9 (-)	-	N/A	N/A	**DM:** FFMQ **PA:** IPAQ **Other:** ECS	DM positively correlated to MPA, VPA, self-efficacy for making time for exercise and self-efficacy for resisting exercise relapse	Weak

Continued…

Table 2.2. Characteristics of the reviewed studies.

Author (year)	Design	Participants			Intervention	Control	Measures	Main findings	Study quality
		N (% female)	Mean years (SD)	Mean BMI (SD)					
Grinnell, Greene, Melanson, Blissmer, & Lofgren (2011)	CS	75 (89.3)	18.1 (.1)	80% healthy, 16% overw., 4% obese	N/A	N/A	**DM:** MAAS **PA:** IPAQ **Other:** WRBQ	DM not correlated with PA, but positively correlated with self-regulation and outcome expectations of PA, and negatively correlated with personal barriers of PA	Weak
Kangasniemi, Lappalainen, Kankaanpää, & Tammelin (2014)	CS	108 (79)	43 (5.2)	**Active:** 23.4 (2.8) **Less active:** 28.3 (5.7)	N/A	N/A	**DM:** KIMS **PA:** accelerometer **Other:** AAQ-2	DM positively correlated with MVPA, but not correlated with HEPA; physically active group scored higher on DM and psychological flexibility than less active group	Moderate
Loucks, Britton, Howe, Eaton, & Buka (2015)	CS	382 (57)	47 (-)	-	N/A	N/A	**DM:** MAAS **PA:** IPAQ **Other:** none	DM level positively associated with PA	Moderate
Martin, Prichard, Hutchinson, & Wilson (2013)	CS	159 (100)	18-80 (-)	24.9 (4.5)	N/A	N/A	**DM:** MAAS **PA:** frequency **Other:** MEQ	DM and mindful eating positively correlated with yoga, but negatively correlated with aerobic exercise	Weak
Murphy, Mermelstein, Edwards, & Gidycz (2012)	CS[a]	441 (100)	19.06 (3.6)	-	N/A	N/A	**DM:** MAAS **PA:** LTEQ **Other:** none	DM not correlated with exercise frequency	Weak

Continued…

Table 2.2. Characteristics of the reviewed studies.

Author (year)	Design	Participants			Intervention	Control	Measures	Main findings	Study quality
		N (% female)	Mean years (SD)	Mean BMI (SD)					
Roberts & Danoff-Burg (2010)	CS	553 (69.6)	18.8 (2.1)	-	N/A	N/A	**DM:** FFMQ **PA:** WLI **Other:** PSS	DM positively correlated with daily PA, weekly PA, and PA enjoyment; DM-PA was partially mediated by stress	Weak
Ruffault et al. (2016a)	CS	280 (58.2)	21 (2.7)	21.9 (2.8)	N/A	N/A	**DM:** MAAS **PA:** IPAQ **Other:** BREQ-2	DM not correlated with PA, but positively correlated with PA motivation; DM moderated PA-intrinsic motivation	Weak
Ruffault, Bernier, Thiénot, Fournier, & Flahault (2017)	CS	100 (48)	33.49 (11.6)	-	N/A	N/A	**DM:** MAAS **PA:** IPAQ **Other:** AAQ-2	PA not correlated with DM, but positively correlated with acceptance	Weak
Sagui-Henson et al. (2018)	CS	233 (53.2)	39.6 (12.3)	-	N/A	N/A	**DM:** FFMQ **PA:** IPAQ **Other:** AAQ-2, PSS	DM not correlated with PA; mindfulness-PA was fully mediated by psychological flexibility and reduced stress	Weak
Slonim, Kienhuis, Di Benedetto, & Reece (2015)	CS	207 (67.1)	21.8 (3.6)	-	N/A	N/A	**DM:** FFMQ **PA:** HPLP-II **Other:** none	PA positively correlated with DM	Weak
Tsafou et al. (2016a)	CS	398 (50.3)	41.28 (13.3)	25.2 (4.5)	N/A	N/A	**DM:** MAAS **PA:** IPAQ, satisfaction **Other:** MFPA	DM not correlated with PA, but positively correlated with PA satisfaction; state mindfulness-PA was mediated by PA satisfaction	Weak

Continued…

Table 2.2. Characteristics of the reviewed studies.

Author (year)	Design	Participants			Intervention	Control	Measures	Main findings	Study quality
		N (% female)	Mean years (SD)	Mean BMI (SD)					
Tsafou et al. (2016b)	CS	305 (51.1)	40.7 (13)	25.2 (4.5)	N/A	N/A	**DM:** FFMQ, MAAS **PA:** IPAQ, satisfaction **Other:** MFPA	DM positively correlated with PA when measured by the MAAS only; DM-PA relationship was mediated first by state mindfulness and then by PA satisfaction	Weak
Ulmer, Stetson, & Salmon (2010)	CS	226 (65)	49.96 (14.7)	26.6 (5.7)	N/A	N/A	**DM:** MAAS **PA:** IPAQ, maintenance, perceived success in meeting goals **Other:** AAQ-9, FMI, WBSI	Participants who scored higher on DM and state mindfulness were less likely to skip exercise	Weak
Kang et al. (2017)	LGT[b]	67 (61.2)	33.4 (13.0)	28.0 (6.8)	Computerized health message + daily text messages	N/A	**DM:** MAAS **PA:** IPAQ, accelerometer **Other:** PANAS, BREQ-2	DM predicted self-reported VPA and exercise motivation (1m only), but not MPA, walking, or objectively measured PA; DM-PA motivation was mediated by negative affect and shame	Moderate
Carlson, Speca, Patel, & Goodey (2004)	COH	42 (78.6)	54.5 (10.9)	-	MBSR 90min x 8w + 3h retreat	N/A	**DM:** none **PA:** frequency **Other:** none	PA frequency increased from pre- to post-intervention	Moderate

Continued…

Table 2.2. Characteristics of the reviewed studies.

Author (year)	Design	Participants			Intervention	Control	Measures	Main findings	Study quality
		N (% female)	Mean years (SD)	Mean BMI (SD)					
Cox, Roberts, Cates, & McMahon (2018)	COH	23 (82.6)	19.3 (1.1)	24.8 (5.0)	10min audio during 30min treadmill test	N/A	**DM:** none **PA:** RPE **Other:** valence, SMS-PA, PACES	State mindfulness, affective valence, and PA enjoyment was higher and RPE was lower in mindfulness condition	Moderate
Goodwin, Forman, Herbert, Butryn, & Ledley (2012)	COH	16 (68.8)	56.42 (12.7)	-	ABBT 4 x 90min (with psycho-education)	N/A	**DM:** PHLMS **PA:** IPAQ **Other:** PAAAQ, values and goals clarity	Participants made moderate increases in PA from pre- to post-treatment; PA change associated with PHLMS-acceptance and values/goals clarity	Moderate
Lucas, Focht, Cohn, Buckworth, & Klatt (2016)	COH	17 (100)	61.1 (7.0)	33.8 (6.5)	MIM+D 1h x 8w + 6w home practice (with dietary counselling)	N/A	**DM:** FFMQ, MAAS **PA:** PAQ, accelerometer, SPPB **Other:** none	There were small to moderate increases in DM (MAAS only), PA (self-reported walking only), and physical performance	Moderate
Salmoirago-Blotcher et al. (2013)	COH	174 (61)	47 (10.3)	-	MBSR 2.5h x 7w + all-day class at 6w + 45min/d home practice	N/A	**DM:** FFMQ **PA:** HBQ **Other:** none	Participants in the "sedentary" category decreased from pre- to post-intervention; increase in activities aimed to improve flexibility and overall strength/flexibility score	Moderate
Ingraham et al. (2016)	CCT	266 (100)	≥40 (-)	-	Mindfulness-based workshops 2h x 12w (with PA psycho-education)	TAU 12-16w (n=106)	**DM:** none **PA:** IPAQ **Other:** MEQ	PA increased from pre- to post-intervention (TAU>MBI); mindful eating increased in the mindfulness group	Weak

Continued…

Table 2.2. Characteristics of the reviewed studies.

Author (year)	Design	Participants			Intervention	Control	Measures	Main findings	Study quality
		N (% female)	Mean years (SD)	Mean BMI (SD)					
Butryn et al. (2011)	RCT	54 (100)	23.1 (3.8)	25.1 (5.6)	ACT-based workshop 2x2h, 2w apart	Education workshop 2x2h, 2w apart (n=19)	**DM:** PHLMS **PA:** athletic centre visits **Other:** PAAAQ	Athletic centre visits increased from pre- to post-intervention (ACT>control); PAAAQ and PHLMS-awareness increased (ACT=control)	Moderate
Davis (2008)	RCT	71 (88.7)	45.1 (8.3)	32.9 (3.7)	SBWL 30min x 24w + MMT	SBWL (n=24) or SBWL + resistance training (n=23)	**DM:** MAAS **PA:** PPAQ **Other:** none	PA increased at 3m (MBI=control) and at 6m (SBWL plus resistance only); DM increased in all groups	Moderate
Fletcher (2012)	RCT	72 (83.3)	52.6 (11.8)	35.5 (SE = .1)	ACT 1 x 6h	Waitlist (n=31)	**DM:** FFMQ **PA:** IPAQ **Other:** AAQ-2, PAAQ	PA increased from pre- to post-intervention (ACT=control)	Moderate
Gotink et al. (2017) *(follow-up of Younge et al., 2015)*	RCT	324 (46.3)	**MBI:** 43.2 (14.1) **Control:** 43.2 (13.7)	**MBI:** 25.9 (4.6) **Control:** 25.7 (4.7)	TAU + 12w online MMT	TAU (n=109)	**DM:** none **PA:** 6-min walk test (6MWT), HR **Other:** PSS	Improvements in the 6MWT and HR in the mindfulness group were not significant at 12m	Moderate
Grossman, Deuring, Walach, Schwarzer, & Schmidt (2017)	RCT	163 (100)	**Fibromyalgia:** 54.1 (9.1) **Control:** 53.4 (6.0)	-	MBSR 2.5h x 8w	Waitlist or matched intervention 2.5h x 8w (n=33)	**DM:** none **PA:** HR, accelerometer **Other:** none	PA and HR decreased from pre- to post-intervention (MBSR=control)	Strong

Continued…

Table 2.2. Characteristics of the reviewed studies.

Author (year)	Design	Participants			Intervention	Control	Measures	Main findings	Study quality
		N (% female)	Mean years (SD)	Mean BMI (SD)					
Ivanova, Jensen, Cassoff, Gu, & Knäuper (2015)	RCT	39 (100)	23 (5)	-	ACT 1 x 40min	Short video of PA goals 1 x 40min (n=21)	**DM:** none **PA:** HR, RPE **Other:** PACES	There was a significant group by time interaction for exercise tolerance time, RPE, and perceived exercise enjoyment (ACT>control)	Moderate
Meyer et al. (2018)	RCT	49 (82)	51.9 (11.1)	31.3 (7.8)	MBSR 2.5h x 8w + 6h retreat + home practice	Aerobic Exercise Training (AET) 2.5h x 8w + 6h retreat + home practice (n=14) or control (n=17)	**DM:** none **PA:** accelerometer **Other:** none	Seasonal declines in PA did not differ between groups (MBSR=AET=control); MVPA bouts of ≥10min increased in the AET group only	Moderate
Miller, Kristeller, Headings, Nagaraja, & Miser (2012)	RCT	52 (63.5)	**MB-EAT-D:** 53.9 (8.2) **SC:** 54.0 (7.0)	**MB-EAT-D:** 36.2 (1.2) **SC:** 36.1 (1.2)	MB-EAT-D 2.5h x 8w + 2.5h x 2w +1 and 3m follow-up (with PA and health psycho-education)	"Smart Choices" Diabetes self-mgmt. 2.5h x 8w + 2.5h x 2w + 1 and 3m follow-up (n=25)	**DM:** none **PA:** MPAQ **Other:** none	PA increased from pre- to post-intervention at 1m (MB-EAT-D=control); no change in PA at 3m	Moderate

Continued…

Table 2.2. Characteristics of the reviewed studies.

Author (year)	Design	Participants			Intervention	Control	Measures	Main findings	Study quality
		N (% female)	Mean years (SD)	Mean BMI (SD)					
Moffitt & Mohr (2015)	RCT	59 (83.1)	**ACT:** 43.5 (12.2) **Control:** 43.9 (10.3)	**ACT:** 32.0 (7.1) **Control:** 31.7 (6.0)	ACT DVD + 12w walking programme building up to 3000 steps in 30min x 5d/w	12w walking programme building up to 3000 steps in 30min x 5d/w (n=27)	**DM:** none **PA:** IPAQ, pedometer **Other:** AAQ, PA goals	Average step count and PA classifications increased from pre- to post-intervention (ACT>control); participants in the ACT group were more likely to reach PA goals	Moderate
Palmeira, Pinto-Gouveia, & Cunha (2017)	RCT	73 (100)	**Kg-Free:** 42.0 (8.8) **TAU:** 42.7 (8.4)	**Kg-Free:** 34.8 (5.3) **TAU:** 33.7 (4.8)	TAU + Kg-Free 2.5h x 10w + 2 x 2.5h (+ health education)	TAU (n=37)	**DM:** FFMQ **PA:** 3-item questionnaire **Other:** none	PA increased from pre- to post-intervention with higher overall PA (Kg-Free>TAU); no between-group differences for DM were found post-intervention	Moderate
Salmoirago-Blotcher et al. (2018)	RCT	53 (59)	**HE-MT:** 14.6 (.3) **HE-AC:** 14.5 (.4)	**HE-MT:** Percentile 66.5 (30.8) **HE-AC:** Percentile 69.4 (31.3)	Health education 4d/w x 2w + modified MBSR 45min x 8w (HE-MT)	Health education 4d/w x 2w + attention control 1 x 8w (HE-AC) (n=23)	**DM:** none **PA:** PAR **Other:** none	MVPA post-intervention was higher among males and those with higher MVPA at baseline (HE-MT>HE-AC)	Moderate
Tapper et al. (2009)	RCT	62 (100)	41 (13)	31.6 (6.1)	ACT-based workshop 3 x 2h over 3w	Normal diet (n=31)	**DM:** none **PA:** BPAT **Other:** AAQ-2	PA increased from pre- to post-intervention (ACT>control); those that still used workshop principles at 6m had greater increases in PA	Weak

Continued…

Table 2.2. Characteristics of the reviewed studies.

Author (year)	Design	Participants			Intervention	Control	Measures	Main findings	Study quality
		N (% female)	Mean years (SD)	Mean BMI (SD)					
VanBuskirk, Roesch, Afari, & Wetherell (2014)	RCT	87 (55.2)	56.25 (11.9)	-	ACT 90min x 8w	CBT 90min x 8w (n=41)	**DM:** none **PA:** accelerometer **Other:** none	No change in PA (ACT=CBT)	Moderate
Younge et al. (2015)	RCT	324 (46.3)	**MBI:** 43.2 (14.1) **TAU:** 43.2 (13.7)	**MBI:** 25.9 (4.6) **TAU:** 25.7 (4.7)	TAU + 12w online MMT	TAU (n=109)	**DM:** none **PA:** 6-min walk test (6MWT), HR **Other:** none	Heart rate, but not the 6MWT, improved at 12w (MBI>TAU)	Moderate

Note. Only measures directly related to mindfulness and/or PA are reported. *Design.* CS, cross-sectional study; CCT, controlled clinical trial; COH, cohort study; LGT, longitudinal study; RCT, randomised controlled trial. *Measures.* AAQ, Acceptance and Action Questionnaire; BMI, body mass index; BPAT, Brief Physical Assessment Tool; BREQ-2, Revised Behavioural Regulation in Exercise Questionnaire; CAMM, Child and Adolescent Mindfulness Measure; ECS, Exercise Confidence Survey; FFMQ, Five-Facet Mindfulness Questionnaire; FMI, Frieberg Mindfulness Inventory; HBQ, Health Behaviour Questionnaire; HPLP-II, Health Promoting Lifestyle Profile II; IPAQ, International Physical Activity Questionnaire; KIMS, Kentucky Inventory of Mindfulness Skills; LTEQ, Leisure-Time Exercise Questionnaire; MAAS, Mindful Attention and Awareness Scale; MEQ, Mindful Eating Questionnaire; MFPA, Mindfulness in Physical Activity; MPAQ, Modifiable Physical Activity Questionnaire; PAAAQ, Physical Activity Acceptance and Action Questionnaire; PAAQ, Physical Activity Acceptance Questionnaire; PACES, Physical Activity Enjoyment Scale; PAR, Physical Activity Recall; PAQ, Paffenbarger Physical Activity Questionnaire; PAQ-C, Physical Activity Questionnaire for Children; PHLMS, Philadelphia Mindfulness Scale; PPAQ, Paffenbarger Physical Activity Questionnaire; RPE, Rating of Perceived Exertion; SDSCA, Summary of Diabetes Self-Care Activities; SMS-PA, State Mindfulness Scale for Physical Activity; SPPB, The Short Physical Performance Battery; SRHI, Self-Report Habit Index; WBSI, White Bear Suppression Inventory; WLI, Weight and Lifestyle Inventory; WRBQ, Weight Related Behaviours Questionnaire. *Interventions.* ABBT, acceptance-based behaviour training; ACT, acceptance and commitment therapy; CBT, cognitive behavioural therapy; MB-EAT-D, mindfulness-based eating awareness training for diabetes; MBSR, mindfulness-based stress reduction. *Other.* BMI, body mass index; DM, dispositional mindfulness; HEPA, health-enhancing physical activity; HR, heart rate; MBI, mindfulness-based intervention; MMT, mindfulness meditation training; MPA, moderate intensity physical activity; MVPA, moderate to vigorous intensity physical activity; PA, physical activity; SBWL, standard behaviour weight loss programme; TAU, treatment as usual; VPA, vigorous intensity physical activity. [a] Cross-sectional data drawn from a longitudinal study, [b] longitudinal data drawn from an intervention study.

2.4.3. Relationship between dispositional mindfulness and physical activity

Nineteen cross-sectional studies (Caluyong et al., 2015; Chatzisarantis & Hagger, 2007; Clevenger et al., 2018; Fanning et al., 2018; Gao & Shi, 2015; Gilbert & Waltz, 2010; Grinnell et al., 2011; Kangasniemi et al., 2014; Loucks et al., 2015; Martin et al., 2013; Murphy et al., 2012; Roberts & Danoff-Burg, 2010; Ruffault et al., 2016a; Ruffault et al., 2017; Sagui-Henson et al., 2018; Slonim et al., 2015; Tsafou et al., 2016a; Tsafou et al., 2016b; Ulmer et al., 2010) and one longitudinal study (Kang et al., 2017) investigated the relationship between DM and PA. DM was assessed with a variety of self-report measures, including MAAS (Chatzisarantis & Hagger, 2007; Fanning et al., 2018; Gao & Shi, 2015; Grinnell et al., 2011; Kang et al., 2017; Loucks et al., 2015; Martin et al., 2013; Murphy et al., 2012; Ruffault et al., 2016a; Ruffault et al., 2017; Tsafou et al., 2016a; Tsafou et al., 2016b; Ulmer et al., 2010), FFMQ (Caluyong et al., 2015; Gilbert & Waltz, 2010; Roberts & Danoff-Burg, 2010; Sagui-Henson et al., 2018; Slonim et al., 2015; Tsafou et al., 2016b), KIMS (Kangasniemi et al., 2014), and CAMM (Clevenger et al., 2018). Additionally, three studies used measures of state mindfulness, including MFPA (Tsafou et al., 2016a; Tsafou et al., 2016b) and FMI (Ulmer et al., 2010).

PA was assessed mostly with self-report questionnaires, including IPAQ (Gao & Shi, 2015; Gilbert & Waltz, 2010; Grinnell et al., 2011; Kang et al., 2017; Loucks et al., 2015; Ruffault et al., 2016a; Ruffault et al., 2017; Sagui-Henson et al., 2018; Tsafou et al., 2016a; Tsafou et al., 2016b; Ulmer et al., 2010), LTEQ (Murphy et al., 2012), PAQ-C (Clevenger et al., 2018), WLI (Roberts & Danoff-Burg, 2010), and other

measures (Caluyong et al., 2015; Chatzisarantis & Hagger, 2007; Fanning et al., 2018; Martin et al., 2013; Slonim et al., 2015). Only two studies used accelerometers to measure PA objectively (Kang et al., 2017; Kangasniemi et al., 2014). Most of the studies investigated total PA (Caluyong et al., 2015; Clevenger et al., 2018; Fanning et al., 2018; Gao & Shi, 2015; Gilbert & Waltz, 2010; Grinnell et al., 2011; Kang et al., 2017; Loucks et al., 2015; Martin et al., 2013; Murphy et al., 2012; Roberts & Danoff-Burg, 2010; Ruffault et al., 2016a; Ruffault et al., 2017; Sagui-Henson et al., 2018; Slonim et al., 2015; Tsafou et al., 2016a; Tsafou et al., 2016b; Ulmer et al., 2010), one study investigated vigorous intensity PA (VPA) and sports (Chatzisarantis & Hagger, 2007), one study investigated moderate to vigorous intensity PA (MVPA) and health-enhancing PA (HEPA; Kangasniemi et al., 2014), and one study investigated yoga and aerobic PA (Martin et al., 2013).

2.4.3.1. Cross-sectional studies

Five of 19 cross-sectional studies reported a positive correlation between DM and PA (Gao & Shi, 2015; Gilbert & Waltz, 2010; Loucks et al., 2015; Roberts & Danoff-Burg, 2010; Slonim et al., 2015). Four reported a positive correlation between DM and psychological factors related to PA, rather than PA (Chatzisarantis & Hagger, 2007; Grinnell et al., 2011; Ruffault et al., 2016a; Tsafou et al., 2016a). Two reported that PA was positively correlated with some mindfulness measures, but not others (Tsafou et al., 2016b; Ulmer et al., 2010) and two reported that DM was positively associated with some PA measures, but not others (Kangasniemi et al., 2014; Martin et al., 2013). Six studies found no correlation between DM and PA

(Caluyong et al., 2015; Clevenger et al., 2018; Fanning et al., 2018; Murphy et al., 2012; Ruffault et al., 2017; Sagui-Henson et al., 2018).

Of the four studies reporting positive correlations with psychological factors related to PA, one study indicated that DM was positively correlated with PA self-regulation and outcome expectations and negatively correlated with perceived personal barriers of PA (Grinnell et al., 2011). Another study indicated positive correlations with perceived behavioural control and attitudes related to PA (Chatzisarantis & Hagger, 2007). The remaining two studies showed positive correlations with PA satisfaction (Tsafou et al., 2016a) and motivation (Ruffault et al., 2016a). Of the two studies that found that PA was positively correlated with some mindfulness measures, one study found a positive correlation between PA and DM measured using the MAAS, but not the FFMQ (Tsafou et al., 2016b). Another study found higher correlations of PA with the FMI than with the MAAS (Ulmer et al., 2010). Of the two studies that found that DM was positively associated with some types of PA, one study showed a positive correlation with yoga, but a negative correlation with aerobic PA (Martin et al., 2013). Another study showed a positive correlation with objectively measured MVPA, but no correlation with objectively measured HEPA (Kangasniemi et al., 2014). The strength of significant correlations among cross-sectional studies varied between .08 and .32 for mindfulness and PA behaviour and between .11 and .50 for mindfulness and psychological factors related to PA.

2.4.3.2. Longitudinal studies

One longitudinal study (Kang et al., 2017) indicated a positive correlation between DM at baseline and self-reported VPA after five weeks, but no correlation with self-reported MPA, self-reported walking, or objectively measured accelerometer data.

2.4.4. Potential psychological factors explaining the mindfulness-physical activity relationship

Four cross-sectional studies (Roberts & Danoff-Burg, 2010; Sagui-Henson et al., 2018; Tsafou et al., 2016a; Tsafou et al., 2016b) and one longitudinal study (Kang et al., 2017) investigated potential mechanisms of the mindfulness-PA relationship by conducting mediation analyses.

2.4.4.1. Cross-sectional studies

One of the four cross-sectional studies indicated that stress partially mediated the relationship between DM and PA, suggesting that mindfulness is related to lower stress, which in turn contributes to increased PA (Roberts & Danoff-Burg, 2010). This was confirmed in a second study that indicated that the mindfulness-PA relationship was mediated by stress and psychological flexibility (Sagui-Henson et al., 2018). Another study found that satisfaction mediated the relationship between state mindfulness and PA (Tsafou et al., 2016a), but DM was not correlated with PA. A follow-up study found that the relationship between DM

and PA was mediated sequentially by state mindfulness followed by PA satisfaction (Tsafou et al., 2016b).

2.4.4.2. Longitudinal studies

Findings from the longitudinal study indicated that negative affect and shame mediated the relationship between DM at baseline and PA motivation after five weeks, but no relationship was found for PA behaviour (Kang et al., 2017).

2.4.5. The effect of mindfulness-based interventions on physical activity

Of the 20 studies that employed a MBI to target PA, five were cohort studies with no control group (Carlson et al., 2004; Cox et al., 2018; Goodwin et al., 2012; Lucas et al., 2016; Salmoirago-Blotcher et al., 2013), one was a non-randomised controlled clinical trial (Ingraham et al., 2016), and 14 were RCTs (Butryn et al., 2011; Davis, 2008; Fletcher, 2012; Gotink et al., 2017; Grossman et al., 2017; Ivanova et al., 2015; Meyer et al., 2018; Miller et al., 2012; Moffitt & Mohr, 2015; Palmeira et al., 2017; Salmoirago-Blotcher et al., 2018; Tapper et al., 2009; VanBuskirk et al., 2014; Younge et al., 2015). Five studies compared usual care with a mindfulness component to a usual care-only group (Davis, 2008; Gotink et al., 2017; Moffitt & Mohr, 2015; Palmeira et al., 2017; Younge et al., 2015), eight studies compared a MBI to another intervention (Butryn et al., 2011; Grossman et al., 2017; Ingraham et al., 2016; Ivanova et al., 2015; Meyer et al., 2018; Miller et al., 2012; Salmoirago-Blotcher et al., 2018; VanBuskirk et al., 2014), and two studies compared a MBI to a no-treatment control group (Fletcher, 2012; Tapper et al., 2009).

MBIs included ACT (Butryn et al., 2011; Fletcher, 2012; Ivanova et al., 2015; Moffitt & Mohr, 2015; Tapper et al., 2009; VanBuskirk et al., 2014), acceptance-based behaviour therapy (ABBT; Goodwin et al., 2012), MBSR (Carlson et al., 2004; Grossman et al., 2017; Meyer et al., 2018; Salmoirago-Blotcher et al., 2018; Salmoirago-Blotcher et al., 2013), mindfulness-based eating awareness training for diabetes (Miller et al., 2012), mindfulness in motion (Lucas et al., 2016), non-standardised mindfulness training (Cox et al., 2018; Davis, 2008; Gotink et al., 2017; Ingraham et al., 2016; Younge et al., 2015), and an intervention that combined mindfulness and acceptance training (Palmeira et al., 2017). The intervention duration ranged from a single session (Ivanova et al., 2015) to 24 weeks (Davis, 2008) and session length varied from 10 minutes (Cox et al., 2018) to six hours (Fletcher, 2012). The follow-up period ranged from none (Cox et al., 2018; Davis, 2008; Fletcher, 2012; Goodwin et al., 2012; Grossman et al., 2017; Ingraham et al., 2016; Ivanova et al., 2015; Meyer et al., 2018; Moffitt & Mohr, 2015; Palmeira et al., 2017; Salmoirago-Blotcher et al., 2013) to a 12-month follow-up (Gotink et al., 2017; Younge et al., 2015).

PA components were present in 14 MBIs and included PA education (Ingraham et al., 2016; Miller et al., 2012; Moffitt & Mohr, 2015) and recommendations (Miller et al., 2012; Moffitt & Mohr, 2015), mindfulness and acceptance-based techniques targeting psychological factors related to PA (Butryn et al., 2011; Fletcher, 2012; Goodwin et al., 2012; Ivanova et al., 2015; Tapper et al., 2009), and PA exercises, such as mindful movement (Ingraham et al., 2016; Lucas et al., 2016; Meyer et al., 2018) and yoga (Carlson et al., 2004; Davis, 2008; Gotink et al., 2017; Lucas et al., 2016; Younge et al., 2015). PA outcomes included PA

frequency (Butryn et al., 2011; Carlson et al., 2004; Davis, 2008; Fletcher, 2012; Goodwin et al., 2012; Grossman et al., 2017; Ingraham et al., 2016; Lucas et al., 2016; Meyer et al., 2018; Miller et al., 2012; Moffitt & Mohr, 2015; Palmeira et al., 2017; Salmoirago-Blotcher et al., 2018; Salmoirago-Blotcher et al., 2013; Tapper et al., 2009; VanBuskirk et al., 2014), tolerance (Cox et al., 2018; Gotink et al., 2017; Grossman et al., 2017; Ivanova et al., 2015; Younge et al., 2015), maintenance (Tapper et al., 2009), enjoyment (Cox et al., 2018; Ivanova et al., 2015), strength (Lucas et al., 2016; Salmoirago-Blotcher et al., 2013), and flexibility (Salmoirago-Blotcher et al., 2013). Only nine studies measured PA objectively (Butryn et al., 2011; Gotink et al., 2017; Grossman et al., 2017; Ivanova et al., 2015; Lucas et al., 2016; Meyer et al., 2018; VanBuskirk et al., 2014; Younge et al., 2015).

Of the 20 MBIs, three cohort studies (Carlson et al., 2004; Cox et al., 2018; Goodwin et al., 2012) and five RCTs (Ivanova et al., 2015; Moffitt & Mohr, 2015; Palmeira et al., 2017; Salmoirago-Blotcher et al., 2018; Tapper et al., 2009) showed significant positive between-subjects effects on PA. Three studies showed significant positive within-subjects effects on PA, but found no differences between the MBI and a control group (Davis, 2008; Fletcher, 2012; Miller et al., 2012). Two cohort studies (Lucas et al., 2016; Salmoirago-Blotcher et al., 2013) and two RCTs (Butryn et al., 2011; Younge et al., 2015) showed positive effects for some PA outcomes. Three RCTs found no effect on PA outcomes in either group (Gotink et al., 2017; Grossman et al., 2017; VanBuskirk et al., 2014) and two RCTs showed better outcomes following the standard intervention than the MBI (Ingraham et al., 2016; Meyer et al., 2018).

Of the eight studies that showed significant positive between-subjects effects of a MBI on PA, four studies employed acceptance-based interventions (Goodwin et al., 2012; Ivanova et al., 2015; Moffitt & Mohr, 2015; Tapper et al., 2009), one study employed another MBI that did not include MMT (Cox et al., 2018), one employed a MBI that combined acceptance-based techniques and MMT (Palmeira et al., 2017), and two studies employed traditional MBIs with an element of MMT (Carlson et al., 2004; Salmoirago-Blotcher et al., 2018). Of the three studies that showed significant positive within-subjects effects on PA, but found no differences between groups, one study employed an acceptance-based intervention (Fletcher, 2012) and two studies employed traditional MBIs with an element of MMT (Davis, 2008; Miller et al., 2012). Of the four studies that showed effects for some PA outcomes, two studies showed improvements in PA in the short term only (Butryn et al., 2011; Younge et al., 2015), one study showed improvements in self-reported walking only (Lucas et al., 2016), and one study showed improvements in some types of PA (e.g., activities aimed at improving flexibility), but not others (e.g., activities aimed at improving strength; Salmoirago-Blotcher et al., 2013). Of these interventions, one was acceptance-based (Butryn et al., 2011) and the remaining three were MBIs with an element of MMT (Lucas et al., 2016; Salmoirago-Blotcher et al., 2013; Younge et al., 2015). Of the three RCTs that found no effect on PA outcomes in either group, one study employed an acceptance-based intervention (VanBuskirk et al., 2014) and two studies employed traditional MBIs with an element of MMT (Gotink et al., 2017; Grossman et al., 2017). Both RCTs that found better results of a standard intervention employed traditional MBIs with an element of MMT (Ingraham et al., 2016; Meyer et al.,

2018). Of the 15 MBIs that reported positive effects on PA outcomes, 12 studies included PA components. Specifically, five studies targeted psychological factors related to PA (Butryn et al., 2011; Fletcher, 2012; Goodwin et al., 2012; Ivanova et al., 2015; Tapper et al., 2009), three studies included PA education and recommendations (Miller et al., 2012; Moffitt & Mohr, 2015; Salmoirago-Blotcher et al., 2018), and four studies included yoga (Carlson et al., 2004; Davis, 2008; Lucas et al., 2016; Younge et al., 2015). Of the remaining five RCTs, one study included yoga (Gotink et al., 2017) and one study included yoga and PA education (Ingraham et al., 2016).

2.4.6. Mindfulness as a potential moderator between psychological factors and physical activity

Although this was not a central objective of this review, mindfulness was briefly examined as a possible moderator between psychological factors related to PA and PA behaviour. One study found that DM moderated the relationship between intrinsic motivation and PA, such that intrinsic motivation was related to PA levels among individuals who scored higher on DM, but not among individuals who scored lower on DM (Ruffault et al., 2016a). Another study found that DM moderated the intention-behaviour relationship, such that intentions predicted PA among individuals who scored higher on DM, but not among individuals who scored lower on DM (Chatzisarantis & Hagger, 2007). In addition, DM decreased the effect of counter-intentional habits in the intention-behaviour relationship (Chatzisarantis & Hagger, 2007).

2.5. Discussion

This review is the first of its kind to investigate the relationship between mindfulness and PA. In terms of DM, nine studies showed weak to moderate correlations with PA, but only one of those studies measured PA objectively. Additionally, only one study compared different types of PA, and found that DM was positively correlated to yoga (r = .23), but negatively correlated to aerobic PA (r = -.18; Martin et al., 2013). This was also seen in one intervention study that showed that a MBI only led to improvements in activities related to flexibility (Salmoirago-Blotcher et al., 2013).

A possible explanation for this could be that typical exercise modes are goal- rather than process-oriented and include a relative disconnect between body and mind (La Forge, 2005). Conversely, some types of PA, such as yoga or Tai Chi, can be seen as geared towards mindfulness and containing mindful components (Kennedy & Resnick, 2015) by being process-oriented and emphasising the mind-body connection (La Forge, 2005). As aerobic exercise is regularly recommended for physical health (Department of Health, 2011; World Health Organisation, 2012), weight maintenance (Haskell et al., 2007), and weight loss (Ohkawara, Tanaka, Miyachi, Ishikawa-Takata, & Tabata, 2007), this finding is of particular relevance. Mindfulness may have a different effect on different types of PA, suggesting that alternative approaches for PA promotion may be required, but more research is needed to investigate differences in various types of PA.

Several cross-sectional studies showed that DM was positively correlated with psychological factors related to PA, such as mental habit (Tsafou et al., 2016a;

Tsafou et al., 2016b), satisfaction (Tsafou et al., 2016a; Tsafou et al., 2016b), motivation (Kang et al., 2017; Ruffault et al., 2016a), and enjoyment (Roberts & Danoff-Burg, 2010), but results were mixed for PA behaviour. It is more likely that mindfulness and PA are associated through psychological factors that mediate this relationship. This could imply that individuals who report higher DM, or who learn to cultivate mindfulness skills, may be better able to translate PA intentions into behaviour, be autonomously motivated to engage in PA, accept negative sensations that are likely to occur during PA (e.g., fatigue), and enjoy the experience of being active. This is particularly important for individuals with overweight and obesity, who often report negative attitudes towards PA (Deforche et al., 2006; Napolitano et al., 2011; Peacock et al., 2014; Piana et al., 2013) or find PA uncomfortable (Egan et al., 2013; Leone & Ward, 2013; Piana et al., 2013; Thomas et al., 2008; Wiklund et al., 2011). Mindfulness-based approaches have the potential to target psychological factors related to PA and therefore better prepare these individuals for sustained PA behaviour change (Kennedy & Resnick, 2015). However, whether the effect of mindfulness on psychological factors related to PA leads to an increase in PA behaviour remains to be tested in longitudinal and controlled studies.

In terms of mindfulness practice, more than half of the MBIs showed positive effects on PA outcomes, but they varied greatly in duration, session length, group size, delivery method, and content. Few studies reported follow-up data and some showed that benefits in PA gained after the intervention were not found at follow-up (Butryn et al., 2011; Miller et al., 2012; Younge et al., 2015). This shows a need for future MBIs to include a follow-up period to assess their long-term effectiveness. Furthermore, the included MBIs all contained additional components

to mindfulness practice, such as goal setting, group discussions about PA and health, and acceptance training, which makes it unclear what the active ingredients in these interventions are (Malinowski, 2017). The review did not find substantial evidence to suggest that MBIs with a meditation component were more effective than acceptance-based interventions without MMT, but it must be acknowledged that the methods used do not allow firm conclusions to be drawn. A meta-analysis would be required to assess the relative importance of the additional meditation component in MBIs.

A previous review of the effect of mindfulness-based approaches on health behaviours in adults with overweight and obesity (Ruffault et al., 2016b) found evidence for a small change in PA from pre- to post-intervention. However, this review only included four studies that measured PA outcomes and all four MBIs contained additional PA components. Three of those studies are also included in the current review (Davis, 2008; Fletcher, 2012; Miller et al., 2012). The fourth was excluded as it assessed the effect of yoga, rather than a mindfulness-specific intervention on PA (McIver, O'Halloran, & McGartland, 2009). Overall, both reviews indicate that cultivating mindful awareness could enhance acceptance of negative or uncomfortable thoughts and sensations that are likely to occur during PA, particularly in individuals with overweight and obesity, but its link with sustained PA needs to be verified in future studies.

The results of the current review indicate that MBIs are more likely to be successful at implementing PA behaviour change if they target psychological factors related to PA. However, evidence for the active components of MBIs is still scarce. Adding mindfulness components to standard PA interventions could improve

psychological factors related to PA, such as exercise self-efficacy and acceptance of PA-related discomfort, but this needs to be determined in matched-control studies with long-term follow-ups. Evidence for the effectiveness of MBIs over standard PA interventions is at present limited and results are mixed. More research is required to establish what makes MBIs successful at increasing PA and what mechanisms are involved in the mindfulness-PA relationship.

2.5.1. Limitations

Despite the rigorous search criteria and study reviews conducted, this review is not without limitations. As this review only considered papers published in English, some relevant literature in other languages may have been excluded. Similarly, this review is subject to publication bias and selective reporting of measures in the literature. This may also be the case Additionally, current literature regarding the relationship between mindfulness and PA cognitions, attitudes, and behaviour is relatively scarce; more research is required before conclusions regarding the effect of mindfulness on PA can be drawn. Consequently, there are also limitations to many of the included studies.

Firstly, in terms of study quality, 18 studies (45%) were considered “weak”, 21 studies (52.5%) were considered “moderate”, and only one study (2.5%) was considered “strong”. Cross-sectional studies typically lacked quality in study design, while intervention studies and RCTs suffered from selection bias and ascertainment bias (from lack of blinding). Additionally, while mediation data from cross-sectional studies provide an insight into the potential mechanisms that link mindfulness and PA, no causal inferences can be made from these observations and further

prospective research is required to substantiate these findings. Secondly, study participants were predominantly white, female, healthy, and with a normal-range BMI, which may compromise the generalisability of findings to men, diverse ethnic groups, individuals with overweight and obesity, and individuals with a variety of physical and mental health concerns.

Thirdly, studies used a variety of mindfulness measures and components. Mindfulness is difficult to define (Bishop et al., 2004) and operationalise (Chiesa, 2013) and thus challenging to measure (Grossman, 2008, 2011; Malinowski, 2008). Different scales measure different aspects of mindfulness (e.g., attention); therefore, consistency among measurement tools is required to draw definitive conclusions. Additionally, it is unclear how validly people can report their levels of mindfulness in self-report questionnaires (Grossman, 2011; Moore & Malinowski, 2009), suggesting the need for future studies to measure additional constructs, such as attention (Semple, 2010) or compassion (Khoury et al., 2015), that may be associated with changes in mindfulness (Grossman, 2011). Moreover, few studies used objective measures of PA (e.g., accelerometers). This is an important limitation considering that some studies indicated that mindfulness was related to self-report measures of PA, but not with objective measures. It is likely that some of these findings suffered from common-method variance and experimental studies are required to test the validity of results found.

Fourthly, interventions differed in length, duration, group size, session content, delivery method, and length of follow-up, making it difficult to establish which components contributed to their effectiveness. In acceptance-based MBIs (e.g., ACT and ABBT), mindfulness is only one component of a variety of other core

processes and specific MMT is not included (Chiesa & Malinowski, 2011). This raises the question of whether mindfulness itself is the active ingredient of such interventions (Malinowski, 2017) or if other components (e.g., acceptance or goal setting) are more likely to impact PA outcomes. Since not all studies computed a mindfulness change score (based on change in self-reported DM), it was not possible to examine to what extent any PA changes were mediated by changes in mindfulness. It was, however, a purposeful decision to include studies even if they did not provide a mindfulness change score, since it is not known to what extent changes in (cultivated) mindfulness resulting from MBIs can be measured using self-report of DM (Van Dam et al., 2018b), thus yielding any such mediational analysis invalid.

Finally, due to the limited number of RCTs conducted on mindfulness and PA, this review included uncontrolled trials, as well as longitudinal and cross-sectional studies. Although, on balance, the review suggests a favourable outcome for the potential of MBIs for PA, quantity of significant findings is no replacement for quantitative analysis of effect sizes through a meta-analysis. To establish the true effect of mindfulness practice and DM on PA, further research is required to build the basis for a meta-analysis of the literature. As this review demonstrated, the quality of available studies is currently too limited for conducting such an analysis.

2.5.2. Future directions

This review shows a need for more rigorous research that compares MBIs against matched-control conditions to establish the active ingredients, so that more

effective PA interventions can be developed. Moreover, experimental studies are required to examine the mechanisms involved in the mindfulness-PA relationship, potentially by examining psychological factors related to sustained PA behaviour change and whether they lead to increased PA in the long term. Finally, future studies should assess PA using objective measures (e.g., accelerometers or pedometers) and compare different exercise types, so that the true effect of mindfulness on PA can be established.

2.6. Conclusions and justification for study two

The overall results of this review suggest that mindfulness may enhance PA, but evidence is currently inconclusive and more research is required to investigate the relationship between mindfulness and PA experimentally and longitudinally. Mindfulness could potentially provide an inexpensive alternative for individuals not benefitting from existing lifestyle interventions. However, the current structure and design of MBIs seems insufficient for increasing PA. MBIs require a re-formulation in terms of PA-specificity and the identification of the active ingredients, which may be responsible for affecting PA behaviour change. MBIs may be more effective for enhancing PA if they are PA-specific and target psychological factors related to sustained PA. Although evidence from this review indicated a potential relationship between DM and PA, particularly in terms of psychological factors related to PA, only one study has so far investigated the relationship between DM and PA longitudinally (Kang et al., 2017). Moreover, no studies have considered psychological correlates of PA as potential mediators between DM and PA. Study

two (chapter three) therefore aimed to investigate the relationship between DM, psychological factors related to PA, and PA outcomes using a prospective cohort study design.

Chapter Three – Modelling the Relationship between Dispositional Mindfulness and Physical Activity Outcomes: A Prospective Cohort Study

3.1. Study overview

Current evidence suggests that mindfulness may have a beneficial effect on PA, particularly by enhancing psychological factors related to PA, such as autonomous exercise motivation and PA acceptance. However, at present, studies investigating the relationship between DM and PA are scarce and evidence is often limited to cross-sectional investigations. The main objective of the current study was therefore to investigate the relationship between DM and PA outcomes (PA and related psychological factors) using a prospective cohort design. Participants (N = 196, age M = 38 years, 80% female) took part in a two-week walking challenge, which encouraged them to increase their walking to meet recommended national guidelines for PA over a two-week period. Measures of DM, psychological factors related to PA (i.e., PA acceptance and autonomous exercise motivation), self-regulation factors (i.e., self-control, impulsivity, and inhibition), and self-reported PA were taken at baseline. Measures assessing PA and PA acceptance were taken again after one week and at the end of the two-week period. Cross-sectional data were analysed for relationships between measures at baseline using structural equation modelling (SEM) and results showed that DM was positively related to autonomous exercise motivation and PA acceptance, which in turn predicted baseline PA. Prospective data were analysed using latent growth curve modelling

(LGCM) and confirmed findings from SEM, but no effect was found for change in PA over time. This study provided evidence for the potential of DM to influence self-reported PA through PA acceptance and autonomous exercise motivation as mediators. However, more research is required to fully understand the mechanisms through which mindfulness impacts change in PA behaviour.

3.2. Introduction

3.2.1. Background

The benefits of regular PA for mental and physical health are well established (Ojiambo, 2013; Penedo & Dahn, 2005; Warburton et al., 2006; Zschucke et al., 2013). However, the majority of the UK (National Health Services, 2016b) and global populations (World Health Organisation, 2010) do not meet the recommended guidelines for PA. In the UK, adults (19 – 64 years) are recommended to engage in ≥ 150 minutes of moderate to vigorous intensity PA weekly (Department of Health, 2011). Several psychological mechanisms may be responsible for promoting PA behaviour, such as autonomous exercise motivation (Teixeira et al., 2012; Teixeira et al., 2015), self-regulation (Best et al., 2014; Teixeira et al., 2015), and tolerance of discomfort related to PA behaviour (measured as PA acceptance; Butryn et al., 2015). Recently, DM has been linked to PA behaviour (see, for example, Ruffault et al., 2017; Tsafou et al., 2016a). However, several reviews show inconsistent findings for a direct effect of DM on PA behaviour (Sala, Rochefort, Priscilla Lui, & Baldwin, 2019; Schneider et al., 2018; Yang & Conroy, 2019) and little is currently know about the DM-PA relationship.

DM, or trait mindfulness, refers to how mindful an individual tends to be in their daily life (Rau & Williams, 2016). Most definitions of DM refer to an open and receptive attention to and awareness of what is occurring in the present moment (Brown & Ryan, 2004; also see chapter one, section 1.1.1). It has been suggested that DM might enhance PA behaviour through its association with psychological determinants of PA (see study one, chapter two). Previous research shows that DM is positively related to intrinsic motivation to engage in exercise, even when no direct relationship between DM and PA behaviour was found (Kang et al., 2017; Ruffault et al., 2016a). Open awareness could be especially valuable in facilitating motivation to choose behaviours that are consistent with one's needs, values, and interests (Brown & Kasser, 2005; Deci & Ryan, 2000), rather than acting automatically or habitually (Brown & Ryan, 2003). Therefore, intentional and present-focused awareness may increase the likelihood that an individual will engage in less automatic and more autonomous and regulated thoughts (Levesque & Brown, 2007) and behaviours (Ryan, 1995).

Additionally, although evidence is currently limited, studies suggest that DM may be related to PA acceptance (Butryn et al., 2015). Individuals who enjoy the experience of PA and tolerate PA-related discomfort (e.g., pain or fatigue) are arguably more likely to maintain PA in the short and long term. Research investigating the links between PA and trait acceptance (e.g., using the Acceptance and Action Questionnaire; Bond et al., 2011), found that PA behaviour was positively associated with acceptance (Kangasniemi et al., 2014; Ruffault et al., 2017; Ulmer et al., 2010), even when no relationship between PA and DM was found (Ruffault et al., 2017). However, very few studies have so far investigated the

relationship between PA behaviour and PA acceptance specifically, using the Physical Activity Acceptance Questionnaire (PAAQ) or the Physical Activity Acceptance and Action Questionnaire (PAAAQ; Butryn et al., 2011; Fletcher, 2012; Goodwin et al., 2012). These studies found limited correlations between PA acceptance and behaviour and only one study showed a positive correlation between PAAQ scores and a PA-related measure, specifically, estimated kcals expended (Fletcher, 2012). All three studies that investigated PA acceptance employed an acceptance-based intervention to increase PA. Additionally, only one study has so far considered a direct relationship between DM and PA acceptance and found a strong correlation between DM, as measured by the FFMQ, and the PAAQ (Butryn et al., 2015).

Beyond autonomous exercise motivation and PA acceptance, self-regulation has emerged as an important correlate of successful PA behaviour change (Best et al., 2014; Teixeira et al., 2015). Self-regulation refers to a psychological function that involves putting effort into changing one's behaviour (Audiffren & André, 2015) and has been described previously (see chapter one, section 1.2.4.1). Three measures of self-regulation were chosen for the present study, specifically self-control, impulsivity, and inhibition. Self-control involves the capacity to alter one's responses in order to adhere to own values in the pursuit of long-term goals (Tice, Baumeister, Shmueli, & Muraven, 2007) and is related to the performance of desired behaviours (de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012). Several factors have been suggested as contributors to self-control, including inhibition and impulsivity (Ansell, Gu, Tuit, & Sinha, 2012; Hamilton, Ansell, Reynolds, Potenza, & Sinha, 2013; Tull, Gratz, Latzman, Kimbrel, & Lejuez, 2010).

Inhibition reflects a psychological orientation to aversive stimuli and impulsivity reflects a behavioural tendency toward rapid action with diminished ability or willingness to consider future consequences (Hamilton, Sinha, & Potenza, 2014). Higher levels of impulsivity and lower levels of inhibition have been linked to impaired self-control (Hamilton et al., 2014).

In terms of PA, individuals with higher levels of self-control and inhibition towards aversive stimuli (e.g., temptation to skip exercise sessions) and lower levels of impulsivity are more likely to regulate their behaviour, such that their actions are consistent with long-term PA goals. Indeed, research has found that trait self-control is associated with PA in several populations (Kinnunen et al., 2012; Wills et al., 2007). Moreover, DM is often characterised through self-regulatory mechanisms (Brown & Ryan, 2003) and has been found to be positively correlated with self-control (Bowlin & Baer, 2012; Yusainy, Chan, Hikmiah, & Anggono, 2019) and inhibition (Oberle, Schonert-Reichl, Lawlor, & Thomson, 2012; Riggs, Black, & Ritt-Olson, 2015) and negatively correlated with impulsivity (Lattimore et al., 2011; Peters et al., 2011) in a variety of populations.

As such, it is plausible that autonomous exercise motivation, PA acceptance, and self-regulation mediate the relationship between DM and PA behaviour. However, what is currently known about mediators of the mindfulness-PA relationship is limited to cross-sectional investigations (see study one, chapter two), making it impossible to determine cause-effect relationships. The present study therefore investigated the DM-PA relationship using cross-sectional *and* prospective data following a brief walking intervention and considered potential psychological factors that may mediate this relationship. Walking was chosen as the

target of the intervention as it is easily accessible for the general population and does not require special equipment or facilities. Moreover, it does not necessarily exclude participants who are less active and therefore may struggle to achieve higher levels of moderate or vigorous intensity PA. Walking is the most common moderate intensity PA and has been deemed important in promoting health benefits in the general population (Lee & Buchner, 2008).

3.2.2. Study objectives

The objective of the current study was to investigate the relationship between DM, psychological factors related to PA, self-regulation, and PA using cross-sectional and prospective data. Specifically, this study aimed to investigate: 1) the relationship between DM and psychological factors related to sustained PA and 2) the direct and indirect effect of DM on PA change over time. Based on the discussed evidence and theoretical considerations, it was hypothesised that: 1) DM would be positively related to psychological factors associated with PA (i.e., autonomous exercise motivation and PA acceptance) and self-regulation factors (i.e., self-control and inhibition) and negatively related to impulsivity, 2) autonomous exercise motivation, PA acceptance, and self-regulation would predict PA, and 3) there would be a partial serial mediation between DM and PA through psychological and self-regulatory mechanisms. The final hypothesised model (model 1) was based on empirically known relationships between constructs and is depicted in Figure 3.1.

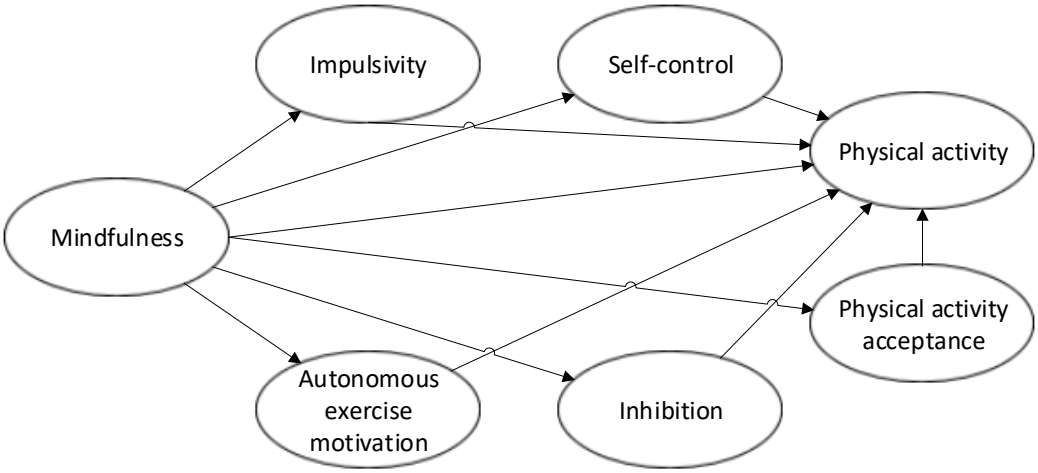

Figure 3.1. Path diagram for the hypothesised model.

3.3. Method

3.3.1. Design

This study used a prospective cohort design to test a model of the relationship between DM, self-regulation, psychological factors, and PA outcomes following a brief walking intervention. Participants were sampled and tracked over a two-week period, after receiving educational advice based on national guidelines (Department of Health, 2011) about the benefits of PA and suggested walking targets to achieve over a period of two consecutive weeks. Measures assessing DM, self-regulation (self-control, impulsivity, and inhibition), and autonomous exercise motivation were taken at baseline and measures assessing self-reported PA and PA acceptance were taken at baseline and again after one week and at the end of the two-week period (see Table 3.1).

Table 3.1. Study two measures assessed at each time point.

Measure	Baseline	One week	Two weeks
1. Self-reported body mass index	✓		
2. Brief Self-Control Scale	✓		
3. Barratt Impulsivity Scale – 15 items	✓		
4. Five Facet Mindfulness Questionnaire – short form	✓		
5. Behavioural Regulation in Exercise Questionnaire – revised	✓		
6. Physical Activity Acceptance Questionnaire	✓	✓	✓
7. International Physical Activity Questionnaire – short form	✓	✓	✓
8. Cued Go/No-Go task (Inquisit)	✓		

3.3.2. Participants

Participants who met eligibility criteria (see Table 3.2) were recruited from the "Call for Participants" website, via email from the Liverpool John Moores University (LJMU) students and staff database and the LJMU research participants panel, newspaper adverts (Liverpool Metro and Liverpool Echo), online advertising, and leaflets and flyers around Liverpool and London. The study was advertised to participants as a daily walking challenge for two weeks.

Table 3.2. Study two inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
• Aged 19 – 64 years old • English speaking	• Have a physical disability, cardiovascular condition, or any other illnesses or injuries that would prevent the individual from walking briskly for 30 minutes per day on five days per week for two weeks

3.3.3. Measures

3.3.3.1. Demographic variables and body mass index

Participants self-reported their height, weight, age, gender, ethnicity, education, and employment. Self-reported height (metres) and weight (kilograms)

were used to calculate participants' body mass index (BMI), to assess whether individuals were underweight (BMI < 18.5), healthy weight (BMI = 18.5 – 24.9), overweight (BMI = 25 – 29.9), or obese (BMI ≥ 30; National Health Services, 2016a).

3.3.3.2. Dispositional mindfulness

DM was assessed using three subscales (15 items) of the short form of the Five-Facet Mindfulness Questionnaire (FFMQ-sf; Bohlmeijer, Ten Klooster, Fledderus, Veehof, & Baer, 2011), which has been used in a wide range of mindfulness research. The FFMQ-sf is rated on a five-point Likert scale, ranging from 1 (never or very rarely true) to 5 (very often or always true), with higher scores indicating higher levels of DM. The three facets investigated in this study were acting with awareness (e.g., "When I do things, my mind wanders off and I'm easily distracted"), non-judging (e.g., "I criticize myself for having irrational or inappropriate emotions"), and non-reacting (e.g., "I perceive my feelings and emotions without having to react to them"). These facets were seen to more closely reflect Kabat-Zinn's (2004) original definition of mindfulness (Lattimore et al., 2016) and were aggregated for a total DM score.

The describing facet may be more related to concepts of dialectical behaviour therapy than with the original meaning of mindfulness (Grossman, 2008; Grossman & Van Dam, 2011). Similarly, the observing facet was excluded as studies have shown that it could not be reliably assessed to compare meditators and non-meditators who may perceive the meaning of this subscale differently (Baer et al., 2008; Bowlin & Baer, 2012) and does not always correlate with the other subscales in mindfulness questionnaires (Baer et al., 2004; Lattimore et al., 2011).

Additionally, research shows that there are limitations to the predictive and face validity of the FFMQ observing and describing subscales (Bergomi et al., 2013a; Christopher, Neuser, Michael, & Baitmangalkar, 2012; Lilja, Lundh, Josefsson, & Falkenström, 2013). Moreover, acting with awareness, non-judging, and non-reacting are the mindfulness facets that are most frequently related to health behaviours (Bodenlos, Noonan, & Wells, 2013; Murphy & MacKillop, 2012). The full FFMQ-sf and the FFMQ-sf composed of the three subscales has shown good reliability (α = .73 – .91) and validity in previous research (Bohlmeijer et al., 2011; de Bruin, Topper, Muskens, Bögels, & Kamphuis, 2012a; Lattimore et al., 2016). The FFMQ-sf was examined as a full scale and as three separate subscales and showed good reliability in the current sample (see Table 3.5).

3.3.3.3. Physical activity acceptance

PA acceptance was measured using the PAAQ. The PAAQ is a 10-item measure, rated on a seven-point Likert scale, ranging from 1 (never true) to 7 (always true), with higher scores indicating higher tolerance for PA-related discomfort (Butryn et al., 2015). The PAAQ includes the subscales of cognitive acceptance (e.g., "If I have the thought 'exercising today won't be enjoyable', it derails me from my exercise plan") and behavioural commitment (e.g., "Even if I have the desire to stop while I am exercising, I can still follow my exercise plan"). The PAAQ has demonstrated good construct validity and test-retest reliability (α = .87) in previous research (Butryn et al., 2015). The PAAQ was examined as a full scale and as two separate subscales and showed good reliability in the current sample (see Table 3.5).

3.3.3.4. Exercise motivation

Exercise motivation was measured using the revised Behavioural Regulation in Exercise Questionnaire (BREQ-3; Markland & Tobin, 2004; Wilson, Rodgers, Loitz, & Scime, 2006). The BREQ-3 is a 24-item measure, rated on a five-point Likert scale, ranging from 0 (not true for me) to 4 (very true for me), with higher scores indicating higher levels of motivation. Subscales include amotivation (e.g., "I don't see why I should have to exercise"), external motivation (e.g., "I exercise because other people say I should"), introjected motivation (e.g., "I feel guilty when I don't exercise"), identified motivation (e.g., "It's important to me to exercise regularly"), integrated motivation (e.g., "I exercise because it is consistent with my life goals"), and intrinsic motivation (e.g., "I exercise because it's fun"). The BREQ-3 showed good reliability in the current sample (see Table 3.5).

A Relative Autonomy Index (RAI; Connell & Ryan, 1985; Grolnick & Ryan, 1987) was calculated for the purposes of this study as a combined measure of the extent to which an individual is autonomously motivated to exercise. Each BREQ subscale was weighted and then summed with negative weightings applied to the less autonomous regulations and positive weightings to the more autonomous regulations, as follows: amotivation -3, external motivation -2, introjected motivation -1, identified motivation +1, integrated motivation +2, and intrinsic motivation +3 (Ryan & Connell, 1989). Higher positive scores for the RAI indicate more autonomous motivation whereas lower negative scores indicate more controlled motivation (Markland & Ingledew, 2007). In order to use the RAI as a latent variable in SEM analyses, four separate RAI indicators were computed in

accordance with similar procedures followed in previously published work (Hagger, Chatzisarantis, & Harris, 2006; Standage, Gillison, Ntoumanis, & Treasure, 2012). One item from each of the six subscales was randomly selected and weighted according to the weightings outlined above. The items were then summed to create an indicator for the latent variable. This process was repeated four times, to achieve four total indicators for the RAI [4].

3.3.3.5. Self-control

Self-control was measured using the brief version (13 items) of the Self-Control Scale (BSCS; Lindner, Nagy, & Retelsdorf, 2015; Tangney, Baumeister, & Boone, 2004). Self-control is seen as a limited resource, which depletes when individuals engage in behaviours that require self-regulation (Audiffren & André, 2015; Baumeister et al., 1998; Baumeister, Vohs, & Tice, 2007b) and is therefore often used as a measure of self-regulatory ability. The BSCS is rated on a five-point Likert scale, ranging from 1 (not at all like me) to 5 (very much like me), with higher scores indicating higher levels of self-control. Two aspects of self-control are assessed: inhibition (e.g., "I am good at resisting temptation") and initiation (e.g., "I am able to work effectively toward long-term goals"). The brief version has been used in research for predicting a variety of behavioural outcomes (Lindner et al., 2015) and has shown a strong correlation with the full scale (r = .93) and high internal consistency (α = .72 – .93) in previous research (de Ridder et al., 2012; Tangney et al., 2004) and in the current sample (see Table 3.5).

[4] It is recommended to include at least three indicator variables for CFA analysis in AMOS.

3.3.3.6. Impulsivity

Impulsivity was measured using the short form (15 items) of the Barratt Impulsivity Scale (BIS-15), which is one of the most common measures of impulsivity (Barratt, Patton, & Stanford, 1975; Patton & Stanford, 1995; Spinella, 2007). The BIS-15 is based on the previously used BIS-11 (Stanford et al., 2009). It is rated on a four-point Likert scale, ranging from 1 (rarely or never) to 4 (always or almost always), with higher scores indicating higher levels of impulsivity. It consists of three subscales: non-planning impulsivity (e.g., "I plan tasks carefully" [reverse scored]), motor impulsivity (e.g., "I do things without thinking"), and attentional impulsivity (e.g., "I am restless at lectures or talks"). The BIS-15 has demonstrated good reliability (α = .79 – .82) and validity in previous research (Spinella, 2007) and was examined as a full scale and as three separate subscales in the present study.

3.3.3.7. Inhibition

Inhibition was measured using the Cued Go/No-Go task. In the task used for this study, participants were instructed to respond to a Go target stimuli and withhold responding to a No-Go target stimuli (Fillmore, 2003). Each target was preceded by either a Go cue or a No-Go cue. Cues were 7.5 × 2.5cm rectangles framed in .8mm black outlines against a white background and were presented either vertically (height = 7.5cm, width = 2.5cm) or horizontally (height = 2.5cm, width = 7.5cm). The green and blue targets were displayed on the monitor as solid hues that filled the inside of the rectangle. Participants were instructed to press the space bar on the keyboard when a green (Go) target was presented and to

inhibit any response when a blue (No-Go) target was presented. Key presses were made with the index finger of the preferred hand. The horizontal cue preceded the Go target (green) on 80% of trials and preceded the No-Go target (blue) on 20% of trials. The vertical cue preceded the Go target on 20% of trials and preceded the No-Go target on 80% of trials. Thus, based on these cue-target pairings, horizontal and vertical cues operated as Go and No-Go cues, respectively (see Figure 3.2). For this study, the particular interest was on the inhibition error rate following an invalid Go cue (Go cue followed by a No-Go target). The Cued Go/No-Go measure has shown validity in measuring impulse control among different populations (Fillmore, 2003; Fillmore, Rush, & Hays, 2006). The task was integrated within Qualtrics using Inquisit 5.0.11 (Inquisit 5 [Computer software], 2016), which participants were asked to install prior to completing the task.

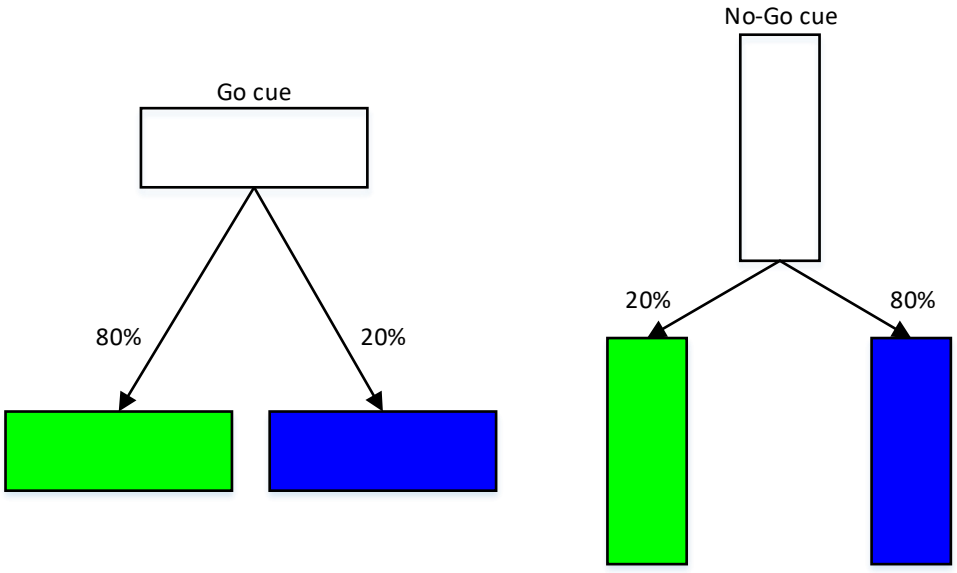

Figure 3.2. Cued Go/No-Go task (Inquisit).

3.3.3.8. Physical activity

Self-reported PA was assessed using the short form of the International Physical Activity Questionnaire (IPAQ-sf). The IPAQ-sf is a seven-item PA questionnaire, giving a result in METs (the metabolic equivalent of a task, an indicator of metabolic energy expenditure; Garber et al., 2011), with higher MET-minute values indicating more PA (Craig et al., 2003). It assesses MPA, VPA, walking, and sitting. MET-minutes were calculated by multiplying days of doing PA × minutes spent doing PA × MET value: 3.3 for walking, 4.0 for MPA, and 8.0 for VPA (IPAQ Research Committee, 2005). The IPAQ-sf has demonstrated adequate reliability and validity as measured in 22 studies and reasonable agreement with the long form (Craig et al., 2003).

3.3.4. The walking challenge

The walking challenge encouraged participants to increase their walking from baseline to two weeks later to meet the national recommended PA guidelines, by engaging in at least 30 minutes of brisk walking on five days per week (National Health Services, 2016b). A walking challenge video was developed specifically for the purposes of this study and recorded prior to participant recruitment. The video presentation was three minutes long and embedded within Qualtrics from YouTube. It contained eight slides with a voice-over by PW and consisted of information about: 1) national guidelines for PA (i.e., ≥ 150 minutes/week), 2) benefits of regular PA (e.g., mental and physical health benefits), 3) walking challenge instructions (see above), 4) tips for how to achieve walking targets (e.g., walking with a friend, walking to work instead of taking the bus, etc.), and 5) tips for

how to keep track of PA over the course of the challenge (e.g., using notes or mobile applications). Participants were able to download the walking challenge instructions from Qualtrics after watching the video (see appendix 3A).

3.3.5. Procedure

Prior to commencing participant recruitment, ethical approval for this study was granted by the LJMU ethics committee (approval number: 16/NSP/057). Following recruitment, participants were asked to complete an online survey hosted on Qualtrics XM (Qualtrics, Provo, UT). At the beginning of the survey, participants self-selected their eligibility to take part in the study by answering yes/no questions regarding their age and the presence of any health conditions. If participants were not eligible to take part in the study for any reason, they were automatically routed out of the survey and debriefed. If they passed the eligibility checks, participants were asked to complete questionnaires of the measures outlined above and watch the walking challenge video (see section 3.3.4 above). After watching the video, participants were able to choose whether they wanted to take part in the walking challenge by selecting “opt in” or “opt out”.

Email reminders were sent after one week to complete a short follow-up survey, containing the IPAQ-sf and the PAAQ, and to continue taking part in the walking challenge. After two weeks, participants were emailed a link to the final survey, containing the IPAQ-sf and the PAAQ. On completion, participants were debriefed and given the option of entering into a prize draw to win one of five shopping vouchers, worth between £50 and £200.

3.3.6. Data processing

Total scores and subscale scores were calculated for all questionnaires. Participant cases were excluded if they did not complete any questionnaires, did not provide data for the main outcome measure (IPAQ-sf), or had more than 5% missing data for the predictor variables. In cases with less than 5% missing data, the missing values were replaced in SPSS using median of surrounding values (Tabachnik & Fidell, 2007). The IPAQ-sf data were processed according to established guidelines (IPAQ Research Committee, 2005). Initially, the values from hours or hours and minutes were translated into minutes. Values of "15, 30, 45, 60, or 90" in the hours box were transferred to the minutes column. Participants who made mistakes not addressed in the protocol (e.g., value of 25 hours or missing data for days or time) were excluded (baseline n = 12, one week n = 7, two weeks n = 7). Secondly, assuming that one sleeps eight hours daily, participants were excluded when the sum of weekly PA exceeded 6720 minutes (i.e., 16 hours × 60 minutes × 7 days; two weeks n = 1). Thirdly, truncation (re-coding) was performed. Any given activity above three hours was re-coded to three hours (i.e., 180 minutes), permitting a maximum value of 21 hours per activity (three hours × seven days) and 63 hours (i.e., 3780 minutes) of total PA per week. Similarly, any value below 10 minutes was recoded to zero (Tsafou et al., 2016a; Tsafou et al., 2016b). Finally, due to the skewed distributions associated with the IPAQ, the MET-minute values were log transformed using the log10 + 1 transformation in SPSS to account for zero values. The distribution of the log-transformed MET-minutes has the property of being normally distributed, in contrast to the raw IPAQ scores (Rzewnicki, Auweele, & De Bourdeaudhuij, 2003).

3.3.7. Data analysis

Statistical analyses were conducted using the Statistical Package for the Social Sciences for Windows (IBM SPSS Statistics version 24.0) and SPSS AMOS (version 24.0). Statistical significance was accepted at the $p < .05$ level. Where appropriate, 95% confidence intervals (CIs) are also reported. Initially, analyses were performed to check for normality and outliers and appropriate transformations were conducted for data that were not normally distributed. Descriptive and correlational analyses were conducted to assess relationships between measures at baseline and over time. The false detection method (Benjamini, 2010) was used to adjust for family wise error rate (FDR rate = 5%) to reduce Type 1 error. According to Cohen's guidelines for Pearson's correlation coefficient (Cohen, 1960, 1988), an $r = .1 – .3$ represented a small effect, an $r = .3 – .5$ represented an intermediate effect, and an $r \geq .5$ represented a strong effect.

SEM with maximum likelihood (ML) estimation was conducted to model the relationship between DM and PA outcomes at baseline. SEM was chosen above mediation as it tolerates complex models and allows researchers to test theoretical propositions with regards to how constructs are linked and the directionality of significant relationships (Schreiber, Nora, Stage, Barlow, & King, 2006). Therefore, SEM is ideally suited for hypotheses that involve one or more mediators (Coffey & Hartman, 2008). Additionally, it does not rely on highly restrictive assumptions about the data, such as error-free measurement, lack of correlation between error terms, and unidirectional relationships among variables (Schreiber et al., 2006).

Moreover, LGCM (with ML) with mediation was conducted to assess the direct and indirect effects of DM on PA change over time (Duncan & Duncan, 1995).

The LGCM approach has been increasingly utilised to investigate longitudinal mediation (Cheong, 2011; von Soest & Hagtvet, 2011) and was chosen for its ability to model individual growth trajectories as well as individual differences in those trajectories over time (Duncan & Duncan, 1996). Moreover, it shares several advantages with SEM, which include its ability to assess the fit of the model to data, assess change in latent variables, and examine predictors of change (Preacher, 2010). LGCM is able to establish growth trajectories (i.e., show increases or decreases in a variable over time) by modelling the means of the observed variable at each time point (Duncan, Duncan, Strycker, & Chaumeton, 2007). This creates a latent slope variable that reflects an underlying continuous growth process (Roesch et al., 2009). Additionally, LGCM includes an intercept factor, which was centred relative to PA scores at baseline, so that the intercept represented the initial status of the growth curve (Roesch et al., 2009). The unconditional model (i.e., the change in PA over time without the predictor or mediator variables) is therefore a two-factor latent growth curve (LGC) model, with an intercept representing initial PA status and a slope factor that expresses the repeated-measures trajectory, or overall PA change (McAuley et al., 1999). As measurements were taken at equally spaced intervals (i.e., one week apart), the loadings of the unspecified model were fixed to zero at baseline, one at one week, and two at two weeks (Preacher, 2010).

Confirmatory factor analysis (CFA) of measurement models was conducted in AMOS to verify the factor structure of observed variables. Model fit of CFA, SEM, and LGCM was assessed using multiple indices, including the relative Chi-Square (χ^2/df) test (Wheaton, Muthen, Alwin, & Summers, 1977). While the Chi-square (χ^2) goodness-of-fit test is the traditional measure for evaluating overall model fit

(Hooper, Coughlan, & Mullen, 2008; Hu & Bentler, 1999), it has several important limitations when used as a stand-alone test. Firstly, it assumes multivariate normality, where deviations from normality may result in a properly specified model being rejected (McIntosh, 2007). Secondly, the χ^2 statistic is sensitive to sample size and often rejects the model when large sample sizes are used (Bentler & Bonett, 1980) or fails to accurately distinguish between good and poor-fitting models when small sample sizes are used (Kenny & McCoach, 2003). Therefore, χ^2 is no longer relied upon as a basis for acceptance or rejection (Schermelleh-Engel, Moosbrugger, & Müller, 2003; Vandenberg, 2006). The relative Chi-square (χ^2/df) test has been proposed as an alternative, which diminishes the impact of sample size (Wheaton et al., 1977). Moreover, researchers suggest that in order to minimise the chances of Type I or Type II errors within the model fit due to sample size and data non-normality (Hooper et al., 2008), indicator combinations containing relative fit indices, such as the Tucker-Lewis Index (TLI ≥ .90 and .95 indicate acceptable and good fit, respectively), non-centrality based indices, such as Root Mean Square Error of Approximation (RMSEA ≤ .08 and .06 indicate acceptable and good fit, respectively) and Comparative Fit Index (CFI ≥ .90 and .95 indicate acceptable and good fit, respectively) along with absolute fit indices, such as Standardised Root Mean square Residual (SRMR ≤ .10 and .08 indicate acceptable and good fit, respectively) and the relative Chi-square (χ^2/df ≤ 3 or 2 indicate acceptable and good fit, respectively), should be considered. Additionally, factor loadings should be ≥ .50 for each indicator variable (Hooper et al., 2008; Hu & Bentler, 1999; Kline, 2015; Streiner, 2006; Tabachnik & Fidell, 2007). Description and cut-off points of these indices are summarised in Table 3B.1 (see appendix 3B).

3.4. Results

3.4.1. Sample characteristics

Of the initial 261 individuals who took part in the baseline survey, six duplicate responses were found and only the first response was kept. The remaining sample included 255 individuals. An additional 47 participants were excluded for not completing the IPAQ-sf, leaving a sample of N = 208. Of these 208 individuals, 167 participants opted in to the walking challenge, 148 completed the one-week survey, and 140 completed the final two-week survey (retention rate = 67%). Due to incomplete data, 13 cases were removed at one week (N = 135) and 17 cases were removed at two weeks (N = 123)[5]. Finally, after processing the IPAQ-sf data (see section 3.3.5), the final sample consisted of N = 196 at baseline, N = 128 at one week, and N = 115 at two weeks. The baseline sample consisted primarily of participants who were white, female, educated, employed, and within a healthy BMI range. Although baseline PA levels varied greatly, on average, participants who took part in the study self-reported being moderately or highly active and engaged in ≥ 150 minutes of PA per week through a combination of VPA, MPA, and walking. According to an independent-samples t-test, there were no significant differences in key variables between those who opted in to and those who opted out of the walking challenge (see Table 3C.1 in appendix 3C). Additionally, one-way ANOVAs indicated no significant differences in total PA across BMI category [$F(3,185) = 1.78$, $p = .152$], gender [$F(1,194) = .01$, $p = .936$], ethnicity [$F(10,185) = 1.44$, $p = .166$],

[5] Removal of incomplete data accounted for removal of individuals who were missing data at any time point throughout the study. As at least three continuous weeks of data are required for a latent growth curve model analysis, only individuals with data at all three time points were included in the final sample (at two weeks).

employment [$F(9,186) = .13$, $p = .999$], or education [$F(5,190) = 1.14$, $p = .341$], so they were not used as covariates in further analysis. Full participant characteristics are detailed in Table 3.3.

Table 3.3. Participant characteristics of study two baseline sample.

Variable	Range	Mean (SD)	Percent (n)
Gender			
Male			19.9% (39)
Female			80.1% (157)
Ethnicity			
White			93.4% (183)
Black			0.0% (0)
Asian			4.1% (8)
Mixed			2.0% (4)
Other			0.5% (1)
Age	19 – 64	37.74 (13.13)	
Education			
Secondary/high school			14.8% (29)
University			70.9% (139)
PhD/professional or higher			9.2% (18)
Other			5.1% (10)
Employment			
Full-time			49.0% (96)
Part-time			17.9% (35)
Self-employed			3.6% (7)
Unemployed			5.6% (11)
Retired			2.6% (5)
Student			16.3% (32)
Other			5.1% (10)
BMI[a]	16.58 – 60.17	26.19 (6.71)	
BMI category[a]			
Underweight (BMI < 18.5)			2.6% (5)
Normal weight (BMI 18.5 – 24.9)			50.8% (96)
Overweight (BMI 25 – 29.9			26.5% (50)
Obese (BMI ≥ 30)			20.1% (38)
Physical activity (minutes/week)			
Total PA	60 – 2520	623.10 (479.84)	
Vigorous PA	0 – 900	138.07 (170.64)	
Moderate PA	0 – 1260	167.68 (231.45)	
Walking	0 – 1260	317.35 (261.70)	
Physical activity (MET-minutes/week)			
Total PA	231 – 11835	2822.53 (162.82)	
Vigorous PA	0 – 7200	1104.57 (97.51)	
Moderate PA	0 – 5040	670.71 (66.13)	
Walking	0 – 4158	1047.24 (61.69)	
Physical activity categories			
Low active			14.8% (29)
Moderately active			41.8% (82)
Highly active			43.4% (85)

Note. N = 196. BMI, body mass index; PA, physical activity. [a] BMI data based on 189 participants.

3.4.2. Data checks

3.4.2.1. Normality

All questionnaire scales showed acceptable reliability, determined by a Cronbach's $\alpha \geq .70$ (see Table 3.5). Normality tests were conducted in SPSS to test for skewness and kurtosis ($\geq \pm 2.58$). The majority of questionnaires showed normal distributions; however the amotivation and external motivation subscales of the BREQ-3 were positively skewed and leptokurtic. These variables were investigated further using boxplots and Q-Q plots, which showed potential outliers and non-normal distributions. For the purposes of this study, the BREQ-3 subscales were weighted and combined to form the RAI (see section 3.3.3.4), which showed a normal distribution and no outliers. Therefore, despite potential limitations of using the RAI (Chemolli & Gagné, 2014), it was deemed the most suitable measure for the current study, due to having a normal distribution and allowing for a single measure of exercise motivation to be modelled (Vallerand & Ratelle, 2002).

3.4.2.2. Confirmatory factor analysis

Prior to statistical modelling analyses, CFA was conducted for all key variables (see Table 3.4 for CFA outcomes and chosen measurement models). Based on CFA, impulsivity was excluded from further analysis, due to low factor loadings (< .50) for most indicators. Moreover, there was high multicollinearity between impulsivity factors when a hierarchical approach was used. Additionally, inhibition was excluded due to a low response rate on the Cued Go/No-Go task. The tested model therefore consisted of DM, autonomous exercise motivation (RAI), self-control, PA acceptance, and self-reported PA (Figure 3.3).

Table 3.4. Confirmatory factor analyses of main study variables.

Model	χ^2	df	χ^2/df	TLI	RMSEA	CFI	SRMR
FFMQ-sf							
Single factor	304.374	80	3.805	.766	.120	.821	.117
Three factors correlated	168.271	88	**1.912**	*.924*	*.068*	*.936*	**.066**
Three factors hierarchical[a]	140.952	85	**1.658**	*.945*	**.058**	**.955**	**.066**
PAAQ							
Single factor	75.345	28	*2.691*	*.932*	.093	**.958**	**.062**
Two factors correlated	90.323	34	*2.657*	*.933*	.092	**.950**	**.053**
Two factors hierarchical[a]	79.650	32	*2.489*	*.940*	.087	**.957**	**.051**
BIS-15[6]							
Single factor	127.775	74	**1.727**	*.921*	**.053**	*.944*	*.090*
Three factors correlated	118.719	77	**1.542**	*.941*	.081	**.957**	**.071**
Three factors hierarchical	114.419	70	**1.635**	*.931*	**.057**	**.954**	*.089*
BSCS-sf							
Single factor[a]	126.333	61	*2.071*	.870	*.074*	.898	**.069**
RAI							
Single factor[a]	1.302	1	**1.302**	**.998**	**.039**	**1.000**	**.003**

Note. Bold indices signify a good model fit, italic indices signify an acceptable model fit. [a] Indicates the measurement models used in path analysis.

3.4.3. Relationship between mindfulness and physical activity outcomes

3.4.3.1. Correlations

DM positively correlated with PA acceptance, autonomous exercise motivation, and self-control (see Table 3.5). Only baseline PA acceptance and autonomous exercise motivation positively correlated with PA behaviour across all time points (see Table 3.6). Self-control positively correlated with PA at baseline and BMI negatively correlated with PA at one week. No significant correlations were found between DM and PA behaviour. All effect sizes were small to intermediate, apart from correlations between mindfulness and self-control and between PA acceptance and autonomous exercise motivation, which showed large effect sizes.

[6] Impulsivity was not included in the full model, due to low factor loadings (< .50) for most indicators and multicollinearity between factors.

Table 3.5. Means, standard deviations, internal consistencies (Cronbach's α), and Pearson's correlations between psychometric measures at baseline.

	Range	Mean	SD	α	2	3	4	5	6	7	8	9
1. Mindfulness (total)	23-72	46.75	9.09	.866	**.699****	**.797****	**.766****	**.341****	**.323****	**.287****	**.330****	**.567****
2. Non-reactivity	5-24	14.76	3.79	.808		**.300****	**.327****	**.218****	**.150***	**.250****	**.191****	**.371****
3. Non-judging	5-25	15.50	4.46	.860			**.438****	**.295****	**.326****	**.194****	**.249****	**.373****
4. Acting with awareness	5-25	16.49	3.77	.851				**.253****	**.242****	**.211****	**.309****	**.555****
5. PA acceptance (total)	13-70	44.03	11.87	.904					**.914****	**.882****	**.736****	**.453****
6. Cognitive acceptance	5-35	21.44	7.10	.882						**.616****	**.613****	**.410****
7. Behavioural commitment	6-35	22.59	6.09	.867							**.719****	**.405****
8. Autonomous motivation	-11-23	9.68	7.54	.858[a]								**.392****
9. Self-control	23-63	42.62	8.41	.831								

Note. N = 196. PA, physical activity. [a] Based on BREQ-3 items. * $p < .05$, ** $p < .01$. All values remained significant (highlighted in bold) when adjusted for family wise error rate using the false detection method (FDR = 5%).

Table 3.6. Pearson's correlations between baseline measures and physical activity over time.

	Baseline PA				PA at one week				PA at two weeks			
	Walking	MPA	VPA	Total	Walking	MPA	VPA	Total	Walking	MPA	VPA	Total
1. Body mass index[a]	.057	.028	-.104	-.001	-.084	-.176*	**-.232****	**-.261****	-.048	-.208*	-.075	-.110
2. Mindfulness (total)	-.075	.049	.111	.033	-.040	-.076	.003	-.038	-.133	.131	.023	.045
3. Non-reactivity	-.083	-.039	.113	-.024	-.098	-.020	.023	-.052	-.158	.086	.039	-.015
4. Non-judging	-.030	.038	.076	.047	.054	-.074	.016	-.005	-.049	.106	.008	.075
5. Acting with awareness	-.064	.113	.064	.050	-.067	-.079	-.036	-.035	-.110	.107	.008	.034
6. PA acceptance (total)	.087	.097	**.390****	**.387****	.019	.163	**.286****	**.286****	-.043	.187*	**.337****	**.338****
7. Cognitive acceptance	.042	.102	**.342****	**.325****	.023	.086	**.221***	**.237****	-.071	.173	**.288****	**.309****
8. Behavioural commitment	.121	.070	**.361****	**.375****	.010	**.219***	**.300****	**.279****	-.002	.165	**.326****	**.304****
9. Autonomous motivation	.118	.024	**.288****	**.325****	-.039	.184*	**.349****	**.297****	-.081	**.262****	**.314****	**.286****
10. Self-control	.011	.053	**.187****	.153*	-.001	.065	.011	.063	-.062	.142	.070	.043

Note. N = 196 at baseline, N = 131 at one week, N = 116 at two weeks. MPA, moderate intensity physical activity; PA, physical activity; VPA, vigorous intensity physical activity. [a] BMI data based on N = 189 at baseline, N = 128 at one week, N = 114 at two weeks. * $p < .05$, ** $p < .01$. Values that remained significant when adjusted for family wise error rate using the false detection method (FDR = 5%) are highlighted in bold.

3.4.3.2. Structural equation model

The full structural model was assessed using the same fit indices and cut-off scores as in CFA (see section 3.3.6). The model presented in Figure 3.3 was constructed after a few iterations that considered alternative approaches. One alternative approach addressed in the iterative process of specifying the model included the separation of the three FFMQ-sf subscales (with and without a covariance between them), with direct paths to the outcome variables. However, the model fit and variance explained were inferior to the hierarchical approach adopted in the final model. This is in line with previous research suggesting that hierarchical factor models sometimes offer the best solution (Bosscher & Smit, 1998). Another approach that was addressed was linking the mediators with direct paths. However, this approach was rejected due to multicollinearity, potentially because of strong correlations between the RAI and the PAAQ. Additionally, an alternative model was tested that considered MPA, VPA, and walking as distinct indicator variables for the latent variable of total PA. This approach was rejected due to reduced model fit, as well as negative estimated variances.

Model 1 (Figure 3.3) indicated a poor fit to the data (see Table 3.7). Following established guidelines (Byrne, 2016), modification indices of possible structural paths were reviewed and indicated that additional paths from self-control to PA acceptance and from autonomous exercise motivation to PA acceptance should be included (Figure 3.4).

Table 3.7. Results of structural equation modelling for the different models.

Model	χ^2 (Sig.)	df	χ^2/df ratio	RMSEA	CFI	TLI	SRMR
Hypothesised models							
Model 1	136.628 (p < .001)	16	8.539	.197	.774	.604	.1049
Model 2 (altered)	20.095 (p = .127)	14	**1.435**	**.047**	**.989**	**.977**	**.0326**
Post-hoc model							
Model 3	13.016 (p = .223)	10	**1.302**	**.039**	**.993**	**.985**	**.0249**

Note. Bold indices signify a good model fit.

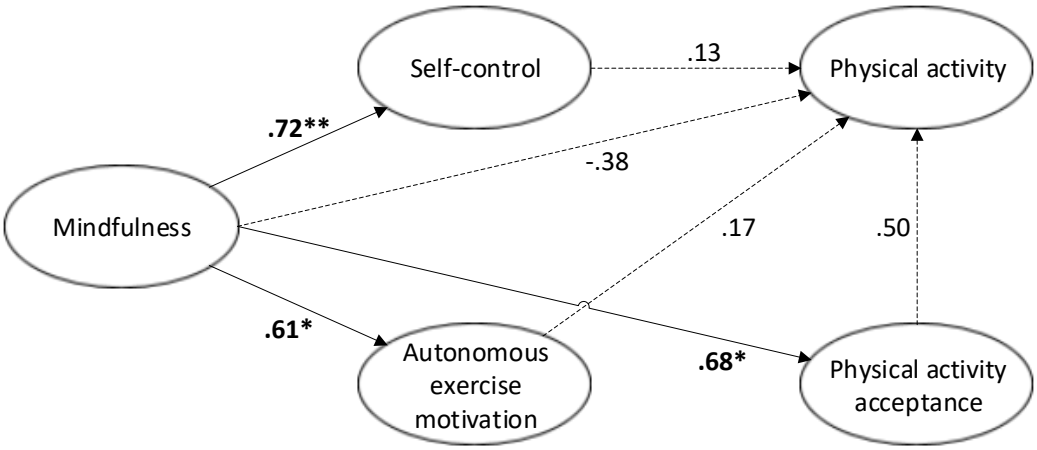

Figure 3.3. *Model 1* – structural equation model depicting relationships between mindfulness, self-control, autonomous exercise motivation, physical activity acceptance, and baseline physical activity.
Note. For reasons of clarity, only the latent variables and structural paths are depicted, whereas indicator variables, error terms, residuals, and covariances are not displayed. Solid lines represent significant paths and dashed lines represent non-significant paths. * p < .05, ** p < .01.

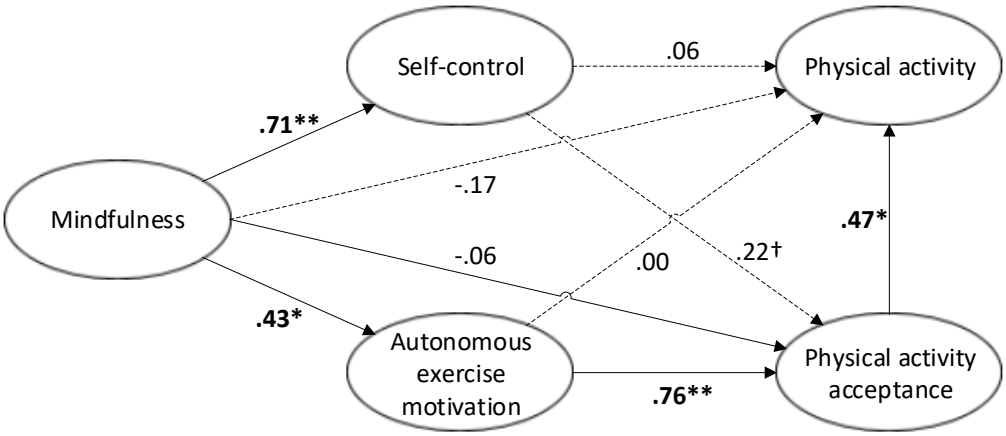

Figure 3.4. *Model 2* – altered structural equation model depicting relationships between mindfulness, self-control, autonomous exercise motivation, physical activity acceptance, and baseline physical activity.
Note. For reasons of clarity, only the latent variables and structural paths are depicted, whereas indicator variables, error terms, residuals, and covariances are not displayed. Solid lines represent significant paths and dashed lines represent non-significant paths. † Path approaches significance (p = .061), * p < .05, ** p < .01.

The altered model (model 2) indicated an excellent fit to the data. The significant paths with beta coefficients for the baseline sample are shown in Figure 3.4. Results indicated that DM had a direct and positive effect on self-control (β = .712, *p* = .005) and autonomous exercise motivation (β = .428, *p* = .009), but no direct effect on PA acceptance (β = -.062, *p* = .536), or self-reported PA (β = -.173, *p* = .360). However, DM appeared to exert an indirect positive effect on PA acceptance through self-control and autonomous exercise motivation, which was statistically significant as observed from Bootstrapping (β = .482, 95% CI: .317, .703, *p* = .004). Moreover, DM also exerted an indirect positive effect on self-reported PA through autonomous exercise motivation and PA acceptance (β = .241, 95% CI: .047, .529, *p* = .020). The full model accounted for 42.0% (β = .420, 95% CI: .203, .634, *p* = .015) of variance in baseline PA acceptance. No total effect was found for self-reported PA (β = .068, 95% CI: -.096, .215, *p* = .430). The standardised indirect effects and the 95% upper and lower limits of bootstrap-generated bias-corrected CIs for the altered model are reported in Table 3.8.

Table 3.8. Standardised parameter estimates of indirect effects.

Parameter	β	Bootstrap bias-corrected 95% CIs (lower, upper)
Mindfulness → physical activity acceptance	.482**	.317, .703
Mindfulness → cognitive acceptance	.318*	.147, .495
Mindfulness → behavioural commitment	.380*	.194, .578
Mindfulness → physical activity	.241*	.047, .529
Autonomous motivation → cognitive acceptance	.574**	.476, .663
Autonomous motivation → behavioural commitment	.686*	.561, .789
Autonomous motivation → physical activity	.358*	.122, .659
Self-control → cognitive acceptance	.167*	.044, .327
Self-control → behavioural commitment	.199*	.036, .367
Self-control → physical activity	.104*	.027, .295

Note. * $p < .05$, ** $p < .01$.

3.4.3.3. Post-hoc model modification

Due to the novelty of this area of research, an exploratory post-hoc model modification was deemed useful for guiding future research (Byrne, 2016). As self-control did not significantly impact either outcome or mediator variables, a modification was considered that excluded self-control (model 3, Figure 3.5). This model indicated improved fit to the data. DM had a direct and positive effect on autonomous exercise motivation (β = .390, *p* = .009), but no direct effect on PA acceptance (β = .088, *p* = .456), or self-reported PA (β = -.138, *p* = .166). DM exerted an indirect positive effect on PA acceptance through autonomous exercise motivation (β = .300, 95% CI: .185, .468, *p* = .006). DM also exerted an indirect positive effect on self-reported PA sequentially through autonomous exercise motivation and PA acceptance (β = .187, 95% CI: .072, .331, *p* = .014). The full model accounted for 38.8% (β = .388, 95% CI: .178, .560, *p* = .009) of variance in baseline PA acceptance, with no total effect on self-reported PA (β = .050, 95% CI: -.086, .233, *p* = .488).

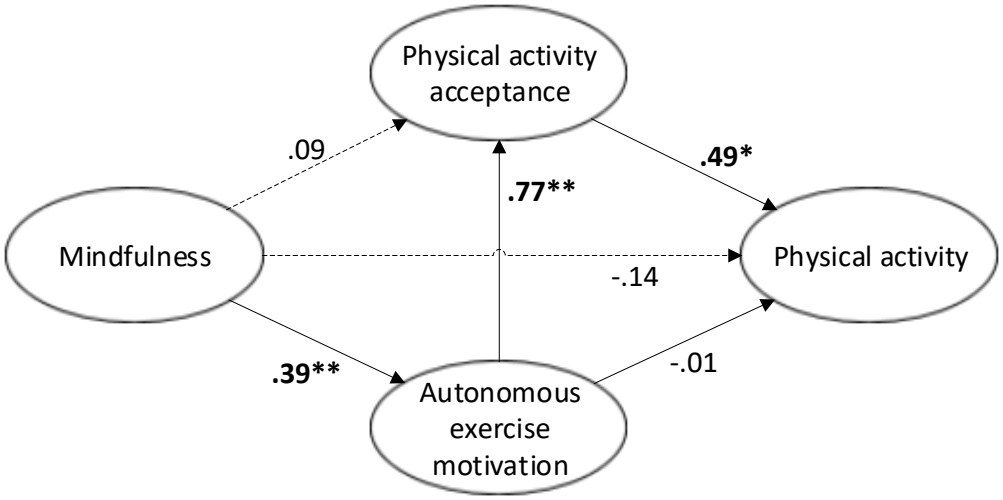

Figure 3.5. *Model 3* – modified structural equation model depicting relationships between mindfulness, autonomous exercise motivation, physical activity acceptance, and baseline physical activity.
Note. For reasons of clarity, only the latent variables and structural paths are depicted, whereas indicator variables, error terms, residuals, and covariances are not displayed. Solid lines represent significant paths and dashed lines represent non-significant paths. * $p < .05$, ** $p < .01$.

3.4.4. Mindfulness as a predictor of change in physical activity

3.4.4.1. Latent growth curve model

Next, DM was modelled as a predictor of PA change over time. The unconditional LGC model of PA (without covariates), which included the intercept set at baseline and a linear change factor (slope), provided an adequate fit to the data (see Table 3.9). The average intercept was 3.283 (SE = .032) and the average linear change factor was .035 (SE = .015), which was significant (p = .024), indicating that PA increased marginally over time. The PA intercept and change factors were uncorrelated (r = .003, p = .734). Overall, total MET-minutes decreased slightly from baseline to one week (2727 ± 204 to 2585 ± 182 MET-minutes/week), but increased at two weeks (3184 ± 246 MET-minutes/week). The LGC model of PA with the intercept and change factors was then regressed on DM as a predictor variable and provided an excellent fit of the data. DM did not significantly predict the PA slope

(i.e., change) factor (β = .182, *p* = .320) or the intercept (i.e., baseline levels) of PA (β = -.063, *p* = .591). Lastly, the model was regressed on DM as a predictor variable and psychological factors related to PA as mediator variables (Figure 3.6) and provided an excellent fit to the data (the full model as produced in AMOS is shown in Figure 3D.1 in appendix 3D). Model 3 from SEM analysis was adopted for the LGC model. DM had a significant positive effect on autonomous exercise motivation (β = .309, *p* < .001), but, notably, a negative effect on the PA intercept factor (β = -.250, *p* = .020). Autonomous exercise motivation had a significant positive effect on PA acceptance (β = .735, *p* < .001) and on the PA intercept factor (β = .453, *p* = .004). Moreover, DM had a significant indirect effect on PA acceptance through autonomous exercise motivation (β = .227, *p* = .001) and on the PA intercept factor through autonomous exercise motivation and PA acceptance (β = .190, *p* = .029). The model R^2 for PA change was .154; thus, the model accounted for 15.4% of change in PA over time.

Table 3.9. Results of latent growth curve modelling for the different models.

Model	χ^2 (Sig.)	df	χ^2/df ratio	RMSEA	CFI	TLI	SRMR
Unconditional	3.232 (*p* = .072)	1	3.232	.139	**.983**	*.949*	**.0034**
Regressed on DM	3.956 (*p* = .266)	3	**1.319**	**.053**	**.993**	**.985**	**.0136**
Full mediation model	6.833 (*p* = .233)	5	**1.367**	**.056**	**.993**	**.979**	**.0156**

Note. Bold indices signify a good model fit, italic indices signify an acceptable model fit.

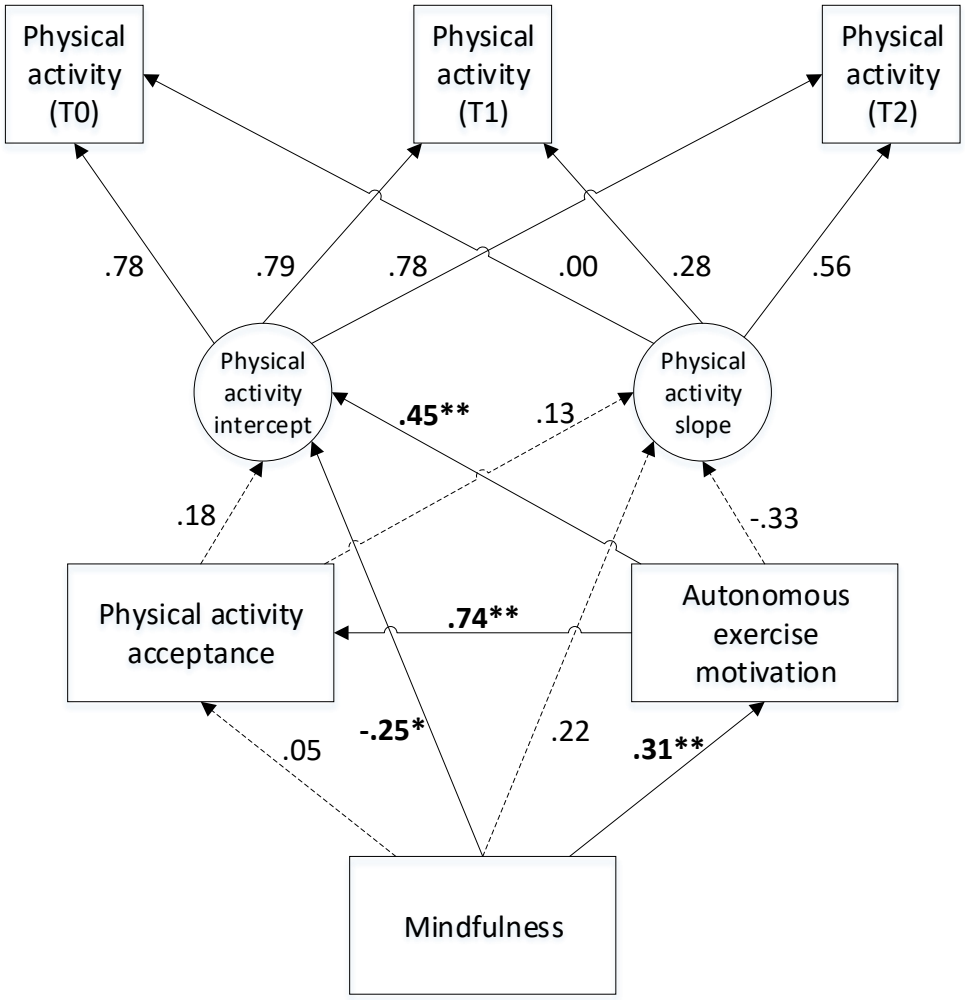

Figure 3.6. Latent growth curve model depicting relationships between mindfulness, autonomous exercise motivation, physical activity acceptance, and physical activity change over two weeks. *Note*. For reasons of clarity, only the imputed variables and structural paths are depicted, whereas error terms, residuals, and covariances are not displayed. Solid lines represent significant paths and dashed lines represent non-significant paths. * $p < .05$, ** $p < .01$.

3.5. Discussion

The present study aimed to investigate the relationship between DM, psychological factors related to PA, self-regulation, and PA using cross-sectional and longitudinal data. It was the first study to model the relationship between DM and PA outcomes using a prospective cohort design. Moreover, this study investigated PA-related psychological factors as potential mediators of the DM-PA relationship. In congruence with earlier studies (Butryn et al., 2011; Ruffault et al., 2016a),

results showed that DM was positively correlated with psychological factors linked to sustained PA, such as autonomous exercise motivation and PA acceptance. Additionally, DM was positively correlated with self-control in line with previous research (Bowlin & Baer, 2012; Yusainy et al., 2019), but no significant correlations were found between DM and PA behaviour. PA acceptance and autonomous exercise motivation were the most consistent predictors of PA at baseline and over time. PA acceptance was also found to have a strong positive correlation with autonomous exercise motivation and an intermediate positive correlation with self-control.

A structural equation model of the cross-sectional data suggested that DM had an indirect effect on both PA acceptance (through autonomous exercise motivation) and PA (through autonomous exercise motivation followed by PA acceptance). Notably, the effect of autonomous exercise motivation on PA seemed to be fully mediated by PA acceptance and PA acceptance was the only direct predictor of PA. The final post-hoc model (model 3) explained 38.8% of variance in PA acceptance, but no total effect was found for baseline PA. These findings were confirmed through a LGCM analysis of longitudinal data, which showed that DM had a direct effect on autonomous exercise motivation and an indirect effect on PA acceptance through autonomous exercise motivation. Moreover, DM had an indirect effect on the PA intercept factor through autonomous exercise motivation and PA acceptance. The findings therefore partially confirm the first hypothesis that DM is directly or indirectly related to psychological factors associated with PA (i.e., autonomous exercise motivation and PA acceptance) and self-control. Additionally, the second hypothesis was partially confirmed as autonomous exercise motivation

and PA acceptance directly or indirectly predicted PA at baseline, but no relationship was found between PA and self-control. Finally, the third hypothesis was partially confirmed as DM indirectly predicted baseline PA through autonomous exercise motivation and PA acceptance. However, DM did not predict change in PA over time.

Overall, findings suggest that mindfulness may enhance psychological factors related to sustained PA and improve individuals' ability to tolerate PA-related discomfort, which may in turn enhance PA. However, evidence regarding the effect of DM on PA change over time could not be established. The lack of total effect found for PA could be due to a number of reasons. There were limitations of several of the self-regulatory measures used, such as low response rate for the Cued Go/No-Go task and poor factor loadings on the BIS-15. As such, these variables had to be excluded from analysis. It is likely that these and other mechanisms that were not included in the current study may better predict total PA. For example, research has found that PA self-efficacy and PA enjoyment are consistent predictors of PA behaviour (Lewis, Williams, Frayeh, & Marcus, 2016; Rhodes, Janssen, Bredin, Warburton, & Bauman, 2017). Therefore, more research is required to understand how these factors interact with DM to predict overall PA. Additionally, although the LGC model confirmed an indirect effect of DM on baseline PA (i.e., PA intercept), the lack of effect on change in PA over time (i.e., PA slope) could be due to the relatively small increase in PA over the two weeks, which could mask the true effects of DM and mediator variables on PA change. Participants were not screened for PA levels prior to data collection so as to achieve as large of a sample as possible, so the final sample in this study consisted of

individuals who were on average highly active. Moreover, the intervention may not have been challenging enough, with study participants already reporting high levels of walking and total PA at baseline. This could cause ceiling effects in PA and obscure possible effects of DM and psychological factors in increasing PA for less active individuals.

Additionally, the effect of DM and psychological factors related to PA may vary with different PA intensities. Correlations showed that self-control, PA acceptance, and autonomous exercise motivation were only significantly associated with VPA, but not with MPA or walking. Arguably, tolerance of PA-related discomfort (i.e., PA acceptance) and autonomous exercise motivation, as well as self-control, are more important at more intense and challenging levels of PA (i.e., VPA). Walking is generally considered a "feel good" type of activity, while more vigorous forms of activity also have a negative side (e.g., fatigue, exertion, muscle pain; Ekkekakis et al., 2011). Additionally, walking is often done as part of a wider range of exercise domains, such as active transportation, compared to more vigorous activities that are often done for leisure and are thus more subject to fluctuations in mood, motivation, and perceived time available (Standage, Sebire, & Loney, 2008). Therefore, while walking is something individuals may have to do, for example to get to and from work, moderate and vigorous activities require a higher degree of acceptance and motivation to sustain. This is in line with previous research, which found that individuals who are autonomously motivated are more likely to exercise at higher intensities (Banting, Dimmock, & Grove, 2011) and that autonomy can enhance exercise adherence (Williams, 2008) and greater tolerance of high intensity exercise (Ekkekakis et al., 2011).

Similarly, given the sample in the present study consisted primarily of females, the perceived walkability of the environment (e.g., safety) could have been a stronger determinant of the walking challenge outcomes than psychological characteristics, such as DM. A previous study found that the perceived walkability of the environment was more influential on female PA than their self-efficacy (Kaczynski, Robertson-Wilson, & Decloe, 2012). Therefore, future studies should consider different domains and intensities of exercise, as well as environmental and other determinants that may interact with psychological mechanisms to induce PA change. As the models investigated in this study included an aggregate measure of total PA, such nuances may have been neglected.

Moreover, it is likely that self-regulation of behaviour plays a bigger role in behaviours that are more challenging. The strength model of self-control (Baumeister et al., 1998) posits that successful self-control involves the ability to overcome urges, impulses, and conditioned responses (Hagger et al., 2009). Moreover, it may be enhanced by self-efficacy, skills, and motivational variables (Baumeister et al., 1998). Self-control is a limited resource and becomes depleted throughout the day, when an individual engages in behaviours that require self-regulation (Baumeister et al., 1998; Baumeister et al., 2006). Mindfulness may protect against self-control depletion (Friese et al., 2012) and help individuals overcome psychological barriers to behaviour change by cultivating a mindful awareness that is flexible and non-reactive, allowing individuals to sustain PA despite challenges and negative thoughts that may occur, especially at higher exercise intensities. The relationship between study variables in the present study

therefore suggest that DM may be most beneficial for higher intensity PA, through enhancing autonomous exercise motivation and PA acceptance.

Similarly, previous research has indicated that DM may relate differently to different types of PA (Martin et al., 2013; Salmoirago-Blotcher et al., 2013). Specifically, studies have found that DM was positively correlated to yoga, but negatively correlated to aerobic PA (Martin et al., 2013) and that a MBI only led to improvements in activities related to flexibility, but not in activities related to strength (Salmoirago-Blotcher et al., 2013; also see study one, chapter two). Therefore, mindfulness may have a different impact on different types of PA, but this needs to be verified in future research that distinguishes between DM and mindfulness practice. The relationship between DM and exercise is likely to be bidirectional to some extent (Mothes et al., 2014) and little is currently known about whether DM on its own enhances PA behaviour. Moreover, it is not clear to what extent self-control, autonomous exercise motivation, and PA acceptance are associated with varying types of PA. A previous study found that participation in cardio-based exercise was associated with appearance-related reasons for exercise, which implies controlled exercise motivation, while participation in yoga-based fitness classes was related to exercising for health and fitness (Prichard & Tiggemann, 2008), which are more autonomous reasons for exercising. This was confirmed in a later study that found that motivations for exercise differ between women practicing yoga and women engaging in aerobic exercise, such that yoga practitioners were more likely to exercise for mental and physical health, while aerobic exercisers were more likely to exercise for weight management (Zajac & Schier, 2011). Moreover, findings from a recent study showed that a yoga

intervention decreased the external (i.e., controlled) motivation for exercise (Martin, Dick, Scioli-Salter, & Mitchell, 2015b). The comparison between various PA types is further important as yoga has consistently shown various health benefits (Ross & Thomas, 2010), yet is often less common than aerobic exercise in lifestyle interventions targeting increased PA (Martin et al., 2015b). The current study did not compare PA types; however, as DM was found to positively correlate with autonomous exercise motivation, the effect of mindfulness on different types of PA and the possible mediators involved should be considered.

Overall, the findings of the current study suggest that DM may be beneficial for enhancing psychological factors related to sustained PA, such as autonomous exercise motivation and PA acceptance, which in turn may contribute to higher PA levels. However, further investigation is still necessary to explore the relationship between DM and PA outcomes using the mediators assessed in this study. Importantly, longer duration studies that control for additional psychological and environmental correlates of PA may be required.

3.5.1. Limitations

Although there are a number of strengths to this study (e.g., the prospective design, use of SEM and LGCM, and assessment of PA acceptance), several limitations should be acknowledged. The sample was homogenous and consisted predominantly of white, healthy, and female participants, thus limiting generalisability to other populations. Additionally, most variables (apart from PA outcomes) were only measured at baseline, so it was not possible to test potential reciprocal or temporal relations between them. Future studies that take an

experimental approach and investigate how the different variables interact over time will provide more definitive answers regarding the effect of DM on PA and the mediating effects of psychological factors related to PA.

Secondly, while there are currently no strict guidelines regarding sample size in research using statistical modelling techniques, a sample size of 200 is typically seen as a realistic goal (Cheong, 2011; Kline, 2015). Others have suggested that a minimum number of five cases per estimated parameter is sufficient (Bentler & Chou, 1987; Tanaka, 1987), especially when considered in combination with other factors (Wolf, Harrington, Clark, & Miller, 2013), such as overall sample size > 100 (Anderson & Gerbing, 1984), factor loadings ≥ .50, and acceptable goodness-of-fit indices (Jackson, 2003). In the current study, 22 – 28 parameters were estimated (without and with the self-control variable, respectively), which would correspond to 110 – 140 cases (i.e., five cases per estimated parameter). This criterion was met at baseline; however, the sample size was at the lower end of this range at two weeks. This could have influenced the results or reduced the power to detect relationships between variables and could explain why the effect of self-control on PA acceptance only approached significance at baseline, but was lost as sample size decreased.

Thirdly, the finding that a structural equation model fits the data does not prove that the selected model is the only one or the best one that fits (Schwarzer, 2008) and the modelling techniques used in this study are not without limitations (Tomarken & Waller, 2005). A valid model should be empirically based and superior to alternative models. Additionally, it should provide the best insight into the causal mechanisms of health behaviour change (Schwarzer, 2008). The final model in the

current study was therefore chosen for three reasons: 1) it yielded the best model fit as shown by the fit indices presented in the results, 2) it explained the most variance in observed PA outcomes, and 3) it was the most parsimonious approach and thus avoided the penalty exacted for over complex fit that is assessed by the family of fit indices that address parsimony (Byrne, 2013).

Finally, due to the nature of the study design and the sample size required for analysis, it was not possible to measure PA objectively. Despite being one of the most widely used self-report measures of PA (Bauman, Nelson, Pratt, Matsudo, & Schoeppe, 2006), there are several problems with using the IPAQ, such as challenges in recall (Bauman et al., 2009), question order effects (Ainsworth et al., 2006; Barnett, Nigg, De Bourdeaudhuij, Maglione, & Maddock, 2007), over-reporting (Lee, Macfarlane, Lam, & Stewart, 2011; Rzewnicki et al., 2003), particularly for higher intensity PA (Bauman et al., 2009; Rzewnicki et al., 2003), and high variance (Bauman et al., 2009). Many of these issues are shared with other self-report measures of PA, as well as other variables of interest. Therefore, future studies should aim to use accelerometers or pedometers as objective measures of PA. Using objective measures of PA removes the issue of over-reporting, which would enable an investigation of different PA intensities in relation to DM and psychological factors. Similarly, self-report measures were employed for the majority of the other study variables (apart from inhibition). The self-control measure was excluded from the final model due to its lack of effects on the key outcome and mediator variables. Although there are practical challenges of integrating such assessments in an online study, future research could consider behavioural measures of self-regulation (Muraven, Baumeister, & Tice, 1999),

which have been employed in recent studies investigating the effect of mindfulness on health behaviours (Jenkins & Tapper, 2014). Additionally, objective measures of mindfulness (e.g., frequency of practice or years of meditation experience) will enhance the conclusions that can be drawn regarding the relationship between mindfulness and PA.

3.5.2. Future directions

As outlined above, future studies should attempt to replicate findings from the current study by employing longitudinal and experimental study designs, larger sample sizes, and objective measures of PA. Moreover, studies should consider the effect of DM on different types and intensities of PA, along with potential benefits of different types of exercise on mental and physical health outcomes. Similarly, additional mechanisms need to be considered in future research that may combine to explain a greater variance in overall PA, such as self-efficacy (Gilbert & Waltz, 2010), exercise intention (Ajzen, 1991), satisfaction with the experience of PA (Tsafou et al., 2016a; Tsafou et al., 2016b), and exercise enjoyment (Cox et al., 2018; Ivanova et al., 2015; Roberts & Danoff-Burg, 2010). Following the findings of the current study and previous literature (see study one, chapter two), it may be prudent to develop MBIs for PA that specifically target the mechanisms related to sustained PA behaviour change, such as PA acceptance and autonomous exercise motivation. Given the mixed effectiveness of current MBIs aimed at increasing PA in the general population, interventions that are theory-based and PA-specific may be more effective at achieving desired outcomes.

3.6. Conclusions and justification for study three

In summary, the present study provided some support for the hypothesised multi-theory model that DM predicts PA by enhancing psychological factors related to sustained PA, such as autonomous exercise motivation and PA acceptance. This finding contributes to current knowledge about the relationship between DM and PA by considering its potential mechanisms of action. It also contributes to the health psychology literature by suggesting the possible contribution of mindfulness to known mediators of successful PA behaviour change. Importantly, the findings from this study provide practical implications, as results can directly be applied to the development of MBIs for PA promotion that specifically target PA acceptance and autonomous exercise motivation. Rigorous and controlled experimental trials have the potential to enhance current understanding about the relationship between DM and PA and explore the causal mechanisms involved. Study three (chapter four) therefore builds on knowledge gained through study one (chapter two) and study two (chapter three) and outlines a novel MBI for the promotion of PA in underactive participants. Specifically, study three considered both DM and mindfulness practice, as both have been suggested as potential predictors of PA outcomes (see study one, chapter two), and investigated PA using both objective and self-report measures of PA.

Chapter Four – Adapting a Mindfulness-Based Programme to Facilitate Physical Activity Uptake in Underactive Participants: A Feasibility Study

4.1. Study overview

Existing PA interventions tend to produce small to moderate improvements in target outcomes. Recently, MBIs have been adapted for PA, but findings are currently inconsistent regarding their effectiveness. Recent evidence (see study one, chapter two and study two, chapter three) suggests that MBIs may be better employed as precursors of behavioural interventions by targeting psychological mechanisms of behaviour change. A mindfulness for PA programme (MfPA) aimed at changing participants' relationship with PA was developed and piloted in the current study. Underactive participants (N = 13, age M = 35 years, 69% female) took part in the six-week MfPA programme that taught mindfulness meditation skills embedded in a psycho-educational curriculum about PA. Accelerometer data and self-report measures assessing DM, exercise motivation, PA acceptance, self-control, and PA behaviour were taken before, after, and four weeks after the intervention. Focus groups were conducted four weeks after the intervention to gain qualitative feedback about the programme and analysed using thematic analysis (TA). A series of one-way, repeated-measures ANOVAs revealed significant improvements in PA acceptance and autonomous exercise motivation (*p*s < .05, *g*s = .367 – .875), but no change in DM, self-control, or PA. Participants reported a positive experience of taking part in the programme and improved cognitions and

attitudes related to PA. However, several participants felt that the link between mindfulness and PA could have been made more explicit within the intervention and wanted more guidance regarding what types of PA they could do. Despite the small sample size and lack of control group in the present study, improvements in PA acceptance and autonomous exercise motivation suggest that mindfulness can help prepare individuals for PA behaviour change and may be an effective add-on approach to existing PA interventions. This study therefore provides proof of principle as a basis to design a RCT to rigorously assess the effectiveness of the MfPA programme.

4.2. Introduction

4.2.1. Background

Despite the established benefits of PA for health promotion and risk reduction, many individuals still do not meet the recommended national guidelines for PA. Additionally, although PA promotion has been widely studied in the scientific community, most behavioural interventions tend to achieve small (Johnson et al., 2010; Michie et al., 2009) to moderate (Foster et al., 2005) effects on PA levels and limited long-term benefits. Benefits of increased PA gained in the short term are often not maintained past the end of the intervention and drop-out rates tend to be relatively high (Blue & Black, 2005; Dishman et al., 2012). One possible explanation for this is that such interventions fail to prepare individuals for PA behaviour change by targeting psychological mechanisms of change (Michie & Abraham, 2004; Teixeira et al., 2015). Previous research has identified several

psychological factors that are likely to predict PA behaviour change, including self-regulation, autonomous exercise motivation, and PA acceptance (see chapter one, section 1.2.4). One approach that has recently been adapted for PA interventions for its potential to target these psychological factors is mindfulness practice (Ivanova et al., 2015; Moffitt & Mohr, 2015; Palmeira et al., 2017; Salmoirago-Blotcher et al., 2018; Tapper et al., 2009). Mindfulness practice has the potential to address psychological barriers to change (Hayes, 2004) and foster greater awareness and acceptance of PA. Furthermore, cross-sectional and longitudinal research has demonstrated that DM (i.e., an individual's disposition to be mindful in daily life) may be correlated with psychological factors related to PA, such as PA self-regulation (Grinnell et al., 2011), perceived behavioural control and attitudes related to PA (Chatzisarantis & Hagger, 2007), PA satisfaction (Tsafou et al., 2016a), and exercise motivation (Kang et al., 2017; Ruffault et al., 2016a). However, cross-sectional investigations limit conclusions that can be drawn regarding cause and effect and do not take into account mindfulness practice as a potential approach for PA behaviour change. Therefore, experimental research is required to assess the effect of mindfulness practice and MBIs on PA outcomes.

So far, MBIs for PA have shown mixed success, but interventions that include specific PA components (e.g., PA education) and target psychological factors related to PA tend to be more successful at influencing PA outcomes. There is currently high variability between intervention components and PA elements in existing MBIs (see study one, chapter two). PA-related MBIs have primarily focused on PA frequency as an outcome, rather than on the mechanisms of PA behaviour change. Few MBIs have specifically targeted psychological factors related to PA and

all such interventions employed acceptance-based approaches, such as ACT (Butryn et al., 2011; Fletcher, 2012; Goodwin et al., 2012; Ivanova et al., 2015; Tapper et al., 2009), rather than traditional MBIs. As such, little is currently known about the potential of MBIs to affect psychological factors related to PA. Moreover, the range of interventions used to date vary in quality, mainly due to a lack of appropriate control groups and no exploration of the potential mechanisms of change. Although mindfulness has received increasing attention as an add-on treatment to interventions targeted at increasing PA, it remains unclear whether mindfulness actively induces PA behaviour change. Mindfulness is more likely to affect psychological factors related to PA behaviour change (see also study two, chapter three), such as autonomous exercise motivation (Kang et al., 2017; Ruffault et al., 2016a), PA acceptance (Ruffault et al., 2017; Sagui-Henson et al., 2018), and PA self-regulation (Chatzisarantis & Hagger, 2007; Grinnell et al., 2011). Thus, there is scope to develop novel MBIs for PA that specifically target such psychological factors and are based on established theories of behaviour change techniques.

Kok et al. (2016) recommends that for a behaviour change method to be effective, it: 1) must target a determinant that predicts behaviour, 2) must be able to change that determinant, and 3) must be translated into a practical application in a way that preserves the parameters for effectiveness and fits with the target population, culture, and context. In line with this recommendation and findings from previous research investigating the effectiveness of MBIs for PA (see study one, chapter two), the MfPA programme was developed, specifically aimed at changing participants' relationship with PA, by promoting acceptance of PA-related discomfort and enhancing autonomous motivation to engage in exercise. The

typical MBSR structure was retained, but shortened (i.e., eight weeks to six weeks) and individual components of the programme were tailored specifically to participants' experience of PA. The MfPA programme was developed in line with recommendations from the MRC (Craig et al., 2008) and guidance on adapting and modifying MBSR programmes (Dobkin et al., 2014). The feasibility and piloting stage is often skipped, but is vital work to identify and correct possible problems of the intervention in the areas of compliance, acceptability, and delivery of the intervention (Craig et al., 2008). Therefore, in the present study, the MfPA programme was tested for acceptability and feasibility prior to evaluation in a future large-scale RCT. As part of the piloting process, participant collaboration was sought through engagement in focus groups after the intervention. In this way, participants could have a say on their experience of the programme and suggest areas for further improvement. The measures chosen reflect the course curriculum and evidence on correlates of PA behaviour change and assess self-control (as a measure of self-regulation), exercise motivation, and PA acceptance, as well as DM and PA behaviour.

4.2.2. Study objectives

Three study objectives were devised to: 1) explore the efficacy of the MfPA intervention by exploring changes in self-control, DM, and PA outcomes, 2) assess the feasibility and acceptability of the intervention for underactive participants, and 3) gather information from participants to generate a basis for the refinement of the MfPA programme.

4.3. Methods

4.3.1. Design

A mixed-methods cohort study design was employed and participants were tested before, after, and four weeks after the MfPA intervention. At each time point, participants completed questionnaires assessing DM, self-control, and various PA outcome measures. This study combined quantitative and qualitative research methods, with focus groups conducted four weeks after the intervention to explore participants' experience of the MfPA programme. This study was registered on Clinical Trials (https://clinicaltrials.gov/) before data collection commenced (registration number: NCT03677687).

4.3.2. Participants

A purposive sampling approach was used to identify and recruit participants who met eligibility criteria (see Table 4.1). Participants were recruited from the general population using social media, emails, leaflets and flyers, the "Call for Participants" website, the LJMU research participants' panel, and a bespoke website[7]. A statistical power analysis was performed for sample size estimation, using an effect size of f = .4 (as expected due to previous findings; see study one, chapter two), which according to Cohen's guidelines is considered to represent a large effect (Cohen, 1988; Tabachnik & Fidell, 2007). It is the equivalent of Cohen's d, but used for one-way ANOVA analysis. With an α = .05 and power = .80, the

[7] Mindfulness for Physical Activity programme participant recruitment website: https://mindfulnessforpa.wordpress.com/.

projected sample size needed with this effect size was calculated *a priori* using G*Power 3.1.9.2 for a repeated-measures, within-factors ANOVA (Faul, Erdfelder, Lang, & Buchner, 2007) and was N = 12 for a single group comparison across three time points.

Table 4.1. Study three inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
• Aged 19 – 64 years old • English speaking • Would like to do more physical activity, but find it boring, uncomfortable, or not enjoyable • Available and willing to attend all sessions and complete all research measures	• Have a physical disability, cardiovascular condition, or any other illnesses or injuries that would prevent from doing physical activity • Currently engaging in regular physical activity • Currently taking medication and/or undergoing therapy for a mental health condition • Have previously completed a mindfulness course • Currently engaged in a regular meditation practice • Away or unavailable for any of the course sessions or research measures

4.3.3. Measures

4.3.3.1. Physical activity measures

PA was measured objectively with accelerometers (ActiGraph wGTX3-BT, developed by ActiGraph LLC, Pensacola, Florida) and through self-report, using the IPAQ-sf (see study two, chapter three for a discussion of the IPAQ-sf processing and analysis procedure). The ActiGraph accelerometer is a small (4.6cm x 3.3cm x 1.5cm) and light (19 grams) instrument that records integrated acceleration information as an activity count, providing an objective estimate of the intensity of vertical bodily movement. Accelerometers are widely used as a cost-effective method of assessing PA and provide objective and precise data on intensity,

frequency, and duration of PA (Freedson & Miller, 2000), as well as sedentary time and posture. Moreover, sealed accelerometers hide the activity output from the wearers, therefore reducing potential bias (Broderick, Ryan, O'Donnell, & Hussey, 2014). Participants were given the same accelerometer (based on serial number) at each time point to prevent inter-device variability. All units were initialised via a computer interface to collect data in 10-second epochs in the 3 axes. The validity of the ActiGraph GTX3 has proved similar to the GT1M devices in laboratory testing and for the measurement of everyday activities (Sasaki, John, & Freedson, 2011; Vanhelst et al., 2012) and the ActiGraph GTX3 was found to be a reliable tool for measuring PA in adults under free-living conditions (Aadland & Ylvisåker, 2015; Santos-Lozano et al., 2012).

Participants were asked to wear the accelerometer attached by an elastic belt on the right hip (Trost, Mciver, & Pate, 2005), during all waking hours (≥ 10 hours a day), for seven consecutive days (Matthews, Ainsworth, Thompson, & Bassett, 2002) at each time point (pre-intervention, post-intervention, and four weeks later). They were asked to remove the accelerometer for bathing or showering and water-based activities (e.g., swimming). To improve compliance (Trost et al., 2005), participants were given an activity monitor log with their accelerometers, which asked them to complete the time they put on and took off the accelerometer each day, as well as any time they took it off in between (e.g., for showering or bathing). Participants also received written instructions regarding how the accelerometer should be worn (see appendix 4A).

Three outcome variables were considered: 1) time spent in moderate to vigorous intensity PA (MVPA minutes/day), 2) time spent in health-enhancing PA

(HEPA minutes/day), and 3) number of steps/day. MVPA was defined as PA that exceeded the intensity of 2690 counts/minute (Sasaki et al., 2011) and HEPA was defined as continuous MVPA lasting for ≥ 10 minutes at a time, according to current PA recommendations (Haskell et al., 2007). Epoch length was set to 10 seconds, as research suggests that the use of a shorter time-sampling interval may potentially reduce misclassification error of PA estimates (Gabriel et al., 2010). In order to meet at least 80% of the data reliability criterion for use as representative data in the analysis, at least three of the seven days of data gathering (Matthews et al., 2002) were required to have shown a minimum of 500 minutes of objectively measured accelerometer-wearing time/day (Kangasniemi et al., 2014; Kangasniemi et al., 2015).

4.3.3.2. Psychological measures

Psychological measures were taken before, after, and four weeks after the intervention. The inclusion of quantitative data in this study allowed for a calculation of effect sizes to be made in consideration for future studies. DM, self-control, exercise motivation, and PA acceptance were assessed with the FFMQ-sf, the BSCS, the BREQ-3, and the PAAQ, respectively. The RAI was calculated as a composite measure of autonomous exercise motivation based on weighted BREQ-3 subscales. These measures were used in study two of this thesis and have been described previously (see study two, chapter three).

4.3.3.3. Attendance and adherence measures

Attendance was taken at the beginning of each session by JS and participants were asked to complete a questionnaire asking them how much they engaged with their home practice at the end of the intervention (see appendix 4B). The questionnaire contained three questions for each week: 1) how many days did you meditate?, 2) what meditations did you try?, and 3) what type of activity did you do? Total days of meditation over the duration of the course were then divided by five weeks[8] to achieve a weekly average.

4.3.3.4. Feasibility and acceptability measures

At the end of the programme, participants filled out a course evaluation form asking whether they felt they gained anything of value from taking part in the course, how useful they found individual course elements, and whether there were any aspects of the course they think could be improved (see appendix 4C).

Additionally, focus groups were conducted by JS four weeks after the intervention to allow participants to share their experience of the programme and provide further feedback on the MfPA intervention. Two focus groups were conducted, each containing four participants, which is in line with recommended guidelines (Barbour, 2008; Peek & Fothergill, 2009). Focus groups took place one week apart and participants were allocated according to their preferred availability. Each focus group took approximately 45 minutes and targeted two main research questions: 1) what were participants' experiences of the MfPA programme? and 2)

[8] Amount of home practice was measured at the start of the sixth week.

what effect did participants feel the MfPA programme had on their relationship with PA? A semi-structured focus group discussion guide (see appendix 4D) was used to facilitate the discussion, but due allowance was made for specific issues raised within a given group. Additionally, the questions were relatively open-ended, allowing participants to raise issues that were important to them, while also ensuring that the two focus groups could be compared in terms of content (Bryman, 2016; Flick, 2018). Several techniques were used to ensure richness and depth of the data, including reflective listening, open-ended questions, and probes. All participants were encouraged to take part and questions were repeated and directed to participants who spoke less than others. Moreover, questions were asked to ascertain agreements and disagreements between different viewpoints. The interval between the focus groups allowed time to transcribe and reflect on the first group to inform any necessary changes to how the second group was conducted (Kidd & Parshall, 2000). No major changes were conducted after the reflection, but it was noted that participants frequently jumped between the two main research questions, so the guide was relaxed slightly in terms of structure for the second focus group.

Qualitative approaches are often recognised as having an important role in contributing to public health research (Dixon-Woods & Fitzpatrick, 2001), as they can offer an in-depth perspective on individuals' perceptions and experiences that are likely important in processes involved in behaviour change (Hardcastle & Hagger, 2011). Focus groups were chosen as they allow researchers to gather individuals with a certain shared experience and interview them in a relatively unstructured way about that experience (Bryman, 2016). They are often used as a

method in evaluation research to gather participant views about an intervention (Ridgers, Knowles, & Sayers, 2012) and have been shown to be an effective way to obtain a diverse range of information (Basch, 1987; Morgan, 1996). Additionally, focus groups are often used in social science research as they: 1) allow the researcher to develop an understanding about why people feel the way they do, 2) allow participants to bring up issues and points that they find important and provide their opinion on issues that others bring up that they may have otherwise not thought of, and 3) allow participants to agree or disagree with each other's views (Kitzinger, 1994), possibly providing more realistic accounts of what people think (Bryman, 2016), compared to when interviews are limited to one participant. As the focus is on group perspectives, rather than individual experiences, interaction between participants is an important element of focus group research.

Focus groups were deemed appropriate for this particular study, as participants had already built a rapport over the six weeks of the MfPA programme. Such "natural groups" enhance the authenticity of focus group discussions, as participants may feel more comfortable sharing their experiences with each other (Bloor, 2001; Kitzinger, 1994). Indeed, listening to others can help individuals to think about their own experiences of the programme in a deeper or novel way. Data gathered through the focus groups provided insight into potential processes and mechanisms of change of the intervention, as well as allowed participants to offer feedback on the intervention structure and content.

4.3.4. Procedure

Prior to commencing participant recruitment, ethical approval for this study was granted by the LJMU ethics committee (approval number: 18/NSP/025).

4.3.4.1. Programme development

The MfPA programme was developed through collaboration between mindfulness experts, psychologists, and sport and exercise scientists (JS, PL, PM, PW, and LS). Bi-weekly meetings took place six months before study commencement to discuss the content and structure of the programme, as well as to design the course materials (i.e., teacher notes, handouts, and participant workbooks). The discussions took into account theoretical considerations from previous literature on mindfulness and PA to identify elements that make MBIs more successful at enhancing PA outcomes, such as focusing on PA in weekly sessions and home practice exercises, targeting psychological factors related to PA (e.g., PA acceptance), and including some PA education in the first session of the course. The meetings also included discussions about the target population (see section 4.3.2) and the focus of the programme, which was agreed to be on changing participants' relationship with PA. Therefore, elements of the content were tailored specifically to this aim by placing participants' experience of PA at the centre of weekly inquiry.

4.3.4.2. Eligibility

As part of the recruitment process, participants were asked to complete an eligibility survey hosted on Qualtrics XM (Qualtrics, Provo, UT). Eligibility was based

on predetermined criteria (see Table 4.1) and was assessed via a variety of questionnaires. Participants' attitude towards PA was assessed according to the Stages of Change model (Prochaska, Redding, & Evers, 2015), using four yes/no questions: 1) I am currently physically active, 2) I intend to become more physically active in the next six months, 3) I currently engage in regular PA, and 4) I have been regularly physically active for the past six months. Only participants who selected that they intend to become more physically active in the next six months, but who were not currently regularly active (i.e., participants in the contemplation stage) were eligible to take part in the study. Similarly, participants were excluded if they scored > 30 (out of 70) points on the PAAQ. This was to ensure that the intervention was delivered to the intended target population of inactive individuals who want to change their relationship with PA, but find activity boring, uncomfortable, or not enjoyable. Additionally, yes/no questions were used to assess whether participants were of the appropriate age (19 – 64 years old), as well as their availability to take part in the programme and all associated research measures, presence of physical and mental health conditions, and previous mindfulness/meditation experience. Participants who met all the eligibility criteria were asked to confirm their interest in taking part in the MfPA programme and had the option to sign up for a taster session taking place two weeks before the programme was due to commence.

The purpose of the taster session was to introduce the aims and content of the programme and answer any questions the participants had, as well as provide participants with a taster meditation practice. Additionally, this session was used to explain the research measures and what was expected of participants at each time point, before and after the MfPA programme. At the end of the taster session,

participants were able to sign up for their first research appointment to complete the baseline measures. The taster session was attended by 10 out of 13 participants and the participants who could not attend were contacted separately via email to arrange their research appointments.

4.3.4.3. Pre-intervention

One week prior to taking part in the MfPA programme, participants were asked to wear an accelerometer for seven days and to complete a batch of questionnaires assessing DM, self-control, PA acceptance, exercise motivation, and self-reported PA. Participants also answered questions about their age, gender, ethnicity, education, marital status, and employment.

4.3.4.4. Intervention

The MfPA programme was led by PL and took place in the LJMU Redmonds building every Monday from 17.30 – 19.30 for six weeks[9]. PL is an experienced mindfulness teacher and is accredited with Breathworks. He has experience of teaching Mindfulness for Stress with higher education and corporate clients and has been practicing meditation for eight years. The MfPA programme structure was based on MBSR with elements of the content tailored specifically to PA. The general MBSR structure was retained and adapted (Dobkin et al., 2014) and followed the typical order of weekly content that introduced participants to mindfulness and then became more advanced as the weeks progressed (see Table 4.2). However,

[9] In week three, the location was changed to the LJMU John Foster building due to a fire alarm incident at the Redmonds building.

the course consisted of only six weekly two-hour sessions (instead of the typical eight) and included core components of MBSR (i.e., formal meditation practice, teaching and training exercises, inquiry, and home practice) alongside additional PA components (i.e., mindful movement and applying mindfulness practice to PA). The first session also included some PA education about the national guidelines for PA in the UK (National Health Services, 2016b) and recommendations for how these guidelines can be achieved. As part of the MfPA programme, participants were provided with a workbook that contained each week's key teachings and home practice, with space to complete how much home practice they had engaged in each week.

Traditional concepts of MBSR were taught each week, such as autopilot, primary and secondary experience, being versus doing, active choice, and the paradox of mindfulness. Although the focus of the programme was on learning mindfulness and meditation skills, the content was tailored towards participants' experience of PA (rather than stress in daily life, as in traditional MBSR programmes). For example, when discussing the concepts of "active choice" and "autopilot", participants were asked to consider daily and physical activities that they did on autopilot, such as taking the lift instead of choosing to take the stairs (week one). Similarly, when the concept of "charged" or negative thoughts was discussed, participants were encouraged to think about their thoughts before, during, or after PA and to spot that those thoughts were not always facts (week four). In addition to the weekly content, participants were asked to complete some home practice that included traditional meditation and mindfulness exercises (e.g., body scan, mindful movement, mindfulness of breath), recommended reading, and

Mindfulness in Action, where they were asked to apply concepts taught during the programme to routine and physical activities (see appendix 4E for a sample from the MfPA workbook). Participants were given free choice regarding what PA to do each week, although in week four, they were advised to select an activity they found challenging in some way, so that they could practice the key concepts of that week (i.e., working with difficult experiences). In the last class, participants were given advice about where they can further pursue their mindfulness practice.

4.3.4.5. Post-intervention

Directly after completing the intervention, participants were asked to complete the same batch of questionnaires as at baseline and wear an accelerometer for seven days. Additionally, participants completed a feedback form and a questionnaire asking about the amount of home practice they had engaged in throughout the duration of the programme. Participants were compensated with £40 in shopping vouchers for completing pre- and post-intervention measures.

Table 4.2. Outline of the Mindfulness for Physical Activity (MfPA) course curriculum.

Week 1: Mindfulness: Learning to choose	Concepts: Mindfulness, physical activity, autopilot, primary and secondary experience, reacting and responding, active choice Practice and inquiry: Introduction to the course, raisin exercise, the cushion enactment, body scan Home practice: Body scan, exploring different types of physical activity, mindful routine activity, mindful physical activity
Week 2: Coming to your senses	Concepts: Doing and being, perceptual and conceptual modes of mind Practice and inquiry: Body scan, mindful movement, mindfulness of breath Home practice: Mindfulness of breath, body scan, mindful movement, reading about doing and being modes, mindful routine activity, mindful physical activity
Week 3: Working with thoughts	Concepts: Meditation and movement, thoughts are not (necessarily) facts Practice and inquiry: Mindful movement, mindfulness of breath, thoughts are not facts exercise, mindfulness of sounds & thoughts meditation Home practice: Mindfulness of breath, body scan, or sounds & thoughts meditation, 3-minute breathing space, mindful movement, noticing thoughts during physical activity
Week 4: Working with difficult experiences	Concepts: Charged thoughts, accepting difficult experiences, the paradox of mindfulness Practice and inquiry: Mindful movement, mindfulness of breath, accepting a difficult experience, kindness meditation Home practice: Mindfulness of breath, sounds & thoughts meditation, or kindness meditation, 3-minute breathing space, mindful movement, psychological flexibility, accepting difficult experiences during physical activity
Week 5: Noticing the good things	Concepts: Negativity bias, noticing the pleasures and positive experiences in our lives Practice and inquiry: Mindful movement, seeking out the pleasant, letting in the good Home practice: Mindfulness of breath, body scan, or kindness meditation, 3-minute breathing space, mindful movement, noticing pleasant experiences during physical activity
Week 6: Kindness and beyond the course	Concepts: The three major emotion systems, kindness to self, self-kindness versus self-criticism Practice and inquiry: Mindful movement, kindness and compassion, kindness meditation, review of course and next steps Home practice: Continue applying course concepts and practices to daily life and physical activity

4.3.4.6. Follow-up

Finally, participants were asked to complete the same batch of questionnaires and wear an accelerometer for seven days four weeks after the intervention and were compensated with £40 in shopping vouchers for completing follow-up measures. Additionally, participants were invited to take part in a focus

group taking place four or five weeks after the intervention, to provide feedback on the intervention and their overall experience of the study. At the start of each focus group, participants were given a consent form to sign and informed of the general structure and proceedings of the session. The focus groups were audio recorded with participants' consent. Refreshments were provided during the session and £10 in shopping vouchers were given as compensation for participation in the focus groups.

4.3.5. Data processing

The IPAQ-sf data were processed according to established guidelines (IPAQ Research Committee, 2005), which have been described previously (see study two, chapter three, section 3.3.6). Data from the accelerometers were downloaded using ActiLife version 5 (Actigraph) and screened for wear time using methods reported by Choi, Liu, Matthews, & Buchowski (2011). Non-wear time was recognised by any continuous zero count[10] that lasted ≥ 90 minutes. Five cut points were selected: sedentary 0 – 99 counts, light PA 100 – 2689 counts, MPA 2690 – 6166 counts, VPA 6167 – 9642 counts, and very vigorous PA ≥ 9643 counts (Sasaki et al., 2011). MVPA was calculated as the sum of MPA, VPA, and very vigorous PA. HEPA was calculated as the sum of MVPA bouts ≥ 10 minutes.

[10] *Counts* are a result of summing post-filtered accelerometer values (raw data at 30Hz) into epoch "chunks". The value of the counts will vary based on the frequency and intensity of the raw acceleration. (Retrieved from: https://theactigraph.com/actilife/)

4.3.6. Data analysis

4.3.6.1. Statistical analysis

Accelerometer data were collected and analysed using ActiLife version 5 (Actigraph). Statistical analyses were conducted using the Statistical Package for the Social Sciences for Windows (IBM SPSS Statistics version 25). Statistical significance was accepted at the $p < .05$ level. The repeated-measures ANOVA test in SPSS was used to determine changes in measured variables over the three time points (baseline, post-intervention, and follow-up). Where Mauchly's assumption of sphericity was not met, the Greenhouse-Geisser correction was used. The Bonferroni adjustment was used in post-hoc tests to compare changes in measures across time points. Additionally, effect sizes were calculated as follows: partial omega squared (ω^2_p) was calculated for the overall effect size and Hedge's *g* was calculated to assess differences between each time point pairing, as it is seen as less sensitive to small sample sizes than Cohen's *d* (Hedges & Olkin, 2014) and has been recommended for use with sample sizes < 20 (Ellis, 2010). According to established guidelines, a Hedge's $g = .2$ was considered a small effect, .5 was considered a medium effect, and .8 was considered a large effect (Hedges & Olkin, 2014). For ω^2_p, .01 was considered a small effect, .06 was considered a medium effect, and .14 was considered a large effect (Cohen, 1988; Miles & Shevlin, 2001). For statistically significant results, 95% CIs are also reported.

4.3.6.2. Thematic analysis

Focus group data were transcribed verbatim and then organised using the NVivo-12 electronic software (QSR International Pty Ltd). The transcripts were

analysed using TA, which is a method for identifying, analysing, and reporting patterns or themes within data (Braun & Clarke, 2006). Other commonly used qualitative analysis methods in psychology that also seek to identify themes in data include interpretative phenomenological analysis, which is used to understand people's everyday experience in great detail, in order to gain an understanding of some phenomenon and grounded theory, which aims to generate theory about a phenomenon from the gathered data (McLeod, 2011). TA was chosen as it may be more appropriate in evaluation research, particularly when the intent is to understand the underlying themes and relationships that explain impacts associated with a programme (Massey, 2011). TA has therefore commonly been used as a tool to evaluate various health and lifestyle interventions (see, for example, Gibson, Umeh, Newson, & Davies, 2018) and is a flexible approach that can provide a rich and detailed account of the data (Braun & Clarke, 2006). Moreover, it is often seen as a useful qualitative approach for more applied research that has implications on policy and practice (Braun & Clarke, 2014).

TA was conducted in line with recommended guidelines for enhancing quality in qualitative research (Braun & Clarke, 2006, 2013) and recommendations by Smith & McGannon (2018) were considered for ensuring rigor in the collection and analysis of qualitative data. Initially the focus groups were transcribed, checked against the audio tapes for accuracy, and then read and re-read in order to note down initial ideas about the data. Following this, codes were generated by systematically working through the data, collating data relevant to each code. The codes were then organised into initial themes by JS (see Figures 4F.1 and 4F.2 in appendix 4F). A consultation process of triangulation was accomplished via a

discussion with other members of the research team (PL and PW), who had independently read the transcripts prior to the meeting, to identify any incongruences and discuss alternative ways to organise and present the data. The authors critically questioned the analysis by consulting the original data to offer alternative interpretations of the texts. Following this discussion, the themes were reviewed and a second iteration was made where codes were reorganised into condensed themes that were more representative of the data. This iteration of the analysis process considered internal homogeneity (i.e., coherence between data within a theme) and external heterogeneity (i.e., clear and identifiable distinctions between themes; Braun & Clarke, 2006; Patton, 1990). Theme definitions were refined in line with the specific codes in each theme. Another meeting was held to check for agreement in theme coding and representation of the data and this process continued until an acceptable consensus had been reached by the group (for an example of this procedure, see Ridgers et al., 2012).

The approach employed in this study focused on examining the experiences of participants and how their experiences related to outcomes of the intervention. Utterances were coded within the context of the surrounding discussion, taking into account participant agreements, disagreements, and prompts and probes from the researcher (Kidd & Parshall, 2000). Direct quotations are offered throughout the results section to ensure that the reader can judge the interpretations being offered (Kvale & Brinkmann, 2009), as well as to acknowledge the possibility that other interpretations could be made from the same data (Sparkes & Smith, 2009).

The current study applied a primarily inductive approach, where the focus group was semi-structured and the analytical process aimed to identify themes

based on the gathered data. However, in recognition of the inherent biases present in the scientific background of the researchers, as well as knowledge and outcome expectations gained through previous research (Smith, 2010), there was a deductive element to the analysis as well. Specifically, the two main research questions guided the discussion and analysis (see section 4.3.3.4). Within each research question, the themes and subthemes were coded using an inductive approach that demands that themes are data-driven, rather than theory-driven (Patton, 1990). This opened the possibility for multiple themes to be identified and extracted that were not pre-determined. Although attempts were made to be open towards the data in terms of what themes were extracted, it must be acknowledged that the interpretation of the data will nonetheless be influenced by the researcher's prior knowledge and biases (Krane, Andersen, & Strean, 1997) and other plausible and defendable interpretations of the data can exist (Smith & McGannon, 2018).

4.4. Results

4.4.1. Sample characteristics

Of the initial 112 individuals who were screened for eligibility, 94 were excluded, as they did not meet one or more of the exclusion criteria, leaving 18 participants who were invited to take part in the taster session. Five participants dropped out before the MfPA course started and 13 participants completed the baseline measures. Two participants dropped out after one session, leaving a sample of N = 11 participants who completed post-intervention measures. One

participant dropped out before the follow-up period for personal reasons, leaving a sample of N = 10 who completed assessments at all three time points. Finally, two participants opted out of taking part in the focus groups, so two focus groups were conducted with four participants in each group. The baseline sample (N = 13) consisted primarily of participants who were white, female, educated, and in either employment or full-time education. On average, participants did not meet the recommended national guidelines of ≥ 150 minutes of PA weekly and had a greater engagement in lower intensity PA (e.g., MPA and walking) than in VPA or HEPA. The full participant characteristics are detailed in Table 4.3.

Table 4.3. Participant characteristics of study three baseline sample.

Variable	Range	Mean (SD)	Percent (n)
Gender			
Male			30.8% (4)
Female			69.2% (9)
Ethnicity			
White			76.9% (10)
Black			0.0% (0)
Asian			7.7% (1)
Mixed			7.7% (1)
Other			7.7% (1)
Age	22 – 60	35.00 (3.37)	
Education			
Secondary/high school			7.7% (1)
University			53.8% (7)
PhD/professional or higher			38.5% (5)
Marital status			
Single			53.8% (7)
Married			46.2% (6)
Employment			
Full-time			38.5% (5)
Part-time			15.4% (2)
Unemployed			7.7% (1)
Student			38.5% (5)
Objectively measured PA minutes/day[a]			
MVPA	18 – 70	50.39 (16.23)	
HEPA	0 – 14	8.63 (5.63)	
Steps/day	1492 – 9041	5035.17 (2096.39)	
Self-reported PA minutes/week[b]			
Total PA	10 – 240	91.36 (86.08)	
VPA	0 – 30	5.45 (12.14)	
MPA	0 – 180	41.82 (65.39)	
Walking	10 – 120	44.09 (35.41)	
Self-reported PA MET-minutes/week[b]			
Total PA	198 – 4026	1097.64 (328.01)	
VPA	0 – 720	87.27 (66.89)	
MPA	0 – 2400	356.36 (216.65)	
Walking	198 – 1485	654.00 (154.77)	

Note. N = 13. HEPA, health-enhancing physical activity; MET, the metabolic equivalent of a task; MPA, moderate intensity physical activity; MVPA, moderate to vigorous intensity physical activity; PA, physical activity; VPA, vigorous intensity physical activity. [a] Objectively measured PA based on n = 10, [b] self-reported PA based on n = 11.

4.4.2. Data checks

The data were tested for normality by examining skewness and kurtosis (≥ ± 2.58), boxplots, and conducting the Shapiro-Wilk test in SPSS. Normality tests indicated normal distributions and no significant outliers, although the Shapiro-Wilk test was significant for non-normality for the amotivation subscale of the BREQ-3 at

follow-up only, potentially due to the presence of a platykurtic distribution. The accelerometer data indicated one significant outlier that unduly influenced the data across all three PA outcomes. This individual's accelerometer data was therefore removed from further analysis.

4.4.3. Quantitative data

4.4.3.1. Change over time

A series of one-way, repeated-measures ANOVAs across three time points were conducted to assess change in PA and psychological measures following the MfPA intervention. There was no significant change in self-reported or objectively measured PA following the intervention (see Table 4.4). An exploration of means ± standard deviations (SD) of PA suggested that self-reported PA almost doubled from pre- to post-intervention, showing a medium to large effect size, but this change was not reflected in objectively measured accelerometer data.

Table 4.4. Self-reported and objectively measured physical activity (M, SD) and ANOVA summary values from pre- to post-intervention and follow-up.

	Pre		Post		Follow-up				
Variable	M	SD	M	SD	M	SD	*F* (2,18)	*p*	ω^2_p
Self-reported PA MET-minutes/week:									
Walking	654.00	513.32	1479.60	1880.93	1852.95	2856.40	2.30	.129	.110
MPA	356.36	718.54	440.00	839.76	168.00	246.43	.04	.960	-.101
VPA	87.27	221.86	112.73	324.38	72.00	152.96	.07	.934	-.097
Total PA	1097.64	1087.88	2032.33	1949.68	2092.95	2812.56	2.43	.117	.120
Objectively measured PA minutes/day[a]:									
MVPA	48.37	15.82	44.38	12.24	37.31	10.96	2.29	.134	.119
HEPA	8.00	5.58	5.99	7.00	6.29	5.80	.428	.659	-.064
Steps	4868.70	2152.32	4526.95	1528.06	3799.05	1068.81	1.28	.305	.029

Note. [a] df = 2, 16. HEPA, health-enhancing physical activity; MPA, moderate intensity physical activity; MVPA, moderate to vigorous intensity physical activity; PA, physical activity; VPA, vigorous intensity physical activity.

There was a significant increase in PA acceptance and autonomous exercise motivation following the intervention, but no significance change in DM or self-control (see Table 4.5). Moreover, no significant changes were observed in the DM subscales. However, changes in PA acceptance, autonomous exercise motivation, and DM all showed large effect sizes. Post-hoc tests revealed an increase in PA acceptance showing medium to large effect sizes from pre- to post-intervention (p = .045, g = .585, 95% CI: .109, 1.881) and from pre-intervention to follow-up (p = .010, g = .875, 95% CI: .365, 2.303), but no change from post-intervention to follow-up (p = .284, g = .357, 95% CI: -.215, 1.589). Autonomous exercise motivation increased with small to medium effect sizes from pre- to post-intervention (p = .014, g = .367, 95% CI: .344, 2.173) and from pre-intervention to follow-up (p = .026, g = .477, 95% CI: .247, 2.151), but no change was observed from post-intervention to follow-up (p = .278, g = .131, 95% CI: -.038, 1.798).

Further exploration of the individual BREQ-3 subscales demonstrated that the intrinsic motivation and amotivation subscales differed significantly between time points. There was no significant change in integrated, identified, introjected, or external motivation following the intervention. Post-hoc tests revealed that intrinsic motivation increased from pre- to post-intervention (p = .025, g = -.474, 95% CI: .316, 2.138) and from pre-intervention to follow-up (p = .020, g = -.876, 95% CI: .628, 2.655), but no change was observed from post-intervention to follow-up (p = .153, g = -.209, 95% CI: .036, 1.888). Moreover, amotivation decreased from pre- to post-intervention (p = .032, g = .343, 95% CI: -2.122, -.303), but no significant change was observed from pre-intervention to follow-up (p = .998, g = .214, 95% CI:

-1.186, .577) or from post-intervention to follow-up (p = .124, g = -.299, 95% CI: .060, 1.917).

Table 4.5. Psychological measures (M, SD) and ANOVA summary values from pre- to post-intervention and follow-up.

	Pre		Post		Follow-up				
Measure	M	SD	M	SD	M	SD	F (2,18)	p	ω^2_p
FFMQ-sf	42.90	6.26	46.80	6.27	47.20	5.94	2.81	.086	.147
PAAQ	26.90	8.67	32.20	7.91	35.80	9.75	10.05	.001	.463
BSCS	37.30	8.76	37.90	7.99	37.00	9.20	.33	.726	-.069
RAI	.90	7.09	3.68	6.72	5.10	8.30	10.10[a]	.006	.464
Amotivation	.98	.82	.58	.51	.80	.66	4.49	.026	.249
External	1.45	1.17	1.43	1.17	1.23	1.32	1.03	.377	.003
Introjected	2.43	1.02	2.18	.96	2.15	.94	1.37	.279	.034
Identified	2.23	.78	2.45	.84	2.48	.85	1.61	.228	.055
Integrated	1.33	.77	1.25	.65	1.63	1.16	1.98	.168	.085
Intrinsic	1.43	.68	1.83	.80	2.13	.33	10.29	.001	.469

Note. BSCS, Brief Self-Control Scale; FFMQ, Five Facet Mindfulness Questionnaire; PAAQ, Physical Activity Acceptance Questionnaire; RAI, Relative Autonomy Index. [a] Greenhouse-Geisser correction used, df = 1.277, 11.493.

4.4.3.2. Participant feedback

Overall, participants reported having a positive experience of the MfPA programme. In terms of how important the course was for them on a scale of 1 (not important at all) to 10 (very important), all participants rated it as ≥ 7, with the majority of participants (n = 7) rating the importance of the course ≥ 9. Moreover, most participants felt that they have gained something of lasting value from taking part in the course, with only one participant selecting “not sure” and the rest of the participants (n = 10) selecting “yes”. In terms of the individual aspects of the course, participants rated components on a scale from 1 (no use) to 10 (very useful). On average, most aspects of the course scored ≥ 7, apart from mindful movement (6.1 ± 3.0).

4.4.3.3. Attendance and home practice

Attendance of the MfPA programme ranged from four to six sessions (5.55 ± .69 sessions). Out of the 11 participants that completed the programme, 63.6% (n = 7) attended all sessions, 27.3% (n = 3) attended five out of six sessions, and one participant attended four out of six sessions. Participants engaged in home practice from two to 32 days over the duration of the course and averaged three days/week of home practice (3.05 ± 1.94 days/week).

4.4.4. Qualitative data

Each focus group contained four participants, with one female and three males in the first group (age M = 27.75, SD = 5.90) and three females and one male in the second group (age M = 38.25, SD = 13.05). Thematic maps for each research question summarising the main themes and subthemes are presented in Figures 4.1 and 4.2. Moreover, illustrative verbatim quotes are provided in Tables 4.6 and 4.7 and throughout the narrative, followed by participant identifiers for participant number (e.g., *P1*) and group (i.e., *G1* or *G2*). Several themes were identified through the analytical process. With regard to participants' experience of the programme, two main themes are presented: 1) positives of the MfPA programme and 2) suggestions for improvement. In terms of participants' perceived impact of the MfPA programme on their relationship with PA, three main themes are presented: 1) outcomes of the programme, 2) barriers to PA participation, and 3) facilitators to PA participation. Each theme further contains several subthemes that are discussed in detail below.

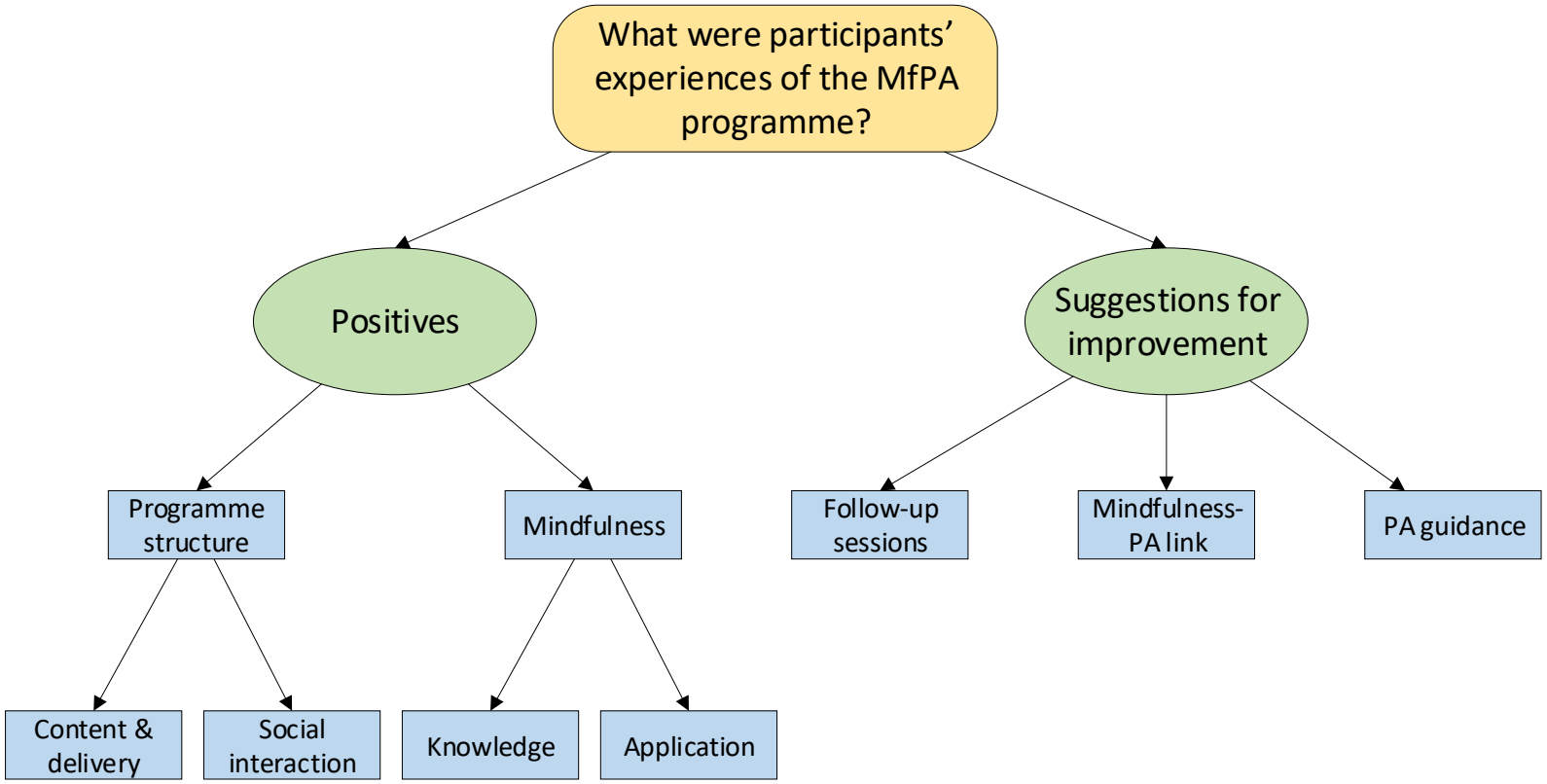

Figure 4.1. Thematic map of participants' experiences of the Mindfulness for Physical Activity (MfPA) programme.
Note. The overarching research question is depicted at the top, the themes are presented as ellipses, and the subthemes are presented as rectangles.

Table 4.6. Participants' experiences of the Mindfulness for Physical Activity (MfPA) programme – themes and subthemes with example quotes.

Research question	Themes	Subthemes		Example quotes
What were participants' experiences of the MfPA programme?	Positives of the programme	Programme structure	Content and delivery	*"I liked the demos that [PL] did to make it interactive in different ways… that was a really good part of the course." (P6, G2)*
			Social interaction	*"The fact that it's not a one man show as well also helps, you know, you've got a group approach to it. If it was, it would be a much more difficult journey." (P4, G1)*
		Mindfulness	Knowledge	*"…having done some mindfulness beforehand, but never gone into the theory at all, in nowhere near as much depth as we did on this course, I think that was nourishing in a way. Like not just experiencing it, but also understanding it…the theory and what goes on with how we think and judgements and where feelings come from and, and that kind of thing, I really enjoyed that aspect." (P6, G2)*
			Application	*"…mindfulness in general has been good in some way on just how I interact with people on day to day basis…I've become more mindful of… what I'm saying, what I'm doing…it's only a very subtle change, but you notice." (P1, G1)*
	Suggestions for improvement	Follow-up sessions		*"I was really looking forward if there's like additional course, a follow-up course. Another four weeks, six weeks, eight weeks… like follow-up courses, rather than just stop it." (P5, G2)*
		Link between mindfulness and PA		*"I [was] actually expecting more the link [between mindfulness and physical activity], or like to boost me to do more PA, before I started the course." (P5, G2)*
		PA guidance		*"It sounds silly, but when [PL] says pick an activity or just focus on something, because no one's telling me what it is, I've gotta then go away and think of something and cause I'm lazy, I won't think of something, you know what I mean…and having a moment to think of something that I want to focus on is harder." (P7, G2)*

Note. MfPA, Mindfulness for Physical Activity course; PA, physical activity. Participants are anonymised by participant *(P)* and group number *(G).*

4.4.4.1. Participants' experience of the programme

Positives of the programme

Overall, all participants enjoyed the programme and believed that they had gained various benefits from engaging in the programme. Subthemes included programme structure (*content and delivery* and *social interaction*) and mindfulness (*knowledge* and *application*). Participants liked the course content and delivery and referred to it as *"spot on"* and *"well-paced"*, suggesting that their *"overall experience has been positive"*. Similarly, social interaction was a positive aspect of the course and participants felt the *"group was very good"* and that *"everyone took part"* and were *"very friendly"*. The majority of participants intended to continue practicing mindfulness beyond the course.

> *"[The course] has definitely given me a kind of interest in meditation…I feel like I got a big interest in the whole subject of mindfulness, so…even if it's just given me an interest in my life, it's positive. But yeah, I do plan on continuing [practicing mindfulness]." (P1, G1)*

In terms of mindfulness, all participants felt that they *"learned a lot of things"* about mindfulness as a result of taking part in the course and *"could understand mindfulness better"* than before, by learning about the theory, techniques, and terminologies of mindfulness. Additionally, several participants found that practicing and experiencing meditation and mindfulness was crucial to the learning process.

> *"Well, the fact that I was able to actually practice meditation was a bonus, I mean, you hear and read a lot about meditative practice being done in the likes of India and things like that. You hear how they have different, like, techniques, but then when you do it yourself, there's a totally different take on it…and I think it's important to actually practice [mindfulness] and not believe what everybody says about it." (P4, G1)*

All participants also found that the course helped them be more mindful in their daily lives and to apply mindfulness practices to different areas of their lives, such as everyday activities, work, studying in the library, cooking, eating, dealing with external situations, and in interactions with other people.

<u>Suggestions for improvement</u>

When asked about what they did not like about the course, participants provided several suggestions for improvement. Subthemes included the need for follow-up sessions, a stronger link between mindfulness and PA taught within the programme, and guidance on what type of PA to do. Firstly, participants mentioned that they *"would like to see more"* of these types of programmes in the future and would have liked additional or follow-up courses lasting *"longer than 6 weeks"*. This was also reflected in that several participants found it harder to maintain both the mindfulness practice and PA after the course had finished, suggesting a potential need for follow-up sessions or a course of longer duration.

> *"I [have] done maybe two or three times mindfulness since we finished doing it as a group, cause I just find it really hard to keep doing it…" (P8, G2)*

Secondly, several participants also suggested that the link between mindfulness and PA could have been made *"stronger"* or *"more explicit"* within the MfPA programme. However, some attributed the "*disconnect*" between mindfulness and PA to themselves, rather than to the course content or delivery.

> *"I guess coming into [the course] from the outside, I thought there might've been a bit more emphasis towards the physical activity, but it was kind of more of a tangent of linking it back to physical activity, and I think it was probably more my own disconnect there, rather than a failing of the group." (P7, G2)*

Moreover, one participant noted the potential limitations of increasing the focus on PA, as this would *"[take] away from…the general introduction to mindfulness"* and that it is *"a fine line"* to balance between PA and general mindfulness that can be applied *"in any situation"*.

In terms of lack of guidance, a few of the participants suggested that they would have benefitted from some *"instruction each week"*, in terms of what activities they could do, so they would not have to think about which activity to select. However, some participants noted that there is a *"delicate balance"* in having prescribed activity, as this could take *"the freedom of choice away from someone"*, *"put too much pressure on people"*, and potentially demotivate individuals who are *"not keeping up with the [exercise] tasks"*.

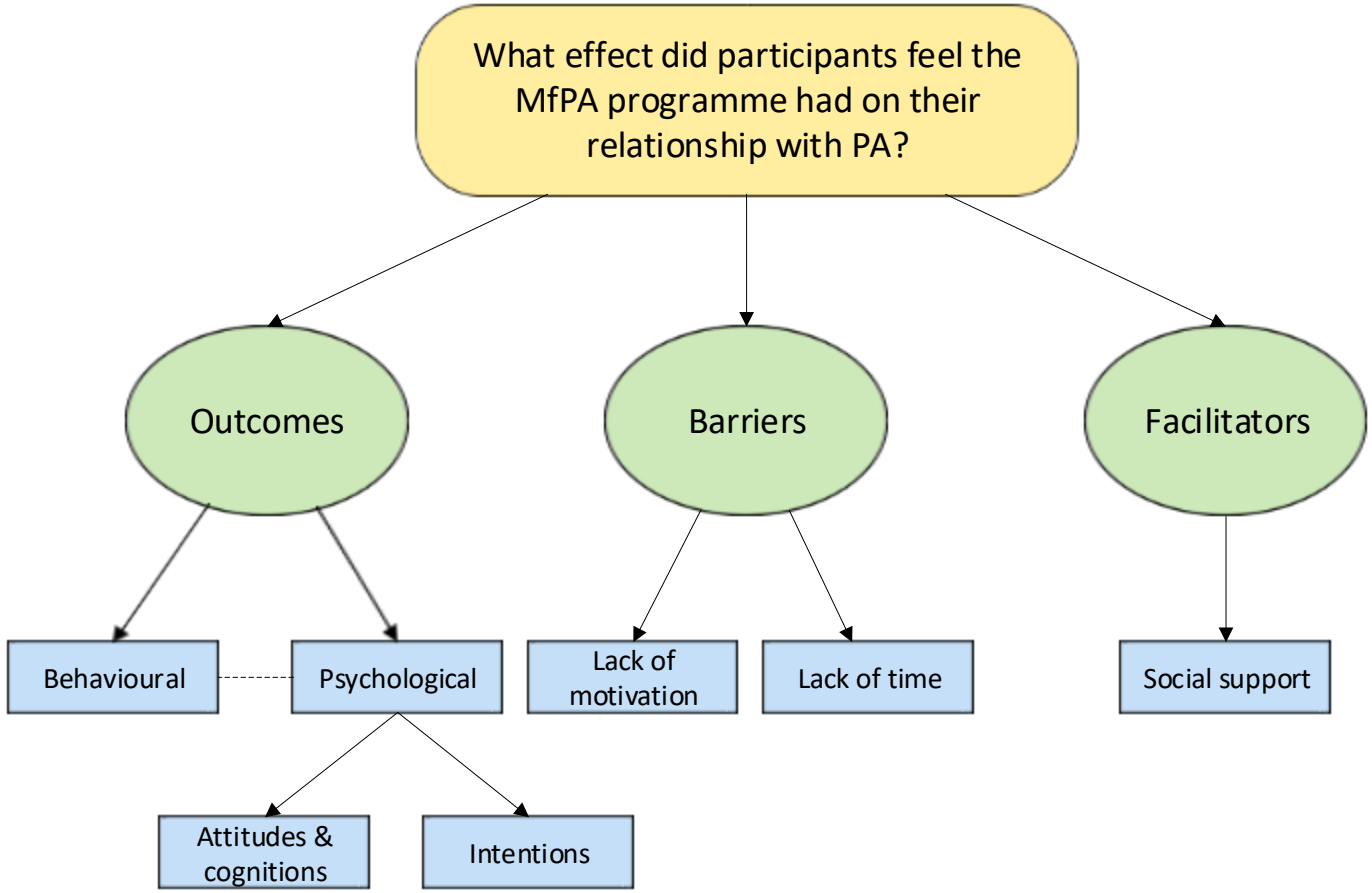

Figure 4.2. Thematic map of participants' perceived relationship with physical activity (PA) following the Mindfulness for Physical Activity (MfPA) programme. *Note*. The overarching research question is depicted at the top, the themes are presented as ellipses, and the subthemes are presented as rectangles. The dashed line signifies a perceived link between psychological and behavioural physical activity outcomes.

Table 4.7. Participants' perceived relationship with physical activity (PA) after the Mindfulness for Physical Activity (MfPA) programme – themes and subthemes with example quotes.

Research question	Themes	Subthemes		Example quotes
What effect did participants feel the MfPA programme had on their relationship with PA?	Outcomes of the programme	Behavioural		*"The other morning was one of the times again, pre-exercise, rather than being in bed nice and warm and feeling off, something came to me thinking what you're feeling now is just a thought and the whole thoughts as mental events came to the front and I thought oh yeah, I'll get up and do [exercise] and went up and did, previously I would've stayed there, especially when it's cold and wet outside." (P7, G2)*
		Psychological	Attitudes and cognitions	*"I'm not dreading [physical activity] as much as I would've been before the course…I'm trying to think of the positive outcomes, rather than the dread, and, you know, and the uncomfortableness, I am trying to think of in the long run how it's beneficial. So that's how I would say it's changed, the relationship with exercise." (P2, G1)*
			Intentions	*"I feel like I've got clearer thoughts about PA and I'm looking forward to getting back into doing something…even though it hasn't increased, it's definitely made me more keen to start doing something and quite soon…" (P1, G1)*
	Barriers of PA	Lack of motivation		*"The motivation is what is lacking. I mean I can complete everything, pain and everything, it's fine for me, I actually enjoy the pain and I enjoy the pain after the workout, but the moments before are the toughest ones for me." (P3, G1)*
		Lack of time and competing demands		*"Cause like, I like doing some certain types of physical activities, but because of you know, lifestyle and everything happening at the same time, you're very busy, so you leave certain things on the side." (P8, G2)*
	Facilitators of PA	Social support		*"…my boyfriend goes climbing so he makes me come with him, which helps." (P6, G2)*

Note. MfPA, Mindfulness for Physical Activity course; PA, physical activity. Participants are anonymised by participant *(P)* and group number *(G).*

4.4.4.2. Relationship with physical activity

Outcomes of the programme

Several participants suggested that the course had some beneficial effects on their PA. Subthemes included behavioural and psychological (*attitudes and cognitions* and *intentions*) PA outcomes. In terms of changes in PA behaviour as a result of the MfPA course, there was some contrast in participants' perceptions regarding whether their PA had improved or not. While several participants indicated that their PA had not changed as a result of the programme, some of them discussed specific examples where they chose to *"instead of taking the lift, [take] the stairs"* or *"[made] an effort to walk every day, even when the weather [was] not that great"*.

Additionally, most participants reported that the course has had some influence on their attitudes and cognitions related to PA. Specifically, participants reported feeling *"more positive about [PA]"* and *"not dreading [PA] as much as [they] would've been before the course"*. Moreover, participants reported different reasons and motivations for exercising following the course, such as *"the desire to do it…rather than pressure [to exercise]"* and *"to enjoy the process of…becoming fitter"*, suggesting that the course may have enhanced participants' autonomous exercise motivation.

> *"Having done bouldering a few months ago, I noticed that maybe I used to push myself too hard and then just completely kill and knacker myself and then just stop going back. But this time I've been more careful, maybe, and I've been taking it easier, cause maybe I'm more aware of…getting tired or pushing myself too hard…" (P6, G2)*

Some participants also described applying mindfulness during their own PA.

> *"Having the appreciation of carrying out that activity…noticing body movements, and signs, feelings…and accepting things as they are, even though some of those might be negative, perspiration, effort…but just having an appreciation of being actively involved in practicing mindfulness and physical activity." (P4, G1)*

Moreover, several participants discussed their intentions to become more active in the near future as a result of the programme, as it had enabled them to *"[think] about they activity [they] could do"* and increased their *"awareness of the need to be more physically active"*.

> *"But I do think that [my physical activity] will improve over time, cause…I've learnt a lot from the course and the [mindful] movement, I think I'm kind of looking forward to applying that to physical activity in the new year." (P2, G1)*

Thus, although several participants were not sure whether the course had helped them increase their PA, some acknowledged that the course had shifted their thinking about PA and helped them start planning to be more active.

> *"So apart from just subtle changes in overall experience of day to day things, as far as physical activity, I don't think it's necessarily increased my levels, but it's made me start thinking a lot more about physical activity and kind of trying to plan out in the future what I'm gonna do, instead of just feeling under constant pressure that I'm not doing this and I'm not doing that." (P1, G1)*

<u>Barriers of physical activity</u>

Participants cited several barriers to PA participation and subthemes included lack of motivation and lack of time. Several participants discussed their

lack of motivation to engage in PA outside and after the course and suggested that they never *"felt too much pressure"* to engage in activity as part of the MfPA home practice. Moreover, as the course took place shortly before Christmas, most participants quoted other commitments, busyness, and the time of the year as potential barriers to their PA.

Facilitators of physical activity

There was less discussion of PA facilitators, with participants believing that the MfPA course gave them the *"key"* to do more activity, but that the rest was up to them. However, the subtheme social support was identified, as some participants felt it was an important facilitator in their own activity.

4.5. Discussion

The present study aimed to investigate the efficacy, feasibility, and acceptability of a novel MBI targeted at changing the relationship with PA in underactive participants. The findings present preliminary support for the MfPA programme. The MfPA intervention had a positive impact on PA acceptance and autonomous exercise motivation, but no effect on PA, self-control, or DM. Qualitative data suggested that participants believed that the course helped them shift how they relate to PA, such that they felt more positive about PA and were focusing more on the enjoyment of being active, rather than on the pressure to be physically active. The present study was a pilot study and the small sample size allowed for a more in-depth analysis of the data to be conducted, which included

both quantitative and qualitative analysis. The mixed-method design of this study enabled a more thorough evaluation of the developed intervention with regard to specific mechanisms and potential changes to the programme prior to future evaluation.

The effect size estimates show a large effect for change in PA acceptance and autonomous exercise motivation, indicating that participants were more tolerant of PA-related discomfort and more likely to be autonomously motivated to engage in PA following the intervention. This finding was further reflected in the focus group data that suggested that participants were thinking more positively about PA, were more intrinsically motivated to be active, and were more present during activity, which allowed them to appreciate and accept thoughts and sensations that occurred, even when they were negative or unpleasant. These findings build on previous cross-sectional (Ruffault et al., 2016a) and longitudinal evidence (Kang et al., 2017) that found a positive correlation between DM and autonomous exercise motivation. Similarly, mindfulness during exercise (i.e., state mindfulness) was previously found to increase internal reasons for exercising (Cox, Ullrich-French, Cole, & D'Hondt-Taylor, 2016). The present study therefore extended findings related to exercise motivation to include the effect of mindfulness practice. Moreover, the results provide support for a positive effect of mindfulness practice on PA acceptance.

Although effect size estimates indicated a large effect for an increase in DM following the intervention, this change did not reach statistical significance, suggesting that the sample was not large enough to draw definitive conclusions about this measure. Moreover, qualitative analysis of focus group data suggested

that participants felt they had learned a lot about mindfulness from taking part in the MfPA programme and have been able to apply it to a wide range of contexts in their daily lives. As such, it is likely that DM benefitted to some extent following the intervention. However, it must be noted that the discrepancy between mindfulness practice and changes in DM is well documented in the mindfulness literature (see chapter one, section 1.1.3).

Although self-reported PA almost doubled following the intervention, this change did not reach statistical significance and objectively measured PA did not reflect this finding. This was further highlighted in the focus groups, as participants did not believe that their PA had improved following the programme. Participants suggested several barriers (e.g., lack of time and competing demands) that may have negatively influenced their PA. Notably, however, participants discussed specific examples where they had engaged in PA during the programme, such as actively making the choice to take the stairs instead of taking the lift or getting up to do PA by acknowledging that thoughts are not facts. This suggests that participants may have become more aware of opportunities to be active, even though overall frequency of PA has not increased. The distinctive feature of the MfPA programme was on shifting participants' relationship with PA, rather than on changing PA behaviour. As such, the intervention may have helped prepare individuals for PA behaviour change in the near future. Indeed, several participants discussed plans to be more active and applying concepts taught during the programme to their own PA.

However, without an active control group, it is not possible to determine which elements of the programme (e.g., group discussion, home practice, mindful

movement) elicited change in PA acceptance and autonomous exercise motivation. Analysis of qualitative data suggests that both theoretical and practical aspects of the course may have been important in learning about mindfulness and applying mindfulness to daily and physical activities. Therefore, a combination of programme elements may have resulted in increases in PA acceptance and autonomous exercise motivation. Further, it remains unclear whether increases in PA acceptance and autonomous exercise motivation will lead to increased PA behaviour in the future. The present study employed a relatively short follow-up period (i.e., four weeks), which limits inferences one can make about long-term outcomes.

Confirming findings of the present study, previous research has indicated that adding mindfulness-based approaches to existing PA interventions may strengthen their effectiveness (Moffitt & Mohr, 2015; Palmeira et al., 2017; Younge et al., 2015). However, the active component(s) of MBIs have yet to be established (Dorjee, 2016; Gotink et al., 2015; Malinowski & Shalamanova, 2017). It is plausible that mindfulness practice may shift the way individuals relate to their PA experience. As outlined earlier (see chapter one, section 1.2.5), mindfulness practice helps cultivate an open, non-judging, and non-reactive mind (Kabat-Zinn, 2004), which may help individuals respond more effectively to difficulties in initiating or attempting to maintain a new exercise programme (Gilbert & Waltz, 2010). A state of mindfulness can also enable individuals to acknowledge their thoughts and emotions without over-identifying with them or responding to them in a habitual way (Bishop et al., 2004). This was evident from the focus group data, where a participant discussed recognising thoughts as external events and got up to do PA despite feeling unmotivated to go out when it was cold and wet outside. The

notable effect sizes in the current study suggest that the MfPA programme can modify probable correlates of PA (i.e., PA acceptance and autonomous exercise motivation) and psychologically prepare individuals embarking on PA behaviour change. However, research employing RCTs is still required to establish the active ingredient(s) of the MfPA programme for PA outcomes, compared to an active control condition.

4.5.1. Limitations

There are several limitations of the present study that need to be considered, including the lack of an appropriate control group, the possible presence of self-selection bias, and the inherent problems of using self-report measures to assesses psychological constructs. Although measuring PA objectively was a strength of this study, this method is also not without limitations. For example, accelerometers do not capture water-based activities, cycling, or upper body movement. However, studies employing multiple accelerometers to measure different types of activity only report marginal improvements in explanatory power and therefore do not warrant the increased subject burden of wearing multiple devices (Trost et al., 2005). The use of the IPAQ-sf in the current study potentially allowed for activities such as swimming to be represented. Additionally, although participants could not see activity output, wearing the accelerometer could in itself provide an incentive to be more active.

Moreover, the small sample size limits conclusions that can be drawn as a result of the study findings. Similarly, a more conservative effect size estimate (e.g., medium) could have been required to find significant results for several of the

measures. A G*Power calculation with a medium effect size (Cohen's $f \geq .25$) would require a sample of 28 participants to detect significant changes for a single-group comparison across three time points. Although the pilot nature of the study and the restriction on the number of participants that can take part in a taught mindfulness group at a time justified the sample size used, future research should consider effect size estimates found in this study and the potential need for larger samples. For a RCT design conducting a repeated-measures ANOVA with two groups and within-between interactions measured at three time points, using an $\alpha = .05$ and power = .80, a G*Power calculation for the projected sample size needed to detect medium ($f \geq .25$) and large ($f \geq .4$) effect sizes yielded 28 and 12 participants, respectively.

Finally, although some studies have shown no differences in the effectiveness of standard versus shorter MBIs (Demarzo et al., 2017), more research is required regarding whether the shorter duration of the MfPA programme compared to standard MBSR programmes could have limited its effectiveness. This may be particularly important as both mindfulness and PA components are taught, which may require longer time and more sessions to grasp. Similarly, there was large variation in how much home practice participants engaged in, which may be related to intervention effectiveness. However, larger sample sizes are needed to evaluate the dose-response relationship between mindfulness home practice and PA outcomes.

4.5.2. Future directions

Future research should therefore employ a RCT study design to evaluate the MfPA programme against an appropriate control group to establish its effects on PA behaviour and psychological outcomes. Several recommendations on modifying the MfPA programme based on findings from qualitative and quantitative data, prior to evaluation in a future RCT, are discussed in the final chapter of this thesis (see chapter five, section 5.2.3). Additionally, the MfPA programme should be investigated as a precursor to established PA interventions or as an add-on approach that may prepare individuals by targeting psychological mechanisms of PA behaviour change. Longer follow-up periods are needed to establish whether the change in PA acceptance and autonomous exercise motivation leads to increased PA behaviour in the long term.

4.6. Conclusions

Overall, qualitative and quantitative findings from the present study suggest the feasibility of the developed MfPA programme and its efficacy in enhancing PA acceptance and autonomous exercise motivation. Despite the small sample size and lack of control group, the positive outcomes suggest that mindfulness can be employed to prepare individuals for PA behaviour change and may be an effective add-on approach to existing PA interventions. This study therefore provided proof of principle as a basis to design a RCT to rigorously assess the effectiveness of the MfPA programme on PA.

Chapter Five – Synthesis and Discussion of Findings

The aim of this PhD was to investigate the role of DM and mindfulness practice in PA. Two central research questions were addressed throughout: 1) what is the effect of mindfulness on PA outcomes? and 2) what is the relationship between mindfulness and psychological factors related to PA? Through answering these questions, this thesis considered the potential of mindfulness as a tool in interventions targeting PA promotion. The key findings are summarised in Table 5.1 at the end of this paragraph. This PhD followed the MRC guidelines for developing and evaluating complex interventions (Craig et al., 2008), starting with a systematic review of the literature and concluding with a pilot trial of a novel MBI targeted at enhancing PA motivation, acceptance, and behaviour. The following chapter synthesises and discusses the findings of this PhD and contains four main parts. Firstly, it provides a summary of the key findings and original contribution to knowledge of this PhD (section 5.1). Secondly, it discusses the findings of this PhD in relation to existing literature (section 5.2). Thirdly, it provides a reflection of the research process and gives suggestions for future research (section 5.3). Finally, it concludes this thesis (section 5.4).

Table 5.1. Key findings for PhD research questions.

What is the effect of mindfulness on PA outcomes?
• There is no direct relationship between mindfulness and PA. • DM has an indirect effect on PA through psychological mechanisms, such as autonomous exercise motivation and PA acceptance. • MBIs are more effective at improving PA if they include an active component and target psychological correlates of PA.
What is the relationship between mindfulness and psychological factors related to PA?
• DM is positively related to autonomous exercise motivation and PA acceptance. • MBIs can be targeted to enhance psychological correlates of PA behaviour change.

Note. DM, dispositional mindfulness; MBI, mindfulness-based intervention; PA, physical activity.

5.1. Key findings and original contribution to knowledge

Study one (chapter two) described the first comprehensive systematic review on mindfulness and PA literature, published up until 1 June 2018 (Schneider et al., 2018). The purpose of the systematic review was to investigate three main objectives: 1) the relationship between DM and PA, 2) psychological factors that potentially explain the relationship between DM and PA, and 3) the effect of mindfulness practice on PA outcomes. Findings showed that DM was positively correlated with psychological factors related to PA and MBIs evidenced positive between-subjects effects on PA, but varied in duration, session length, group size, delivery, content, and follow-up. MBIs were more likely to be successful if they were PA-specific and targeted psychological factors related to PA, such as PA acceptance and autonomous exercise motivation.

Study two (chapter three) investigated the relationship between DM and self-reported PA outcomes following a short-term prospective cohort study. Results showed that DM predicted self-reported PA by enhancing autonomous exercise motivation and PA acceptance and that the relationship between DM and PA acceptance was fully mediated by autonomous exercise motivation. A LGC model of PA change over time confirmed findings from analysis of cross-sectional data at baseline, but found no effect on PA change.

Study three (chapter four) integrated knowledge gained from studies one and two to design and pilot the MfPA programme for underactive participants. Results showed that PA acceptance and autonomous exercise motivation increased following the MfPA programme, but no change was observed in self-control, DM, or

PA behaviour. Qualitative data gained from focus groups suggested that the MfPA intervention helped shift participants' relationship with PA, such that they felt more positive about PA and were focusing more on the enjoyment of PA, rather than on the pressure to be physically active. Focus group data also provided support for the feasibility and acceptability of the MfPA programme with minor modifications (see section 5.2.3).

This PhD extended existing knowledge regarding the role of mindfulness in PA in several important aspects. Firstly, the systematic review presented in chapter two was the first published comprehensive review that investigated mindfulness in relation to PA specifically, as well as by distinguishing between DM and mindfulness practice. The novel contribution of this study was threefold: 1) it showed that mindfulness was positively associated with psychological factors related to PA, such as autonomous exercise motivation and satisfaction with the experience of PA, 2) it showed that MBIs were more successful at promoting PA when they were PA-specific and targeted psychological factors related to PA behaviour change, and 3) it identified potential psychological mechanisms of the mindfulness-PA relationship for investigation in future research.

Secondly, this PhD considered potential mechanisms of action involved in the mindfulness-PA relationship, which is a growing area of interest that has often been overlooked in previous mindfulness research. Although previous studies have considered some potential mechanisms of action, such as stress (Roberts & Danoff-Burg, 2010), psychological flexibility (Sagui-Henson et al., 2018), negative affect and shame (Kang et al., 2017), satisfaction with PA, and state mindfulness (Tsafou et al., 2016a; Tsafou et al., 2016b), they have all employed cross-sectional study designs

and only one study investigated the relationship between variables using a modelling approach (Sagui-Henson et al., 2018). Therefore, study two was original in that it investigated mechanisms of action using a modelling approach following a prospective cohort study. Findings from study two showed that autonomous exercise motivation and PA acceptance sequentially mediated the DM-PA relationship. Additionally, although previous studies have investigated the relationship between acceptance and PA outcomes (Kangasniemi et al., 2014; Ruffault et al., 2017; Ulmer et al., 2010), few studies have considered PA acceptance specifically (Butryn et al., 2011; Fletcher, 2012; Goodwin et al., 2012) and none assessed the relationship between DM and PA acceptance. The current research therefore filled a gap by showing that DM is positively correlated with PA acceptance, which in turn predicts PA (study two, chapter three).

Finally, study three (chapter four) was original in that it took a systematic approach to develop a MBI specifically aimed at changing participants' relationship with PA, by considering evidence gained through previous research, MRC guidance, and participant feedback and involvement. The final "product" of this thesis is therefore a novel MBI for PA (the MfPA programme), to be investigated in a future larger-scale RCT. Study three showed the effectiveness of the MfPA programme on PA acceptance and autonomous exercise motivation in a sample of underactive participants and employed a mixed-methods study design to demonstrate the feasibility and acceptability of a short-term MBI for promoting PA. Outcomes of study three also included the production of the MfPA course materials to be investigated in future evaluation and implementation trials.

5.2. The potential of mindfulness in lifestyle interventions

5.2.1. Psychological mechanisms through which mindfulness influences physical activity

Findings from the studies presented in this thesis show that DM is positively correlated with several psychological factors related to sustained PA, specifically autonomous exercise motivation, PA acceptance, and self-control. Additionally, these factors mediate the relationship between DM and PA. This finding is in line with previous research that shows that individuals who self-report higher levels of DM are more likely to be intrinsically motivated to engage in PA and enjoy the experience of PA (Chatzisarantis & Hagger, 2007; Grinnell et al., 2011; Ruffault et al., 2016a; Tsafou et al., 2016a). Moreover, these individuals are more likely to accept and tolerate negative or unpleasant sensations that can occur during exercise (e.g., pain or fatigue) and persist with a PA programme despite external events and challenges. Above and beyond DM, mindfulness practice can enhance psychological factors, such as PA acceptance and autonomous exercise motivation, in underactive individuals (see study three, chapter four). By engaging in mindfulness practice before and during PA, participants were more likely to enjoy being active, focus on the positive thoughts and sensations that occurred during PA, and feel satisfied with the experience of PA.

Although it is unlikely that higher levels of DM or mindfulness practice inherently make an individual more active, it is possible that improvements in psychological factors related to sustained PA may lead to long-term PA behaviour change. Previous research has shown the potential of mindfulness as an add-on or

stand-alone approach in health and lifestyle interventions targeting increased PA, both through DM (Gao & Shi, 2015; Gilbert & Waltz, 2010; Loucks et al., 2015; Roberts & Danoff-Burg, 2010; Slonim et al., 2015) and mindfulness practice (Carlson et al., 2004; Cox et al., 2018; Goodwin et al., 2012; Ivanova et al., 2015; Moffitt & Mohr, 2015; Palmeira et al., 2017; Salmoirago-Blotcher et al., 2018; Tapper et al., 2009). The evidence implies that individuals who practice mindfulness or who report higher levels of DM are more likely to persist with PA, by acknowledging urges to skip exercise sessions and accepting negative thoughts surrounding exercise as mental events, rather than facts. They may also be more aware of these urges and other challenges as they occur, while still continuing to engage in behaviours (e.g., PA) that are in line with their long-term goals and values.

Building on findings from the systematic review presented in this thesis (see study one, chapter two), a novel systematic review on mindfulness and PA was recently published (Yang & Conroy, 2019). This review confirmed evidence regarding the relationship between trait (i.e., dispositional) mindfulness and PA and expanded findings to include an investigation of the role of state mindfulness for PA promotion. The results showed a large gap in the current literature on state mindfulness and PA. State mindfulness, although a separate construct, is likely to be related to both DM and PA, as it refers to a transient state of mindful awareness during a particular task or at a certain time (see chapter one, section 1.1.3.1). Moreover, state mindfulness represents a potentially modifiable target for behavioural interventions aimed at improving PA experiences and maintenance. As such, Yang & Conroy (2019) suggest a three-level hierarchical mindfulness framework, which differentiates between three levels of mindfulness: 1) situational

(i.e., the level of mindfulness that individuals experience during a specific activity at a specific moment), 2) contextual (i.e., individuals' typical level of mindfulness within a specific context), and 3) global (i.e., individuals' general disposition towards mindfulness across varied contexts and moments of daily life). The three-level mindfulness framework therefore expands on the previous two-level differentiation between trait and state mindfulness (Medvedev et al., 2017) and is a promising avenue for future research. Particularly, it opens up new research avenues that investigate the role of all three levels of mindfulness within a PA context. Indeed, it could be hypothesised that situational and contextual levels of mindfulness have a different and potentially more direct impact on PA than global (i.e., dispositional) mindfulness.

However, evidence from this PhD and existing literature shows that it is not currently clear to what extent changes in psychological factors related to PA reflect changes in actual PA behaviour. Evidence from a recent systematic review and meta-analysis highlighted that interventions aimed at reducing sedentary behaviour and increasing PA are more likely to be effective if they include an active exercise component (Zabatiero et al., 2018). This was similarly found in study one (chapter two) of this PhD, which showed that MBIs were more likely to be successful if they were PA-specific and contained active components. As such, mindfulness may be better applied as an add-on approach to PA-based interventions, which target PA more explicitly, while teaching elements of mindfulness, to prepare individuals for sustained behaviour change (Davis, 2008; Gotink et al., 2017; Moffitt & Mohr, 2015; Palmeira et al., 2017; Younge et al., 2015). Mindfulness programmes are relatively

inexpensive to implement and to run (Strowger et al., 2018) and can be delivered flexibly across location, time, and even through online delivery systems.

5.2.2. Mindfulness programmes for novice exercisers

The additional benefits of mindfulness practice alongside established lifestyle interventions lies in its potential to induce a shift in attitude and perspective. This may be especially important for novice exercisers who find exercise difficult or are self-critical with regard to their exercise ability. For example, individuals with overweight and obesity often report discomfort while exercising (Egan et al., 2013; Leone & Ward, 2013; Piana et al., 2013; Thomas et al., 2008; Wiklund et al., 2011), feeling too overweight (Atlantis et al., 2008; Ball et al., 2000; Napolitano et al., 2011), feeling embarrassed or insecure (Ball et al., 2000), lacking motivation (Egan et al., 2013; Napolitano et al., 2011; Peacock et al., 2014; Piana et al., 2013), and feeling less positive about PA (Deforche et al., 2006; Napolitano et al., 2011; Peacock et al., 2014; Piana et al., 2013) and are therefore more likely to quit exercise programmes shortly after initiation. Mindfulness may enhance positive affect and enjoyment of exercise, which have been associated with exercise maintenance in several populations (Pasco et al., 2011; Schneider, Dunn, & Cooper, 2009; Wankel, 1993). This was also found in study three (chapter four) of this PhD, where participants reported feeling more positive about PA and were focusing on the enjoyment of PA, rather than on the negative thoughts and sensations or the external pressures to be physically active.

Moreover, MBIs that include elements of self-compassion and kindness meditation (as taught in the sixth week of the MfPA programme) can help foster a

non-critical self-awareness and positive affect (Hofmann et al., 2011), which may be particularly important for individuals experiencing self-criticism or negative rumination about PA. Recent studies have found that self-compassion predicts autonomous exercise motivation in women exercisers (Cox, Ullrich-French, Tylka, & McMahon, 2019; Magnus, Kowalski, & McHugh, 2010) and that a stance of self-compassion, kindness, acceptance, and mindfulness can enhance health-promoting behaviours, including PA (Homan & Sirois, 2017; Sirois, 2015; Sirois, Kitner, & Hirsch, 2015). As such, mindfulness approaches may be particularly beneficial for individuals experiencing additional or unique barriers to being active.

5.2.3. Modifications to the MfPA programme

Following completion of study three, analysis of qualitative and quantitative data identified several potential areas for improvement of the MfPA programme. Through focus groups, participants indicated that they would have liked for the link between mindfulness and PA to be more explicit and for PA to be taught as a separate and distinct component of the programme, e.g., through organised activities or a short exercise session after the main content of each week. Consideration regarding the balance between the mindfulness and the PA components should be taken into account in future iterations of the programme content and structure, to ensure that no core mindfulness teachings are lost.

Additionally, although participants enjoyed the autonomous nature of selecting what activities to do, some found it hard to think of activities on their own. This may be especially common in participants who are underactive or new to exercise. Previous research has found that in novice exercisers, the SDT concepts of

competence and relatedness (see chapter one, section 1.2.4.2) are important during the early stages of commencing a new PA programme (Kinnafick, Thøgersen-Ntoumani, & Duda, 2014). Notably, satisfaction of the needs for competence and relatedness appear important for PA at the adoption stages, while autonomy is particularly pertinent in facilitating PA adherence. Therefore, in addition to the webpage links and weekly examples already provided in the participant workbooks, an additional page was added at the end of the workbook with examples and images of exercises and activities that participants could try, ranging from no equipment (e.g., taking the stairs) to gym-based exercise classes (e.g., spin). This will provide participants with some "guided choice", which supports participants' autonomy to choose what type of PA they want to do and recognises individuals' different levels and abilities (i.e., competence), while still giving some directions for activities.

A second concern that was raised was the relatively low engagement with the workbooks outside of class. Participants found it difficult to remember to complete the workbook each week and some expressed a preference for having the workbook in an electronic format. Therefore, provision of the workbook in alternative formats (i.e., hard copy and electronic versions) and sending SMS text reminders to participants may increase engagement with the workbook and home practice. This is in line with previous research that found that reminders (e.g., in the form of text messages) can enhance exercise implementation intention effects (Prestwich, Perugini, & Hurling, 2009) and encourage behaviour change in a variety of health domains (Armstrong et al., 2009; Free et al., 2011; Hurling, Fairley, & Dias, 2006; Kinnafick, Thøgersen-Ntoumani, & Duda, 2016; Rodgers et al., 2005).

Similarly, some participants found that due to the limited storage of their email inbox, it was difficult to receive and download the guided meditation audio recordings over email. There is therefore potential to upload the audio recordings to a private YouTube channel or other media account, which participants can then access via a link, or provide the recordings via a CD or USB disk that participants can receive and keep as part of the course.

Finally, a common theme that was identified from the focus group data was the need for follow-up sessions after the course. Due to the relatively short nature of the MfPA programme, some participants felt that they would benefit from continued meetings, even if they were conducted on a less frequent basis. Long-term follow-up is arguably an important component of interventions targeting enduring behaviour change and may help create a habit to engage in exercise (Lally, Van Jaarsveld, Potts, & Wardle, 2010). Notably, there is currently a lack of secular mindfulness follow-on courses or mindfulness drop-in sessions in Liverpool, where this research took place.

In line with the Western approach to treatment, much research on health behaviours focuses on quick solutions, perhaps explaining the integration of mindfulness in shorter courses, single-session interventions, or unguided self-administered approaches. Although one benefit of MBIs is that they are able to be self-administered, findings from the focus group data suggest that participants would benefit from continued support after the intervention. There is therefore potential to create such drop-in groups so that participants who finish a mindfulness programme are not left on their own after just six or eight weeks.

An alternative consideration, however, is the potential of MBIs to be integrated in national healthcare systems (NHSs) worldwide, which often require effective, short, and low-cost interventions to enhance accessibility and uptake (Demarzo et al., 2017). MBIs for PA (e.g., the MfPA programme) might be offered by NHSs if cost-effective programmes adjusted for different target populations can be achieved (Demarzo, Cebolla, & Garcia-Campayo, 2015). Similarly, the mindfulness teacher is an important aspect of how a mindfulness course is experienced (van Aalderen, Breukers, Reuzel, & Speckens, 2014), which was confirmed in the focus groups after the MfPA programme. As such, if the MfPA programme were to be integrated within the NHS, it should be ensured that practitioners who deliver the programme are both trained in, and embody, mindfulness (Crane, Kuyken, Hastings, Rothwell, & Williams, 2010). More research is required regarding the optimal length of MBIs and their potential for self-help learning (Cavanagh, Strauss, Forder, & Jones, 2014). This is particularly important when MBIs are taught within different contexts and include ancillary components to mindfulness (e.g., PA). However, it is likely that short-duration MBIs with provision of follow-up sessions (e.g., monthly) may achieve a balance between cost-effectiveness and intervention benefits.

5.3. Reflection on research process

5.3.1. Strengths

In addition to the novel aspects of this thesis outlined above (see section 5.1), several unique strengths are highlighted below. Specific strengths and

limitations associated with each study are discussed in the relevant chapters. The following sections therefore outline general strengths and limitations of the programme of research as a whole.

The main strength of this research programme was the multiple approaches employed to investigate the role of mindfulness in PA. The advantage of using multiple approaches is that a deeper understanding of a phenomenon can be gained, due to the richness of the data produced. By conducting a systematic review, a prospective cohort study, and a mixed-methods intervention study, both statistical and clinical significance, as well as personal insight into mechanisms of action and behavioural outcomes, could be assessed. Quantitative data, including the application of SEM and LGCM as rigorous methods of analysis, provided insight into potential mechanisms in the relationship between mindfulness and self-reported and objectively measured PA. Qualitative data provided narrative and approached the outcomes from a participant-centred perspective, allowing for a greater understanding of the potential processes targeted by the MfPA programme and perceived outcomes and benefits gained. Qualitative research offers rich insights into the perspectives of individuals in ways that are different from, but complimentary to, quantitative research (Braun & Clarke, 2014). Intervention studies often do not gather qualitative data in the evaluation process or publish the qualitative data separately from the quantitative data. Including both quantitative and qualitative outcomes in the evaluation of the feasibility and preliminary efficacy of the MfPA programme allowed for a more complete picture of outcomes and processes to be gained through formative and process evaluation. Additionally,

methods and findings from each study informed subsequent studies to ensure rigorous hypotheses-driven research.

A further strength of the research presented in this thesis lies in the development of a novel MBI for PA. Along with the challenges of PA and lifestyle interventions outlined in chapter one (see section 1.2.5), current PA research tends to show a gap between efficacy (i.e., the effect of an intervention for a target audience applied in a controlled setting) and effectiveness (i.e., the effect of an intervention for the general population applied in a real-world setting) of PA interventions (Beedie et al., 2016). The challenge of translating evidence to practice is well-documented in public health literature (Boaz, Baeza, & Fraser, 2011) and research is urgently required to identify how to better bridge the gap between efficacy and effectiveness (Glasgow, Lichtenstein, & Marcus, 2003). There appears to be a need for multi-stakeholder development of interventions that reflect the needs of end users (Donaldson & Finch, 2012) and that have the potential to improve implementation and effectiveness of interventions aimed at enhancing long-term PA behaviour change (Harden, Johnson, Almeida, & Estabrooks, 2017). A shift towards translational research is required that brings together evidence, policy, and practice (Watson, Dugdill, Murphy, Knowles, & Cable, 2012). Moreover, there is a call for translational research of behavioural interventions that are well-defined and standardised (Glasgow et al., 2003), so that they can be replicated in future studies. MBI developers should consequently base the development in a clearly articulated aim and intention regarding the benefit and relevance of the program for a particular context and/or population (Dobkin et al., 2014; Teasdale, Segal, & Williams, 2003). It was therefore important, and a strength of this PhD, to

involve potential service-users themselves to test the feasibility and acceptability of the MfPA programme. As such, the strengths of the novel MfPA programme emerge from including participants in the evaluation process and the production of standardised course instructor notes and participant workbooks that can be used in future studies evaluating the effectiveness of the programme.

Finally, the research programme considered mechanisms of action in the mindfulness-PA relationship and contributed to knowledge regarding the relationship between mindfulness and psychological factors related to PA, such as autonomous exercise motivation and PA acceptance. Furthermore, the series of studies presented within this thesis are the first to consider psychological factors related to PA as potential mediators using a modelling approach. Little was previously known about the effect of DM and mindfulness practice on psychological factors related to PA, particularly in terms of PA acceptance. This PhD therefore extended previous knowledge by directly exploring PA acceptance as a target variable with the potential to enhance PA behaviour change.

5.3.2. Limitations

Despite the numerous strengths of the current research programme outlined above, some notable limitations should be considered. Firstly, due to stringent exclusion criteria and the generally homogenous population across studies (i.e., white, healthy females), findings cannot as of yet be extrapolated to other populations, settings, or individuals with various needs and health concerns. It is not currently known to what extent MBIs are effective for individuals of different backgrounds. Additionally, even though the MfPA programme was

specifically targeted to PA, considerations should include individuals that may benefit the most from lifestyle interventions (e.g., individuals with overweight or obesity), but who may not be open or available to take part in a face-to-face group-based programme. Similarly, a notable limitation is the small sample size in the pilot study of the MfPA programme, which could have reduced the statistical power of the research and thus limit the conclusions that can be drawn. However, clinical significance of beneficial changes in outcomes measures, along with medium to large effect sizes of changes in key outcome measures, indicate that the MfPA programme has the potential to enhance PA outcomes in underactive participants.

Secondly, the majority of measures included in the studies that form this PhD rely on self-report of constructs, such as self-control and DM. Although widely used in psychological and health research, self-report questionnaires suffer from the Hawthorne effect, the overconfidence effect, social desirability bias, and cognitive dissonance (Grossman, 2008; Grossman & Van Dam, 2011) and are often not representative of actual behaviour (Baumeister et al., 2007a). However, both self-reported and objectively measured PA data were used to evaluate the preliminary efficacy of the MfPA programme. Moreover, all questionnaires used throughout this PhD have been validated in previous research and showed sound psychometric properties in the current programme of research.

In terms of mindfulness specifically, there are several limitations of the FFMQ, which was used to assess DM for the purposes of this PhD, such as inconsistent factor structure (Baer et al., 2006; Baer et al., 2008), difficulties in replicating and fitting proposed factor structures in large representative samples (Bohlmeijer et al., 2011; Morgan, Dalrymple, Multach, & Zimmerman, 2017),

reports of item response differences between meditators and non-mediators (Baer, Samuel, & Lykins, 2011; de Bruin et al., 2012a; Van Dam et al., 2009), and potential concerns about method effects and/or response bias (Baer et al., 2011; Van Dam, Hobkirk, Danoff-Burg, & Earleywine, 2012), as well as the lack of association between the FFMQ and actual meditation practice (Manuel et al., 2017) and the lack of discriminant validity in FFMQ scores following MBSR compared to a control condition (Goldberg et al., 2016). Although there are criticisms in the literature regarding the assessment of mindfulness using self-report measures, novel questionnaires are being developed that may overcome some of the limitations of previous measures (see, for example, Van Dam et al., 2018a). Additionally, there may still be value in assessing DM, as long as it is considered unique and separate from mindfulness practice, as DM itself has been linked to a variety of positive health outcomes. Therefore, the present research considered both DM and mindfulness practice and distinguished between them as separate constructs (Van Dam et al., 2018a).

Thirdly, the MBI field is still at an early stage of development (Crane et al., 2016), with the majority of studies involving intervention development and efficacy trials (Dimidjian & Segal, 2015). Few studies currently consider real-world implementation and effectiveness. Considering that study three (chapter four) found that some benefits in key outcomes were not maintained at follow-up and that most participants suggested a need for continued sessions, the findings of the current programme of research are limited to short-term benefits and further research is required to assess how effective mindfulness is for enhancing PA in the long term and in a real-world setting, specifically whether benefits gained in PA

acceptance and autonomous exercise motivation actually lead to future PA behaviour change.

Finally, as the MfPA programme is still in the early stages of evaluation, it shares a limitation with other MBIs in that it is a multi-component intervention (i.e., education, group discussion, meditation, home practice, etc.) with no control group, making it difficult to establish the active ingredient(s) of this intervention. Although this was a feasibility study and the purpose was not to determine effectiveness (Craig et al., 2008), the lack of a control group limits the conclusions that can be drawn about the effect of specific components of the MfPA programme on PA outcomes. There is a possibility that any benefits seen in PA outcomes is a result of group discussions about PA, rather than mindfulness meditation specifically.

5.3.3. Suggestions for future research

The following section outlines suggestions for future research with regard to the MfPA programme and more generally in relation to research on mindfulness and PA.

5.3.3.1. Evaluating efficacy of mindfulness-based interventions

As outlined previously, a common criticism of MBIs is the difficulty in establishing the active ingredient(s) of programmes (Dorjee, 2016; Gotink et al., 2015; Malinowski & Shalamanova, 2017). It is not known whether benefits in target outcomes (e.g., PA) are a result of mindfulness per se, or rather a combination of group discussion, PA education, and therapy effects. Moreover, it is currently not

clear whether changes in mindfulness skills (e.g., awareness, acceptance, non-judging) are unique outcomes of mindfulness practice or are a result of the cumulative effect of other aspects of mindfulness-based approaches, such as the development of kindness and self-compassion, group therapy effects, acceptance practices, etc. (Dorjee, 2016). Delving deeper, mindfulness itself in its original state, as discussed in the *Abhidhamma*, arises alongside six other "enlightenment factors", such as equanimity, tranquillity, and joy. Moreover, it is nested within a wider framework of constructs on the path towards enlightenment and therefore can be seen as an integrated, rather than as a stand-alone practice by nature. As such, benefits in target outcomes following MBIs could result from the development of self-compassion or feelings of relatedness due to group therapy effects. To identify the active ingredient(s) of MBIs and working mechanisms, two approaches have been suggested (Malinowski, 2017). Firstly, MBIs can be compared to active control interventions that match all other components of the MBI, but without mindfulness meditation (Williams et al., 2014), so that the added value of MMT can be established. Recently, attempts have been made to develop active treatment comparison programmes that control for non-mindfulness treatment factors, such as group support, home practice exercises, relaxation, and placebo expectancies (Creswell, 2017). Such programmes provide the opportunity for establishing the effects of mindfulness above and beyond other intervention components on a variety of health outcomes. Secondly, studies can investigate a single component of MBIs at a time (e.g., mindful breath awareness meditation; Moore, Gruber, Derose, & Malinowski, 2012; Pozuelos, Mead, Rueda, & Malinowski, 2019), in comparison to an active condition matched for intensity and

duration (e.g., muscle relaxation technique; Malinowski, Moore, Mead, & Gruber, 2017; Schöne et al., 2018). Alternatively, studies can investigate specific mindfulness-based strategies (e.g., decentering versus acceptance) to discover which strategies are most effective for health and PA outcomes (Jenkins & Tapper, 2014; Tapper & Ahmed, 2018).

5.3.3.2. Evaluating effectiveness of mindfulness-based interventions

A more recent recommendation has been to assess more realistic outcome measures of MBIs within an appropriate time frame (Rosenkranz, Dunne, & Davidson, 2019). For a variety of pragmatic and financial reasons, most studies employ relatively short assessment and follow-up periods, which may not reflect the potential longer-term effects of MBIs. Nonetheless, it is plausible that short-term changes in cognitive processes and mechanisms may lead to changes in desired behavioural outcomes in the future. Additionally, change resulting from meditation practice may not be linear and the trajectory of change can vary widely between individuals (Rosenkranz et al., 2019). It should also be noted that most real-world settings by nature are uncontrolled environments. It is plausible that multi-component interventions work beyond the sum of their parts. Therefore, real-world effectiveness studies are required with process analyses to learn more about what works, how components interact, and what could be improved. Equally, a more complete evaluation of outcomes following complex and multi-component MBIs should be investigated. These outcomes could focus on the overall enhancement in an individual's well-being after undergoing mindfulness practice (Grossman et al., 2004) and should necessarily consider possible negative outcomes

of taking part in a MBI and/or MMT (Cebolla, Demarzo, Martins, Soler, & Garcia-Campayo, 2017; Lindahl, Fisher, Cooper, Rosen, & Britton, 2017; Lustyk, Chawla, Nolan, & Marlatt, 2009).

5.3.3.3. Investigating different types and intensities of physical activity

In line with overall enhancements in health and well-being, future MBIs targeting PA should consider alternative forms of PA that are often overlooked in lifestyle interventions. For example, aerobic exercise is often recommended as an approach to weight loss and maintenance (Haskell et al., 2007; Ohkawara et al., 2007), but some preliminary support suggests that it may be negatively associated with mindfulness and positively associated with disordered eating, compared to other types of PA, such as yoga (Martin et al., 2013; see study one, chapter two). Additionally, researchers have proposed that there may be scope for more holistic approaches (i.e., yoga) in lifestyle interventions targeting health benefits and risk reduction (Byatt, 2004; Ross & Thomas, 2010). Several studies have also found that non-clinical mind-body practices such as yoga (Brisbon & Lowery, 2011; Cox & McMahon, 2019), Pilates (Caldwell et al., 2010), and Tai Chi (Caldwell et al., 2011) may foster DM, which in turn may lead to increased psychological well-being and perceived health (Bränström, Duncan, & Moskowitz, 2011; Carmody & Baer, 2008; Murphy et al., 2012). Therefore, future MBIs should consider additional benefits beyond simply the frequency of PA. It would be of interest to investigate the role of mindfulness for different types and intensities of PA, through an investigation of psychological factors related to PA as mechanisms of action (see study two, chapter three), as these may vary in importance among PA intensities (e.g., exercise

motivation may be more important for moderate or vigorous intensity PA than for walking or light intensity PA). Moreover, longitudinal and controlled trials are required to further investigate the directionality of the mindfulness-PA relationship.

5.3.3.4. Next steps for the MfPA programme

In line with guidance from the MRC and the Standard Evaluation Framework for PA interventions (Cavill, Roberts, & Rutter, 2012), as well as considerations discussed above, the MfPA programme should undergo an iteration according to the areas for improvement outlined previously (see chapter four, section 4.5 and chapter five, section 5.2.3) prior to being tested in a large-scale RCT. Specifically, the MfPA intervention needs to be evaluated against a matched-control study, where specific components (i.e., meditation) are eliminated to find which components actually contribute to the desired outcomes. A logic model was produced as part of the final stages of this PhD to show the phases of evaluation for the MfPA programme (see Figure 5.1). Immediate (increased PA acceptance and autonomous exercise motivation) and short/mid-term outcomes (PA behaviour change) should be assessed before and after the intervention, as well as at three, six, and 12 months. Longer-term outcomes should include information on regular engagement in PA and maintenance of mindfulness practice and should be assessed at six and 12 months. Monteiro et al. (2015) suggest that contemporary MBIs would benefit from a more comprehensive and holistic application of mindfulness that goes beyond symptomatic relief. It is therefore important to investigate long-term outcomes of practice using a holistic approach that considers both behaviour change outcomes and psychological outcomes.

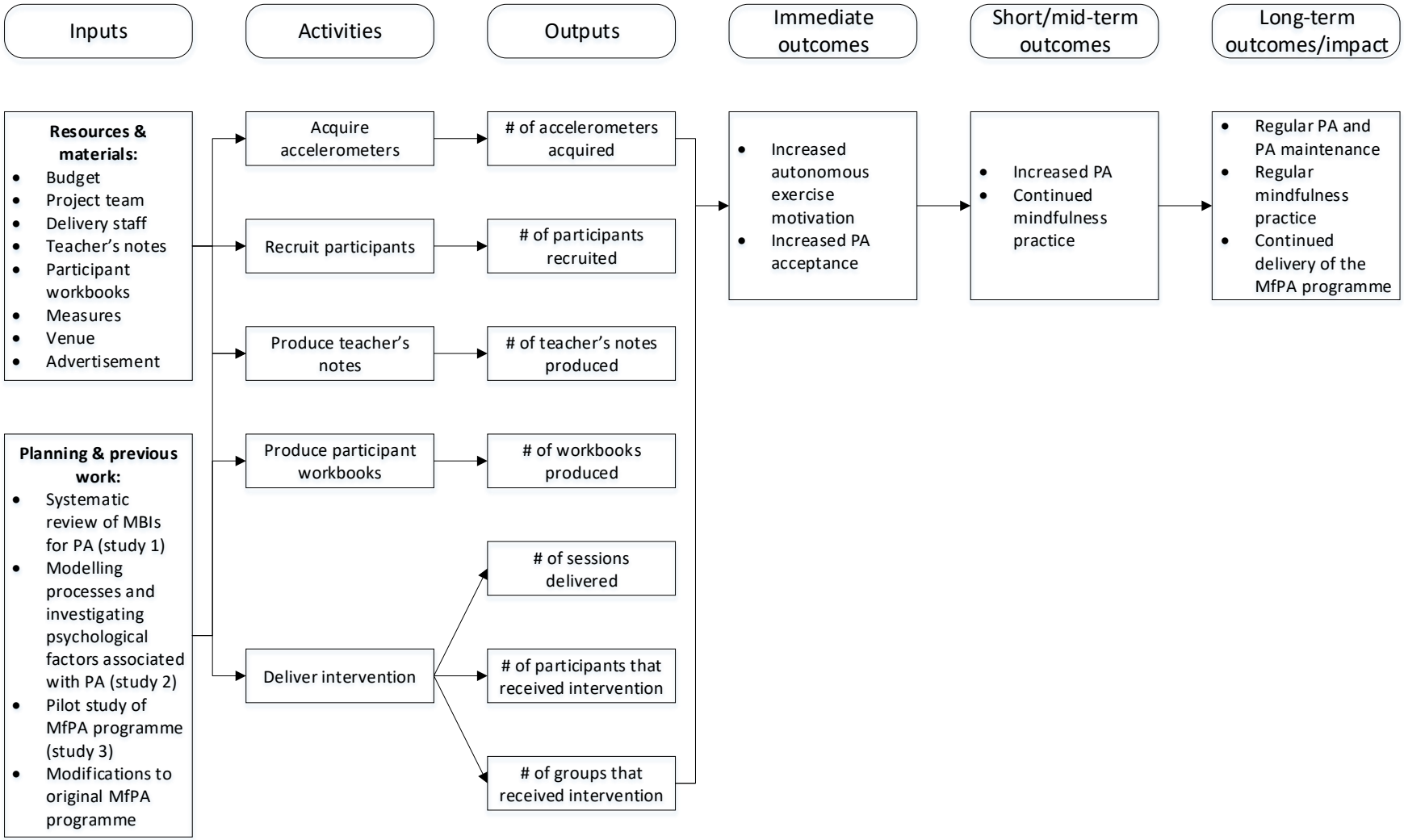

Figure 5.1. Logic model showing phases of evaluation for the Mindfulness for Physical Activity (MfPA) programme.
Note. MBI, mindfulness-based intervention; MfPA, Mindfulness for Physical Activity intervention; PA, physical activity.

5.3.3.5. Beyond this PhD

Beyond the field of PA and lifestyle behaviours, it is essential to deconstruct the exaggerated claims made about mindfulness in research and elsewhere (Grossman, 2019). While mindfulness can indeed be effectively employed in a wide variety of situations, researchers should be careful when making claims about what it can and cannot do (Van Dam et al., 2018b). Additionally, it has been suggested that clinical significance and overall positive outcomes may be more important than statistical significance and putative changes on self-report measures of DM (Quaglia et al., 2016). Thus, future research should ensure that mindfulness programmes are led by established teachers with substantial personal practice and experience in teaching mindfulness (Crane et al., 2016) and aim to provide a more complete picture of the positive and negative outcomes associated with the programme, specifically by considering the active ingredient(s) of the programmes, the potential mechanisms of action involved, and the experience of participants.

5.4. Conclusions

Overall, this PhD has contributed to current knowledge on the role of mindfulness in PA by investigating the effect of DM and mindfulness practice on psychological and behavioural PA outcomes. Findings suggest that mindfulness may be a useful add-on approach to lifestyle interventions targeted at increasing PA in the general population. More research is required among clinical populations, but preliminary evidence shows that individuals who perceive themselves to be more mindful or who engage in mindfulness practice are better prepared to embark on

behavioural lifestyle change, engage in behaviours that are good for their physical and mental health, and persist with behaviours in spite of challenges that may occur. Importantly, it must be noted that neither DM nor mindfulness practice inherently make an individual more active. Rather, mindfulness has the potential to prepare individuals for change through its influence on overall cognitions and attitudes. The combined findings of this PhD reveal that mindfulness has a positive relationship with and effect on psychological factors related to sustained PA and may be particularly beneficial for increasing acceptance and tolerance of PA-related discomfort, especially for novice exercisers and inactive individuals. Additionally, mindfulness may positively impact PA behaviour through its influence on autonomous exercise motivation and PA acceptance. Future research is required to evaluate the effectiveness of the MfPA intervention through a RCT, by employing an active matched control group without a mindfulness component. Overall, results are promising for an overall health model that incorporates mindfulness in all aspects of daily life. Mindfulness and MBIs may therefore have a valuable place in lifestyle interventions to help individuals overcome the intention-behaviour barrier and increase PA uptake and maintenance, as well as to enhance overall health and well-being.

References

Aadland, E., & Ylvisåker, E. (2015). Reliability of the Actigraph GT3X+ accelerometer in adults under free-living conditions. *PloS One, 10*(8), e0134606.

Adams, S. A., Der Ananian, C. A., DuBose, K. D., Kirtland, K. A., & Ainsworth, B. E. (2003). Physical activity levels among overweight and obese adults in South Carolina. *Southern Medical Journal, 96*(6), 539-544.

Ainsworth, B. E., Macera, C. A., Jones, D. A., Reis, J. P., Addy, C. L., & Bowles, H. R. (2006). Comparison of the 2001 BRFSS and the IPAQ physical activity questionnaires. *Medicine and Science in Sports and Exercise, 38*(9), 1584-1592.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211.

Allender, S., Foster, C., Scarborough, P., & Rayner, M. (2007). The burden of physical activity-related ill health in the UK. *Journal of Epidemiology and Community Health, 61*(4), 344-348.

Anderson, J. C., & Gerbing, D. W. (1984). The effect of sampling error on convergence, improper solutions, and goodness-of-fit indices for maximum likelihood confirmatory factor analysis. *Psychometrika, 49*(2), 155-173.

Ansell, E. B., Gu, P., Tuit, K., & Sinha, R. (2012). Effects of cumulative stress and impulsivity on smoking status. *Human Psychopharmacology: Clinical and Experimental, 27*(2), 200-208.

Armijo-Olivo, S., Stiles, C. R., Hagen, N. A., Biondo, P. D., & Cummings, G. G. (2012). Assessment of study quality for systematic reviews: A comparison of the Cochrane Collaboration Risk of Bias Tool and the Effective Public Health Practice Project quality assessment tool: Methodological research. *Journal of Evaluation in Clinical Practice, 18*(1), 12-18.

Armstrong, A. W., Watson, A. J., Makredes, M., Frangos, J. E., Kimball, A. B., & Kvedar, J. C. (2009). Text-message reminders to improve sunscreen use: A randomized, controlled trial using electronic monitoring. *JAMA Dermatology, 145*(11), 1230-1236.

Asztalos, M., Wijndaele, K., De Bourdeaudhuij, I., Philippaerts, R., Matton, L., Duvigneaud, N., . . . Cardon, G. (2012). Sport participation and stress among women and men. *Psychology of Sport and Exercise, 13*(4), 466-483.

Atlantis, E., Barnes, E. H., & Ball, K. (2008). Weight status and perception barriers to healthy physical activity and diet behavior. *International Journal of Obesity, 32*(2), 343.

Audiffren, M., & André, N. (2015). The strength model of self-control revisited: Linking acute and chronic effects of exercise on executive functions. *Journal of Sport and Health Science, 4*(1), 30-46.

Baer, R. (2010). *Assessing mindfulness and acceptance processes in clients: Illuminating the theory and practice of change*. Oakland, CA: New Harbinger.

Baer, R. A., Samuel, D. B., & Lykins, E. L. B. (2011). Differential item functioning on the Five Facet Mindfulness Questionnaire is minimal in demographically matched meditators and nonmeditators. *Assessment, 18*(1), 3-10.

Baer, R. A., Smith, G. T., & Allen, K. B. (2004). Assessment of mindfulness by self-report: The Kentucky Inventory of Mindfulness Skills. *Assessment, 11*(3), 191-206.

Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of mindfulness. *Assessment, 13*(1), 27-45.

Baer, R. A., Smith, G. T., Lykins, E., Button, D., Krietemeyer, J., Sauer, S., . . . Williams, J. M. G. (2008). Construct validity of the Five Facet Mindfulness Questionnaire in meditating and nonmeditating samples. *Assessment, 15*(3), 329-342.

Ball, K., Crawford, D., & Owen, N. (2000). Obesity as a barrier to physical activity. *Australian and New Zealand Journal of Public Health, 24*(3), 331-333.

Banting, L. K., Dimmock, J. A., & Grove, J. R. (2011). The impact of automatically activated motivation on exercise-related outcomes. *Journal of Sport & Exercise Psychology, 33*(4), 569-585.

Barbour, R. (2008). *Doing focus groups*. London: Sage.

Barnes, R. T., Coombes, S. A., Armstrong, N. B., Higgins, T. J., & Janelle, C. M. (2010). Evaluating attentional and affective changes following an acute exercise bout using a modified dot-probe protocol. *Journal of Sports Sciences, 28*(10), 1065-1076.

Barnett, J., Nigg, C., De Bourdeaudhuij, I., Maglione, C., & Maddock, J. (2007). The effect of item order on physical activity estimates using the IPAQ. *Californian Journal of Health Promotion, 5*(1), 23-29.

Barratt, E. S., Patton, J., & Stanford, M. (1975). *Barratt Impulsiveness Scale*. University of Texas: Barratt-Psychiatry Medical Branch.

Barrett, B., Torres, E. R., Meyer, J., Barnet, J. H., & Brown, R. (2019). Predictors of mindfulness meditation and exercise practice, from MEPARI-2, a randomized controlled trial. *Mindfulness*, 1-13.

Bartholomew, J. B., Morrison, D., & Ciccolo, J. T. (2005). Effects of acute exercise on mood and well-being in patients with major depressive disorder. *Medicine and Science in Sports and Exercise, 37*(12), 2032-2037.

Basch, C. E. (1987). Focus group interview: An underutilized research technique for improving theory and practice in health education. *Health Education Quarterly, 14*(4), 411-448.

Batchelor, S. (1998). *Buddhism without beliefs: A contemporary guide to awakening*: Penguin.

Bauman, A., Ainsworth, B. E., Bull, F., Craig, C. L., Hagströmer, M., Sallis, J. F., . . . Sjöström, M. (2009). Progress and pitfalls in the use of the International Physical Activity Questionnaire (IPAQ) for adult physical activity surveillance. *Journal of Physical Activity and Health, 6*(s1), S5-S8.

Bauman, A. E., Nelson, D. E., Pratt, M., Matsudo, V., & Schoeppe, S. (2006). Dissemination of physical activity evidence, programs, policies, and surveillance in the international public health arena. *American Journal of Preventive Medicine, 31*(4), 57-65.

Bauman, A. E., Reis, R. S., Sallis, J. F., Wells, J. C., Loos, R. J. F., Martin, B. W., & Group, L. P. A. S. W. (2012). Correlates of physical activity: Why are some people physically active and others not? *The Lancet, 380*(9838), 258-271.

Bauman, A. E., Sallis, J. F., Dzewaltowski, D. A., & Owen, N. (2002). Toward a better understanding of the influences on physical activity: The role of determinants, correlates, causal variables, mediators, moderators, and confounders. *American Journal of Preventive Medicine, 23*(2), 5-14.

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of Personality and Social Psychology, 74*(5), 1252-1265.

Baumeister, R. F., Gailliot, M., DeWall, C. N., & Oaten, M. (2006). Self-regulation and personality: How interventions increase regulatory success, and how depletion moderates the effects of traits on behavior. *Journal of Personality, 74*(6), 1773-1802.

Baumeister, R. F., Vohs, K. D., & Funder, D. C. (2007a). Psychology as the science of self-reports and finger movements: Whatever happened to actual behavior? *Perspectives on Psychological Science, 2*(4), 396-403.

Baumeister, R. F., Vohs, K. D., & Tice, D. M. (2007b). The strength model of self-control. *Current Directions in Psychological Science, 16*(6), 351-355.

Beedie, C., Mann, S., Jimenez, A., Kennedy, L., Lane, A. M., Domone, S., . . . Whyte, G. (2016). Death by effectiveness: Exercise as medicine caught in the efficacy trap! *British Journal of Sports Medicine, 50*, 323-324.

Belzer, F., Schmidt, S., Lucius-Hoene, G., Schneider, J. F., Orellana-Rios, C. L., & Sauer, S. (2013). Challenging the construct validity of mindfulness assessment: A cognitive interview study of the Freiburg Mindfulness Inventory. *Mindfulness, 4*(1), 33-44.

Benjamini, Y. (2010). Discovering the false discovery rate. *Journal of the Royal Statistical Society: series B (statistical methodology), 72*(4), 405-416.

Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin, 88*(3), 588-606.

Bentler, P. M., & Chou, C.-P. (1987). Practical issues in structural modeling. *Sociological Methods & Research, 16*(1), 78-117.

Bergomi, C., Tschacher, W., & Kupper, Z. (2013a). The assessment of mindfulness with self-report measures: Existing scales and open issues. *Mindfulness, 4*(3), 191-202.

Bergomi, C., Tschacher, W., & Kupper, Z. (2013b). Measuring mindfulness: First steps towards the development of a comprehensive mindfulness scale. *Mindfulness, 4*(1), 18-32.

Berman, M. I., Morton, S. N., & Hegel, M. T. (2016). Uncontrolled pilot study of an acceptance and commitment therapy and health at every size intervention for obese, depressed women: Accept yourself! *Psychotherapy, 53*(4), 462-467.

Best, J. R., Nagamatsu, L. S., & Liu-Ambrose, T. (2014). Improvements to executive function during exercise training predict maintenance of physical activity over the following year. *Frontiers in Human Neuroscience, 8*, 353.

Biddle, S. J. H., & Asare, M. (2011). Physical activity and mental health in children and adolescents: A review of reviews. *British Journal of Sports Medicine, 45*, 886-895.

Biddle, S. J. H., & Fuchs, R. (2009). Exercise psychology: A view from Europe. *Psychology of Sport and Exercise, 10*(4), 410-419.

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., . . . Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice, 11*(3), 230-241.

Bize, R., Johnson, J. A., & Plotnikoff, R. C. (2007). Physical activity level and health-related quality of life in the general adult population: A systematic review. *Preventive Medicine, 45*(6), 401-415.

Black, D. S. (2011). A brief definition of mindfulness. *Mindfulness Research Guide.* Retrieved from http://www.mindfulexperience.org

Black, D. S., O'Reilly, G. A., Olmstead, R., Breen, E. C., & Irwin, M. R. (2015). Mindfulness meditation and improvement in sleep quality and daytime impairment among older adults with sleep disturbances: A randomized clinical trial. *JAMA Internal Medicine, 175*(4), 494-501.

Blair, S. N., Kohl, H. W., Barlow, C. E., Paffenbarger, R. S., Gibbons, L. W., & Macera, C. A. (1995). Changes in physical fitness and all-cause mortality: A prospective study of healthy and unhealthy men. *JAMA, 273*(14), 1093-1098.

Bloor, M. (2001). *Focus groups in social research*. London: Sage.

Blue, C. L., & Black, D. R. (2005). Synthesis of intervention research to modify physical activity and dietary behaviors. *Research and Theory for Nursing Practice, 19*(1), 25-62.

Boaz, A., Baeza, J., & Fraser, A. (2011). Effective implementation of research into practice: An overview of systematic reviews of the health literature. *BMC Research Notes, 4*, 212-212.

Bodenlos, J. S., Noonan, M., & Wells, S. Y. (2013). Mindfulness and alcohol problems in college students: The mediating effects of stress. *Journal of American College Health, 61*(6), 371-378.

Bodenlos, J. S., Wells, S. Y., Noonan, M., & Mayrsohn, A. (2015). Facets of dispositional mindfulness and health among college students. *Journal of Alternative and Complementary Medicine, 21*(10), 645.

Bodhi, B. (2000). The connected discourses of the Buddha. *A New Translation of the Saṃyutta Nikāya, 1*, 2.

Bodhi, B. (2011). What does mindfulness really mean? A canonical perspective. *Contemporary Buddhism, 12*(01), 19-39.

Bodhi, B. (2012). *Comprehensive manual of Abhidhamma: The Abhidhammattha Sangaha*: Pariyatti Publishing.

Bohlmeijer, E., Prenger, R., Taal, E., & Cuijpers, P. (2010). The effects of mindfulness-based stress reduction therapy on mental health of adults with a chronic medical disease: A meta-analysis. *Journal of Psychosomatic Research, 68*(6), 539-544.

Bohlmeijer, E., Ten Klooster, P. M., Fledderus, M., Veehof, M., & Baer, R. (2011). Psychometric properties of the Five-Facet Mindfulness Questionnaire in depressed adults and development of a short form. *Assessment, 18*(3), 308-320.

Bond, F. W., Hayes, S. C., Baer, R. A., Carpenter, K. M., Guenole, N., Orcutt, H. K., . . . Zettle, R. D. (2011). Preliminary psychometric properties of the Acceptance and Action Questionnaire–II: A revised measure of psychological inflexibility and experiential avoidance. *Behavior Therapy, 42*(4), 676-688.

Bosscher, R. J., & Smit, J. H. (1998). Confirmatory factor analysis of the general self-efficacy scale. *Behaviour Research and Therapy, 36*(3), 339-343.

Bowen, S., Witkiewitz, K., Clifasefi, S. L., Grow, J., Chawla, N., Hsu, S. H., . . . Lustyk, M. K. (2014). Relative efficacy of mindfulness-based relapse prevention, standard relapse prevention, and treatment as usual for substance use disorders: A randomized clinical trial. *JAMA psychiatry, 71*(5), 547-556.

Bower, J. E., Crosswell, A. D., Stanton, A. L., Crespi, C. M., Winston, D., Arevalo, J., . . . Ganz, P. A. (2015). Mindfulness meditation for younger breast cancer survivors: A randomized controlled trial. *Cancer, 121*(8), 1231-1240.

Bowlin, S. L., & Baer, R. A. (2012). Relationships between mindfulness, self-control, and psychological functioning. *Personality and Individual Differences, 52*(3), 411-415.
Boyle, M. P. (2011). Mindfulness training in stuttering therapy: A tutorial for speech-language pathologists. *Journal of Fluency Disorders, 36*(2), 122-129.
Bränström, R., Duncan, L. G., & Moskowitz, J. T. (2011). The association between dispositional mindfulness, psychological well-being, and perceived health in a Swedish population-based sample. *British Journal of Health Psychology, 16*(2), 300-316.
Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101.
Braun, V., & Clarke, V. (2013). *Successful qualitative research: A practical guide for beginners*. London: Sage.
Braun, V., & Clarke, V. (2014). What can "thematic analysis" offer health and wellbeing researchers? *International Journal of Qualitative Studies on Health and Well-being, 9*, 26152.
Brefczynski-Lewis, J. A., Lutz, A., Schaefer, H. S., Levinson, D. B., & Davidson, R. J. (2007). Neural correlates of attentional expertise in long-term meditation practitioners. *Proceedings of the national Academy of Sciences, 104*(27), 11483-11488.
Brewer, J. A., Mallik, S., Babuscio, T. A., Nich, C., Johnson, H. E., Deleone, C. M., . . . Weinstein, A. J. (2011). Mindfulness training for smoking cessation: Results from a randomized controlled trial. *Drug and Alcohol Dependence, 119*(1-2), 72-80.
Brisbon, N. M., & Lowery, G. A. (2011). Mindfulness and levels of stress: A comparison of beginner and advanced hatha yoga practitioners. *Journal of religion and health, 50*(4), 931-941.
Broderick, J. M., Ryan, J., O'Donnell, D. M., & Hussey, J. (2014). A guide to assessing physical activity using accelerometry in cancer patients. *Supportive Care in Cancer, 22*(4), 1121-1130.
Brown, K. W., & Kasser, T. (2005). Are psychological and ecological well-being compatible? The role of values, mindfulness, and lifestyle. *Social Indicators Research, 74*(2), 349-368.
Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84*(4), 822-848.
Brown, K. W., & Ryan, R. M. (2004). Perils and promise in defining and measuring mindfulness: Observations from experience. *Clinical Psychology: Science and Practice, 11*(3), 242-248.
Brown, K. W., Ryan, R. M., & Creswell, J. D. (2007). Addressing fundamental questions about mindfulness. *Psychological Inquiry, 18*(4), 272-281.
Bryan, A., Hutchison, K. E., Seals, D. R., & Allen, D. L. (2007). A transdisciplinary model integrating genetic, physiological, and psychological correlates of voluntary exercise. *Health Psychology, 26*(1), 30-39.
Bryman, A. (2016). *Social research methods*. Oxford: Oxford University Press.
Buchheld, N., Grossman, P., & Walach, H. (2001). Measuring mindfulness in insight meditation (Vipassana) and meditation-based psychotherapy: The development of the Freiburg Mindfulness Inventory (FMI). *Journal for Meditation and Meditation Research, 1*(1), 11-34.
Buckley, J., Cohen, J. D., Kramer, A. F., McAuley, E., & Mullen, S. P. (2014). Cognitive control in the self-regulation of physical activity and sedentary behavior. *Frontiers in Human Neuroscience, 8*, 747.
Buddhaghosa, B. (2010). *Visuddhimagga: The path of purification*. Seattle: Shambala.
Bush, M. (2011). Mindfulness in higher education. *Contemporary Buddhism, 12*(01), 183-197.
Butryn, M. L., Forman, E., Hoffman, K., Shaw, J., & Juarascio, A. (2011). A pilot study of acceptance and commitment therapy for promotion of physical activity. *Journal of Physical Activity and Health, 8*(4), 516-522.
Butryn, M. L., Kerrigan, S. G., Forman, E. M., Arigo, D., Raggio, G. A., & Kaufman, A. I. (2015). Measuring the ability to tolerate activity-related discomfort: Initial validation of the Physical Activity Acceptance Questionnaire (PAAQ). *Journal of Physical Activity and Health, 12*(5), 717-726.
Byatt, K. (2004). *An exploration of the experience of individuals choosing yoga or exercise in a continuing cardiac rehabilitation programme.* Liverpool John Moores University,
Byrne, B. M. (2013). *Structural equation modeling with LISREL, PRELIS, and SIMPLIS: Basic concepts, applications, and programming*: Psychology Press.
Byrne, B. M. (2016). *Structural equation modeling with AMOS: Basic concepts, applications, and programming*. New York: Routledge.

Cabanac, M. (1992). Pleasure: The common currency. *Journal of Theoretical Biology, 155*(2), 173-200.

Caldwell, K., Baime, M., & Wolever, R. (2012). Mindfulness based approaches to obesity and weight loss maintenance. *Journal of Mental Health Counseling, 34*(3), 269-282.

Caldwell, K., Emery, L., Harrison, M., & Greeson, J. (2011). Changes in mindfulness, well-being, and sleep quality in college students through taijiquan courses: A cohort control study. *The Journal of Alternative and Complementary Medicine, 17*(10), 931-938.

Caldwell, K., Harrison, M., Adams, M., Quin, R. H., & Greeson, J. (2010). Developing mindfulness in college students through movement-based courses: Effects on self-regulatory self-efficacy, mood, stress, and sleep quality. *Journal of American College Health, 58*(5), 433-442.

Caluyong, M. B., Zambrana, A. F., Romanow, H. C., Nathan, H. J., Nahas, R., & Poulin, P. A. (2015). The relationship between mindfulness, depression, diabetes self-care, and health-related quality of life in patients with type 2 diabetes. *Mindfulness, 6*(6), 1313-1321.

Cardaciotto, L., Herbert, J. D., Forman, E. M., Moitra, E., & Farrow, V. (2008). The assessment of present-moment awareness and acceptance: The Philadelphia Mindfulness Scale. *Assessment, 15*(2), 204-223.

Carlson, L. E. (2012). Mindfulness-based interventions for physical conditions: A narrative review evaluating levels of evidence. *ISRN psychiatry, 2012*.

Carlson, L. E., Speca, M., Patel, K. D., & Goodey, E. (2004). Mindfulness-based stress reduction in relation to quality of life, mood, symptoms of stress and levels of cortisol, dehydroepiandrosterone sulfate (DHEAS) and melatonin in breast and prostate cancer outpatients. *Psychoneuroendocrinology, 29*, 448-474.

Carmody, J., & Baer, R. A. (2008). Relationships between mindfulness practice and levels of mindfulness, medical and psychological symptoms and well-being in a mindfulness-based stress reduction program. *Journal of Behavioral Medicine, 31*(1), 23-33.

Carmody, J., Baer, R. A., Lykins, E. L. B., & Olendzki, N. (2009). An empirical study of the mechanisms of mindfulness in a mindfulness-based stress reduction program. *Journal of Clinical Psychology, 65*(6), 613-626.

Carmody, J., Reed, G., Kristeller, J., & Merriam, P. (2008). Mindfulness, spirituality, and health-related symptoms. *Journal of Psychosomatic Research, 64*(4), 393-403.

Carson, J. W., Carson, K. M., Gil, K. M., & Baucom, D. H. (2004). Mindfulness-based relationship enhancement. *Behavior Therapy, 35*(3), 471-494.

Carver, C. S., & Scheier, M. F. (2000). On the structure of behavioral self-regulation. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 41-84). San Diego, CA: Academic Press.

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports, 100*(2), 126.

Cavanagh, K., Strauss, C., Forder, L., & Jones, F. (2014). Can mindfulness and acceptance be learnt by self-help?: A systematic review and meta-analysis of mindfulness and acceptance-based self-help interventions. *Clinical Psychology Review, 34*(2), 118-129.

Cavill, N., Roberts, K., & Rutter, H. (2012). *Standard Evaluation Framework for Physical Activity Interventions*. London: National Obesity Observatory.

Cayoun, B. A. (2011). *Mindfulness-integrated CBT: Principles and practice*: John Wiley & Sons.

Cebolla, A., Demarzo, M., Martins, P., Soler, J., & Garcia-Campayo, J. (2017). Unwanted effects: Is there a negative side of meditation? A multicentre survey. *PloS One, 12*(9), e0183137.

Chadwick, P., Hember, M., Symes, J., Peters, E., Kuipers, E., & Dagnan, D. (2008). Responding mindfully to unpleasant thoughts and images: Reliability and validity of the Southampton Mindfulness Questionnaire (SMQ). *British Journal of Clinical Psychology, 47*(4), 451-455.

Chan, J. S. Y., Liu, G., Liang, D., Deng, K., Wu, J., & Yan, J. H. (2019). Therapeutic benefits of physical activity for mood: A systematic review on the effects of exercise intensity, duration, and modality. *The Journal of psychology, 153*(1), 102-125.

Chatzisarantis, N. L. D., & Hagger, M. S. (2007). Mindfulness and the intention-behavior relationship within the theory of planned behavior. *Personality and Social Psychology Bulletin, 33*(5), 663-676.

Chemolli, E., & Gagné, M. (2014). Evidence against the continuum structure underlying motivation measures derived from self-determination theory. *Psychological Assessment, 26*(2), 575.

Cheong, J. (2011). Accuracy of estimates and statistical power for testing meditation in latent growth curve modeling. *Structural equation modeling, 18*(2), 195-211.
Chiesa, A. (2013). The difficulty of defining mindfulness: Current thought and critical issues. *Mindfulness, 4*(3), 255-268.
Chiesa, A., & Malinowski, P. (2011). Mindfulness-based approaches: Are they all the same? *Journal of Clinical Psychology, 67*(4), 404-424.
Chiesa, A., & Serretti, A. (2009). Mindfulness-based stress reduction for stress management in healthy people: A review and meta-analysis. *Journal of Alternative and Complementary Medicine, 15*(5), 593-600.
Chiesa, A., & Serretti, A. (2011a). Mindfulness-based cognitive therapy for psychiatric disorders: A systematic review and meta-analysis. *Psychiatry Research, 187*(3), 441-453.
Chiesa, A., & Serretti, A. (2011b). Mindfulness-based interventions for chronic pain: A systematic review of the evidence. *Journal of Alternative and Complementary Medicine, 17*(1), 83-93.
Chiesa, A., & Serretti, A. (2014). Are mindfulness-based interventions effective for substance use disorders? A systematic review of the evidence. *Substance Use and Misuse, 49*(5), 492-512.
Choi, L., Liu, Z., Matthews, C. E., & Buchowski, M. S. (2011). Validation of accelerometer wear and nonwear time classification algorithm. *Medicine and Science in Sports and Exercise, 43*(2), 357-364.
Christopher, M. S., Charoensuk, S., Gilbert, B. D., Neary, T. J., & Pearce, K. L. (2009). Mindfulness in Thailand and the United States: A case of apples versus oranges? *Journal of Clinical Psychology, 65*(6), 590-612.
Christopher, M. S., Neuser, N. J., Michael, P. G., & Baitmangalkar, A. (2012). Exploring the psychometric properties of the five facet mindfulness questionnaire. *Mindfulness, 3*(2), 124-131.
Church, T. S., Earnest, C. P., Skinner, J. S., & Blair, S. N. (2007). Effects of different doses of physical activity on cardiorespiratory fitness among sedentary, overweight or obese postmenopausal women with elevated blood pressure: A randomized controlled trial. *JAMA, 297*(19), 2081-2091.
Clevenger, K. A., Pfeiffer, K. A., Yee, K. E., Triplett, A. N., Florida, J., & Selby, S. (2018). Mindfulness and children's physical activity, diet, quality of life, and weight status. *Mindfulness, 9*(1), 221-229.
Coffey, K. A., & Hartman, M. (2008). Mechanisms of action in the inverse relationship between mindfulness and psychological distress. *Complementary Health Practice Review, 13*(2), 79-91.
Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement, 20*(1), 37-46.
Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (Vol. 2). Hilsdale, NJ: Lawrence Earlbaum Associates.
Colcombe, S., & Kramer, A. F. (2003). Fitness effects on the cognitive function of older adults: A meta-analytic study. *Psychological Science, 14*(2), 125-130.
Conn, V. S., Hafdahl, A. R., & Mehr, D. R. (2011). Interventions to increase physical activity among healthy adults: Meta-analysis of outcomes. *American Journal of Public Health, 101*(4), 751-758.
Connell, J. P., & Ryan, R. M. (1985). *Internalization and self-regulation: From theory to assessment.* Paper presented at the Meeting of the Society for Research in Child Development, Toronto, Canada.
Cox, A. E., & McMahon, A. K. (2019). Exploring changes in mindfulness and body appreciation during yoga participation. *Body image, 29*, 118-121.
Cox, A. E., Roberts, M. A., Cates, H. L., & McMahon, A. K. (2018). Mindfulness and affective responses to treadmill walking in individuals with low intrinsic motivation to exercise. *International Journal of Exercise Science, 11*(5), 609.
Cox, A. E., Ullrich-French, S., Cole, A. N., & D'Hondt-Taylor, M. (2016). The role of state mindfulness during yoga in predicting self-objectification and reasons for exercise. *Psychology of Sport and Exercise, 22*, 321-327.
Cox, A. E., Ullrich-French, S., Tylka, T. L., & McMahon, A. K. (2019). The roles of self-compassion, body surveillance, and body appreciation in predicting intrinsic motivation for physical

activity: Cross-sectional associations, and prospective changes within a yoga context. *Body image, 29*, 110-117.
Craig, C., Marshall, A., Sjöström, M., Bauman, A., Booth, M., Ainsworth, B., . . . Sallis, J. (2003). International Physical Activity Questionnaire: 12-country reliability and validity. *Medicine and Science in Sports and Exercise*(8), 1381-1395.
Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I., & Petticrew, M. (2008). Developing and evaluating complex interventions: The new Medical Research Council guidance. *BMJ, 337*, a1655.
Crane, C., Barnhofer, T., Hargus, E., Amarasinghe, M., & Winder, R. (2010). The relationship between dispositional mindfulness and conditional goal setting in depressed patients. *British Journal of Clinical Psychology, 49*(3), 281-290.
Crane, R. S., Brewer, J., Feldman, C., Kabat-Zinn, J., Santorelli, S., Williams, J. M. G., & Kuyken, W. (2016). What defines mindfulness-based programs? The warp and the weft. *Psychological Medicine, 47*(6), 990-999.
Crane, R. S., Kuyken, W., Hastings, R. P., Rothwell, N., & Williams, J. M. G. (2010). Training teachers to deliver mindfulness-based interventions: Learning from the UK experience. *Mindfulness, 1*(2), 74-86.
Creswell, J. D. (2017). Mindfulness interventions. *Annual Review of Psychology, 68*, 491-516.
Cullen, M. (2011). Mindfulness-based interventions: An emerging phenomenon. *Mindfulness, 2*(3), 186-193.
Das, P., & Horton, R. (2012). Rethinking our approach to physical activity. *The Lancet, 380*(9838), 189-190.
Daubenmier, J., Moran, P. J., Kristeller, J., Acree, M., Bacchetti, P., Kemeny, M. E., . . . Hecht, F. M. (2016). Effects of a mindfulness-based weight loss intervention in adults with obesity: A randomized clinical trial. *Obesity, 24*(4), 794-804.
Davids, T. W. R. (1881). *Buddhist suttas*. Oxford: Clarendon Press.
Davids, T. W. R. (1899). *Dialogues of the Buddha (Vol. 1)*. London: Henry Frowde.
Davids, T. W. R. (1910). *Dialogues of the Buddha (Vol. 2)*. London: Henry Frowde.
Davidson, R. J., & Kaszniak, A. W. (2015). Conceptual and methodological issues in research on mindfulness and meditation. *American Psychologist, 70*(7), 581-592.
Davis, K. K. (2008). *Effect of mindfulness meditation and home-based resistance exercise on weight loss, weight loss behaviors, and psychosocial correlates in overweight adults.* University of Pittsburgh,
Davis, K. M., Lau, M. A., & Cairns, D. R. (2009). Development and preliminary validation of a trait version of the Toronto Mindfulness Scale. *Journal of Cognitive Psychotherapy, 23*(3), 185-197.
de Bruin, E. I., Meppelink, R., & Bögels, S. M. (2015). Mindfulness in higher education: Awareness and attention in University students increase during and after participation in a mindfulness curriculum course. *Mindfulness, 6*(5), 1137-1142.
de Bruin, E. I., Topper, M., Muskens, J. G. A. M., Bögels, S. M., & Kamphuis, J. H. (2012a). Psychometric properties of the Five-Facet Mindfulness Questionnaire (FFMQ) in a meditating and a non-meditating sample. *Assessment, 19*(2), 187-197.
de Bruin, M., Sheeran, P., Kok, G., Hiemstra, A., Prins, J. M., Hospers, H. J., & van Breukelen, G. J. P. (2012b). Self-regulatory processes mediate the intention-behavior relation for adherence and exercise behaviors. *Health Psychology, 31*(6), 695.
de Ridder, D. T. D., Lensvelt-Mulders, G., Finkenauer, C., Stok, F. M., & Baumeister, R. F. (2012). Taking stock of self-control: A meta-analysis of how trait self-control relates to a wide range of behaviors. *Personality and Social Psychology Review, 16*(1), 76-99.
Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*: Springer Science & Business Media.
Deci, E. L., & Ryan, R. M. (2000). The" what" and" why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227-268.
Deci, E. L., & Ryan, R. M. (2011). Self-determination theory. In P. A. Van Lange, A. W. Kruglanski, & E. T. Higgins (Eds.), *Handbook of theories of social psychology* (pp. 416-433). London: SAGE Publications.

Deforche, B. I., De Bourdeaudhuij, I. M., & Tanghe, A. P. (2006). Attitude toward physical activity in normal-weight, overweight and obese adolescents. *Journal of Adolescent Health, 38*(5), 560-568.

Demarzo, M., Montero-Marin, J., Puebla-Guedea, M., Navarro-Gil, M., Herrera-Mercadal, P., Moreno-González, S., . . . Garcia-Campayo, J. (2017). Efficacy of 8-and 4-session mindfulness-based interventions in a non-clinical population: A controlled study. *Frontiers in Psychology, 8*, 1343.

Demarzo, M. M. P., Cebolla, A., & Garcia-Campayo, J. (2015). The implementation of mindfulness in healthcare systems: A theoretical analysis. *General Hospital Psychiatry, 37*(2), 166-171.

Denkinger, M. D., Nikolaus, T., Denkinger, C., & Lukas, A. (2012). Physical activity for the prevention of cognitive decline. *Zeitschrift für Gerontologie und Geriatrie, 45*(1), 11-16.

Department of Health. (2011). *Start Active, Stay Active: A report on physical activity for health from the four home countries' Chief Medical Officers*. Retrieved from https://www.sportengland.org/media/2928/dh_128210.pdf

Dimidjian, S., & Segal, Z. V. (2015). Prospects for a clinical science of mindfulness-based intervention. *American Psychologist, 70*(7), 593-620.

Dinas, P. C., Koutedakis, Y., & Flouris, A. D. (2011). Effects of exercise and physical activity on depression. *Irish Journal of Medical Science, 180*(2), 319-325.

Ding, D., Lawson, K. D., Kolbe-Alexander, T. L., Finkelstein, E. A., Katzmarzyk, P. T., Van Mechelen, W., . . . Committee, L. P. A. S. E. (2016). The economic burden of physical inactivity: a global analysis of major non-communicable diseases. *The Lancet, 388*(10051), 1311-1324.

Dishman, R., Heath, G., & Lee, I.-M. (2012). *Physical activity epidemiology* (2 ed.). Champaign, IL: Human Kinetics.

Dishman, R. K., Sallis, J. F., & Orenstein, D. R. (1985). The determinants of physical activity and exercise. *Public Health Reports, 100*(2), 158-171.

Dixon-Woods, M., & Fitzpatrick, R. (2001). Qualitative research in systematic reviews. *BMJ, 323*, 765-766.

Dobkin, P. L., Hickman, S., & Monshat, K. (2014). Holding the heart of mindfulness-based stress reduction: Balancing fidelity and imagination when adapting MBSR. *Mindfulness, 5*(6), 710-718.

Donaldson, A., & Finch, C. F. (2012). Planning for implementation and translation: Seek first to understand the end-users' perspectives. *British Journal of Sports Medicine, 46*(5), 306-307.

Donnelly, J. E., Greene, J. L., Gibson, C. A., Smith, B. K., Washburn, R. A., Sullivan, D. K., . . . Williams, S. L. (2009). Physical activity across the curriculum (PAAC): A randomized controlled trial to promote physical activity and diminish overweight and obesity in elementary school children. *Preventative Medicine, 49*(4), 336-341.

Dorjee, D. (2010). Kinds and dimensions of mindfulness: Why it is important to distinguish them. *Mindfulness, 1*(3), 152-160.

Dorjee, D. (2016). Defining contemplative science: The metacognitive self-regulatory capacity of the mind, context of meditation practice and modes of existential awareness. *Frontiers in Psychology, 7*, 1788.

Dreyfus, G. (2011). Is mindfulness present-centred and non-judgmental? A discussion of the cognitive dimensions of mindfulness. *Contemporary Buddhism, 12*(01), 41-54.

Duncan, L. G., & Bardacke, N. (2010). Mindfulness-based childbirth and parenting education: Promoting family mindfulness during the perinatal period. *Journal of Child and Family Studies, 19*(2), 190-202.

Duncan, L. R., Hall, C. R., Wilson, P. M., & Jenny, O. (2010). Exercise motivation: A cross-sectional analysis examining its relationships with frequency, intensity, and duration of exercise. *International Journal of Behavioral Nutrition and Physical Activity, 7*(1), 7-16.

Duncan, S. C., & Duncan, T. E. (1996). A multivariate latent growth curve analysis of adolescent substance use. *Structural Equation Modeling: A Multidisciplinary Journal, 3*(4), 323-347.

Duncan, S. C., Duncan, T. E., Strycker, L. A., & Chaumeton, N. R. (2007). A cohort-sequential latent growth model of physical activity from ages 12 to 17 years. *Annals of Behavioral Medicine, 33*(1), 80-89.

Duncan, T. E., & Duncan, S. C. (1995). Modeling the processes of development via latent variable growth curve methodology. *Structural Equation Modeling: A Multidisciplinary Journal, 2*(3), 187-213.

Dunne, J. (2011). Toward an understanding of non-dual mindfulness. *Contemporary Buddhism, 12*(01), 71-88.
Dutton, G. R. (2008). The role of mindfulness in health behavior change *ACSM's Health & Fitness Journal, 12*(4), 7-12.
Edwards, M. K., & Loprinzi, P. D. (2019). Affective responses to acute bouts of aerobic exercise, mindfulness meditation, and combinations of exercise and meditation: A randomized controlled intervention. *Psychological Reports, 122*(2), 465-484.
Egan, A. M., Mahmood, W. A. W., Fenton, R., Redziniak, N., Kyaw Tun, T., Sreenan, S., & McDermott, J. H. (2013). Barriers to exercise in obese patients with type 2 diabetes. *International Journal of Medicine, 106*(7), 635-638.
Ekkekakis, P., & Lind, E. (2006). Exercise does not feel the same when you are overweight: The impact of self-selected and imposed intensity on affect and exertion. *International Journal of Obesity, 30*(4), 652-660.
Ekkekakis, P., Parfitt, G., & Petruzzello, S. J. (2011). The pleasure and displeasure people feel when they exercise at different intensities. *Sports Medicine, 41*(8), 641-671.
Ellis, P. D. (2010). *The essential guide to effect sizes: Statistical power, meta-analysis, and the interpretation of research results*: Cambridge University Press.
Fanning, J., Osborn, C. Y., Lagotte, A. E., & Mayberry, L. S. (2018). Relationships between dispositional mindfulness, health behaviors, and hemoglobin A1c among adults with type 2 diabetes. *Journal of Behavioral Medicine*, 1-8.
Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175-191.
Feldman, G., Hayes, A., Kumar, S., Greeson, J., & Laurenceau, J.-P. (2006). Mindfulness and emotion regulation: The development and initial validation of the Cognitive and Affective Mindfulness Scale-Revised (CAMS-R). *Journal of Psychopathology and Behavioral Assessment, 29*(3), 177.
Fillmore, M. T. (2003). Drug abuse as a problem of impaired control: Current approaches and findings. *Behavioral and Cognitive Neuroscience Reviews, 2*(3), 179-197.
Fillmore, M. T., Rush, C. R., & Hays, L. (2006). Acute effects of cocaine in two models of inhibitory control: Implications of non-linear dose effects. *Addiction, 101*(9), 1323-1332.
Fjeldsoe, B., Neuhaus, M., Winkler, E., & Eakin, E. (2011). Systematic review of maintenance of behavior change following physical activity and dietary interventions. *Health Psychology, 30*(1), 99-109.
Fletcher, L. (2012). *A mindfulness and acceptance-based intervention for increasing physical activity and reducing obesity.* (Dissertation Abstracts International: Section B: The Sciences and Engineering), ProQuest Information and Learning, US. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2012-99220-436&site=eds-live Available from EBSCOhost psyh database.
Flick, U. (2018). *An introduction to qualitative research*. London: Sage.
Forman, E. M., Butryn, M. L., Hoffman, K. L., & Herbert, J. D. (2009). An open trial of an acceptance-based behavioral intervention for weight loss. *Cognitive and Behavioral Practice, 16*(2), 223-235.
Foster, C., Hillsdon, M., Thorogood, M., Kaur, A., & Wedatilake, T. (2005). Interventions for promoting physical activity. *Cochrane Database of Systematic Reviews*(1), Art. No.: CD003180.
Free, C., Knight, R., Robertson, S., Whittaker, R., Edwards, P., Zhou, W., . . . Roberts, I. (2011). Smoking cessation support delivered via mobile phone text messaging (txt2stop): A single-blind, randomised trial. *The Lancet, 378*(9785), 49-55.
Freedson, P. S., & Miller, K. (2000). Objective monitoring of physical activity using motion sensors and heart rate. *Research Quarterly for Exercise and Sport, 71*(S2), 21-29.
Frewen, P., Lundberg, E., MacKinley, J., & Wrath, A. (2011). Assessment of response to mindfulness meditation: Meditation breath attention scores in association with subjective measures of state and trait mindfulness and difficulty letting go of depressive cognition. *Mindfulness, 2*(4), 254-269.
Friese, M., Loschelder, D. D., Gieseler, K., Frankenbach, J., & Inzlicht, M. (2019). Is ego depletion real? An analysis of arguments. *Personality and Social Psychology Review, 23*(2), 107-131.

Friese, M., Messner, C., & Schaffner, Y. (2012). Mindfulness meditation counteracts self-control depletion. *Consciousness and Cognition, 21*(2), 1016-1022.
Fuller, N. R., Sainsbury, A., Caterson, I. D., Enarsson, M., Denyer, G., Manns, C., . . . Markovic, T. P. (2017). Examining mindfulness as a predictor of weight loss: Findings from the DIABEGG study. *Obesity Research & Clinical Practice, 11*(1), 88-96.
Gabriel, K. P., McClain, J. J., Schmid, K. K., Storti, K. L., High, R. R., Underwood, D. A., . . . Kriska, A. M. (2010). Issues in accelerometer methodology: The role of epoch length on estimates of physical activity and relationships with health outcomes in overweight, post-menopausal women. *International Journal of Behavioral Nutrition and Physical Activity, 7*(1), 53.
Gao, Y., & Shi, L. (2015). Mindfulness, physical activity and avoidance of secondhand smoke: A study of college students in Shanghai. *International Journal of Environmental Research and Public Health, 12*(8), 10106-10116.
Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I.-M., . . . Swain, D. P. (2011). Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise. *Medicine and Science in Sports and Exercise, 43*(7), 1334-1359.
Gardner, M. M., Robertson, M. C., & Campbell, A. J. (2000). Exercise in preventing falls and fall related injuries in older people: A review of randomised controlled trials. *British Journal of Sports Medicine, 34*(1), 7-17.
Garland, E. L. (2013). *Mindfulness-oriented recovery enhancement for addiction, stress, and pain*: NASW Press, National Association of Social Workers.
Gaur, V., & Pathak, O. P. (2000). *Abhidhammapitake Puggalapannattipali (with English translation)*: Eastern Book Linkers.
Germer, C. (2009). *The mindful path to self-compassion: Freeing yourself from destructive thoughts and emotions*. New York, NY: Guilford Press.
Gethin, R. (2011). On some definitions of mindfulness. *Contemporary Buddhism, 12*(1), 263-279.
Gibson, B., Umeh, K. F., Newson, L., & Davies, I. (2018). Efficacy of the Best Possible Self protocol in diabetes self-management: A mixed-methods approach. *Journal of Health Psychology*, 1-13.
Gifford, E. V., Kohlenberg, B. S., Hayes, S. C., Antonuccio, D. O., Piasecki, M. M., Rasmussen-Hall, M. L., & Palm, K. M. (2004). Acceptance-based treatment for smoking cessation. *Behavior Therapy, 35*(4), 689-705.
Gilbert, D., & Waltz, J. (2010). Mindfulness and health behaviors. *Mindfulness, 1*(4), 227-234.
Gilbert, P., & Irons, C. (2015). Compassion focused therapy. In S. Palmer (Ed.), *The Beginner's Guide to Counselling & Psychotherapy* (pp. 127). London: SAGE.
Giles-Corti, B., & Donovan, R. J. (2002). The relative influence of individual, social and physical environment determinants of physical activity. *Social Science and Medicine, 54*(12), 1793-1812.
Glasgow, R. E., Lichtenstein, E., & Marcus, A. C. (2003). Why don't we see more translation of health promotion research to practice? Rethinking the efficacy-to-effectiveness transition. *American Journal of Public Health, 93*(8), 1261-1267.
Godsey, J. (2013). The role of mindfulness based interventions in the treatment of obesity and eating disorders: An integrative review. *Complementary Therapies in Medicine, 21*(4), 430-439.
Goldberg, S. B., Wielgosz, J., Dahl, C., Schuyler, B., MacCoon, D. S., Rosenkranz, M., . . . Davidson, R. J. (2016). Does the Five Facet Mindfulness Questionnaire measure what we think it does? Construct validity evidence from an active controlled randomized clinical trial. *Psychological Assessment, 28*(8), 1009-1014.
Good, D. J., Lyddy, C. J., Glomb, T. M., Bono, J. E., Brown, K. W., Duffy, M. K., . . . Lazar, S. W. (2016). Contemplating mindfulness at work: An integrative review. *Journal of management, 42*(1), 114-142.
Goodwin, C. L., Forman, E. M., Herbert, J. D., Butryn, M. L., & Ledley, G. S. (2012). A pilot study examining the initial effectiveness of a brief acceptance-based behavior therapy for modifying diet and physical activity among cardiac patients. *Behavior Modification, 36*(2), 199-217.
Gotink, R. A., Chu, P., Busschbach, J. J. V., Benson, H., Fricchione, G. L., & Hunink, M. G. M. (2015). Standardised mindfulness-based interventions in healthcare: An overview of systematic reviews and meta-analyses of RCTs. *PloS One, 10*(4), e0124344.

Gotink, R. A., Younge, J. O., Wery, M. F., Utens, E. M. W. J., Michels, M., Rizopoulos, D., . . . Hunink, M. M. G. (2017). Online mindfulness as a promising method to improve exercise capacity in heart disease: 12-month follow-up of a randomized controlled trial. *PloS One, 12*(5), e0175923.

Gould, L. F., Dariotis, J. K., Mendelson, T., & Greenberg, M. T. (2012). A school-based mindfulness intervention for urban youth: Exploring moderators of intervention effects. *Journal of Community Psychology, 40*(8), 968-982.

Greaves, C. J., Sheppard, K. E., Abraham, C., Hardeman, W., Roden, M., Evans, P. H., & Schwarz, P. (2011). Systematic review of reviews of intervention components associated with increased effectiveness in dietary and physical activity interventions. *BMC Public Health, 11*(1), 119.

Grinnell, S., Greene, G., Melanson, K., Blissmer, B., & Lofgren, I. E. (2011). Anthropometric and behavioral measures related to mindfulness in college students. *Journal of American College Health, 59*(6), 539-545.

Grolnick, W. S., & Ryan, R. M. (1987). Autonomy in children's learning: An experimental and individual difference investigation. *Journal of Personality and Social Psychology, 52*(5), 890-898.

Grossman, P. (2008). On measuring mindfulness in psychosomatic and psychological research. *Journal of Psychosomatic Research, 64*(4), 405-408.

Grossman, P. (2010). Mindfulness for psychologists: Paying kind attention to the perceptible. *Mindfulness, 1*(2), 87-97.

Grossman, P. (2011). Defining mindfulness by how poorly I think I pay attention during everyday awareness and other intractable problems for psychology's (re) invention of mindfulness: Comment on Brown et al. (2011). *Psychological Assessment, 23*(4), 1034-1040.

Grossman, P. (2019). On the porosity of subject and object in “mindfulness” scientific study: Challenges to “scientific” construction, operationalization and measurement of mindfulness. *Current opinion in psychology, 28*, 102-107.

Grossman, P., Deuring, G., Walach, H., Schwarzer, B., & Schmidt, S. (2017). Mindfulness-based intervention does not influence cardiac autonomic control or the pattern of physical activity in fibromyalgia during daily life: An ambulatory, multimeasure randomized controlled trial. *The Clinical Journal of Pain, 33*(5), 385-394.

Grossman, P., Niemann, L., Schmidt, S., & Walach, H. (2004). Mindfulness-based stress reduction and health benefits: A meta-analysis. *Journal of Psychosomatic Research, 57*(1), 35-43.

Grossman, P., & Van Dam, N. T. (2011). Mindfulness, by any other name…: Trials and tribulations of sati in western psychology and science. *Contemporary Buddhism, 12*(1), 219-239.

Gu, J., Strauss, C., Bond, R., & Cavanagh, K. (2015). How do mindfulness-based cognitive therapy and mindfulness-based stress reduction improve mental health and wellbeing? A systematic review and meta-analysis of mediation studies. *Clinical Psychology Review, 37*, 1-12.

Guiney, H., & Machado, L. (2013). Benefits of regular aerobic exercise for executive functioning in healthy populations. *Psychonomic Bulletin and Review, 20*(1), 73-86.

Gunaratana, B., & Gunaratana, H. (2011). *Mindfulness in plain English*: Simon and Schuster.

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2018). Worldwide trends in insufficient physical activity from 2001 to 2016: A pooled analysis of 358 population-based surveys with 1· 9 million participants. *The Lancet Global Health, 6*(10), e1077-e1086.

Hagger, M. S., Chatzisarantis, N. L. D., & Harris, J. (2006). The process by which relative autonomous motivation affects intentional behavior: Comparing effects across dieting and exercise behaviors. *Motivation and Emotion, 30*(4), 307–321.

Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. D. (2009). The strength model of self-regulation failure and health-related behaviour. *Health Psychology Review, 3*(2), 208-238.

Hamilton, K. R., Ansell, E. B., Reynolds, B., Potenza, M. N., & Sinha, R. (2013). Self-reported impulsivity, but not behavioral choice or response impulsivity, partially mediates the effect of stress on drinking behavior. *Stress, 16*(1), 3-15.

Hamilton, K. R., Sinha, R., & Potenza, M. N. (2014). Self-reported impulsivity, but not behavioral approach or inhibition, mediates the relationship between stress and self-control. *Addictive Behaviors, 39*(11), 1557-1564.

Hamilton, M. T., Healy, G. N., Dunstan, D. W., Zderic, T. W., & Owen, N. (2008). Too little exercise and too much sitting: Inactivity physiology and the need for new recommendations on sedentary behavior. *Current Cardiovascular Risk Reports, 2*(4), 292.

Hardcastle, S., & Hagger, M. S. (2011). “You can’t do it on your own”: Experiences of a motivational interviewing intervention on physical activity and dietary behaviour. *Psychology of Sport and Exercise, 12*(3), 314-323.

Harden, S. M., Johnson, S. B., Almeida, F. A., & Estabrooks, P. A. (2017). Improving physical activity program adoption using integrated research-practice partnerships: An effectiveness-implementation trial. *Translational Behavioral Medicine, 7*(1), 28-38.

Haskell, W. L., Lee, I.-M., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A., . . . Bauman, A. (2007). Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation, 116*(9), 1081-1093.

Hawkes, A. L., Pakenham, K. I., Chambers, S. K., Patrao, T. A., & Courneya, K. S. (2014). Effects of a multiple health behavior change intervention for colorectal cancer survivors on psychosocial outcomes and quality of life: A randomized controlled trial. *Annals of Behavioral Medicine, 48*(3), 359-370.

Hayes, S. C. (2004). Acceptance and commitment therapy, relational frame theory, and the third wave of behavioral and cognitive therapies. *Behavior Therapy, 35*(4), 639-665.

Hayes, S. C., Follette, V. M., & Linehan, M. (2004). *Mindfulness and acceptance: Expanding the cognitive-behavioral tradition*: Guilford Press.

Hayes, S. C., Strosahl, K. D., & Wilson, K. G. (1999). *Acceptance and commitment therapy: An experiential approach to behavior change*. New York, NY: Guilford Press.

Hedges, L. V., & Olkin, I. (2014). *Statistical methods for meta-analysis*. London: Academic Press.

Helber, C., Zook, N., & Immergut, M. (2012). Meditation in higher education: Does it enhance cognition? *Innovative Higher Education, 37*(5), 349-358.

Herring, M. P., Jacob, M. L., Suveg, C., Dishman, R. K., & O’Connor, P. J. (2012). Feasibility of exercise training for the short-term treatment of generalized anxiety disorder: A randomized controlled trial. *Psychotherapy and Psychosomatics, 81*(1), 21-28.

Herring, M. P., Jacob, M. L., Suveg, C., & O’Connor, P. J. (2011). Effects of short-term exercise training on signs and symptoms of generalized anxiety disorder. *Mental Health and Physical Activity, 4*(2), 71-77.

Hillman, C. H., Erickson, K. I., & Kramer, A. F. (2008). Be smart, exercise your heart: Exercise effects on brain and cognition. *Nature Reviews Neuroscience, 9*(1), 58-65.

Hilton, L., Hempel, S., Ewing, B. A., Apaydin, E., Xenakis, L., Newberry, S., . . . Sorbero, M. E. (2017). Mindfulness meditation for chronic pain: Systematic review and meta-analysis. *Annals of Behavioral Medicine, 51*(2), 199-213.

Hofmann, S. G., Grossman, P., & Hinton, D. E. (2011). Loving-kindness and compassion meditation: Potential for psychological interventions. *Clinical Psychology Review, 31*(7), 1126-1132.

Hofmann, S. G., Sawyer, A. T., Witt, A. A., & Oh, D. (2010). The effect of mindfulness-based therapy on anxiety and depression: A meta-analytic review. *Journal of Consulting and Clinical Psychology, 78*(2), 169-183.

Hölzel, B. K., Lazar, S. W., Gard, T., Schuman-Olivier, Z., Vago, D. R., & Ott, U. (2011). How does mindfulness meditation work? Proposing mechanisms of action from a conceptual and neural perspective. *Perspectives on Psychological Science, 6*(6), 537-559.

Homan, K. J., & Sirois, F. M. (2017). Self-compassion and physical health: Exploring the roles of perceived stress and health-promoting behaviors. *Health psychology open, 4*(2), 1-9.

Hooper, D., Coughlan, J., & Mullen, M. (2008). Structural equation modelling: Guidelines for determining model fit. *Electronic Journal of Business Research Methods, 6*(1), 53-60.

Howell, A. J., Digdon, N. L., & Buro, K. (2010). Mindfulness predicts sleep-related self-regulation and well-being. *Personality and Individual Differences, 48*(4), 419-424.

Hu, F. B., Manson, J. E., Stampfer, M. J., Colditz, G., Liu, S., Solomon, C. G., & Willett, W. C. (2001). Diet, lifestyle, and the risk of type 2 diabetes mellitus in women. *New England Journal of Medicine, 345*(11), 790-797.

Hu, L. t., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1-55.

Hurling, R., Fairley, B. W., & Dias, M. B. (2006). Internet-based exercise intervention systems: Are more interactive designs better? *Psychology & Health, 21*(6), 757-772.

Ingraham, N., Eliason, M. J., Garbers, S., Harbatkin, D., Minnis, A. M., McElroy, J. A., & Haynes, S. G. (2016). Effects of mindfulness interventions on health outcomes in older lesbian/bisexual women. *Women's Health Issues, 26*(Supplement 1), S53-S62.

Ingraham, N., Harbatkin, D., Lorvick, J., Plumb, M., & Minnis, A. M. (2017). Women's health and mindfulness (WHAM): A randomized intervention among older lesbian/bisexual women. *Health Promotion Practice, 18*(3), 348-357.

Inquisit 5 [Computer software]. (2016). Retrieved from https://www.millisecond.com

Inzlicht, M., Schmeichel, B. J., & Macrae, C. N. (2014). Why self-control seems (but may not be) limited. *Trends in Cognitive Sciences, 18*(3), 127-133.

IPAQ Research Committee. (2005). Guidelines for data processing and analysis of the International Physical Activity Questionnaire (IPAQ)-short and long forms. Retrieved from http://www.ipaq.ki.se/scoring.pdf

Ivanova, E., Jensen, D., Cassoff, J., Gu, F., & Knäuper, B. (2015). Acceptance and commitment therapy improves exercise tolerance in sedentary women. *Medicine and Science in Sports and Exercise, 47*(6), 1251-1258.

Jackson, D. L. (2003). Revisiting sample size and number of parameter estimates: Some support for the N:q hypothesis. *Structural equation modeling, 10*(1), 128-141.

Jakicic, J. M., Marcus, B. H., Lang, W., & Janney, C. (2008). Effect of exercise on 24-month weight loss maintenance in overweight women. *Archives of Internal Medicine, 168*(14), 1550-1559.

Jenkins, K. T., & Tapper, K. (2014). Resisting chocolate temptation using a brief mindfulness strategy. *British Journal of Health Psychology, 19*(3), 509-522.

Jha, A. P., Morrison, A. B., Dainer-Best, J., Parker, S., Rostrup, N., & Stanley, E. A. (2015). Minds "at attention": Mindfulness training curbs attentional lapses in military cohorts. *PloS One, 10*(2), e0116889.

Jha, A. P., Stanley, E. A., Kiyonaga, A., Wong, L., & Gelfand, L. (2010). Examining the protective effects of mindfulness training on working memory capacity and affective experience. *Emotion, 10*(1), 54-64.

Johnson, B. T., Scott-Sheldon, L. A. J., & Carey, M. P. (2010). Meta-synthesis of health behavior change meta-analyses. *American Journal of Public Health, 100*(11), 2193-2198.

Johnston, V. (2003). The origin and function of pleasure. *Cognition & Emotion, 17*(2), 167-179.

Kabat-Zinn, J. (1982). An outpatient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation: Theoretical considerations and preliminary results. *General Hospital Psychiatry, 4*(1), 33-47.

Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: Past, present, and future. *Clinical Psychology: Science and Practice, 10*(2), 144-156.

Kabat-Zinn, J. (2004). *Wherever you go, there you are: Mindfulness meditation for everday life*. London: Piatkus.

Kabat-Zinn, J. (2005). *Coming to our senses: Healing ourselves and the world through mindfulness*: Hachette UK.

Kabat-Zinn, J. (2007). Mindfulness meditation: What it is, what it isn't, and its role in health care and medicine. In Y. Haruki, Y. Ishii, & M. Suzuki (Eds.), *Comparative and psychological study on meditation* (pp. 161-170): Eburon.

Kabat-Zinn, J. (2011). Some reflections on the origins of MBSR, skillful means, and the trouble with maps. *Contemporary Buddhism, 12*(1), 281-306.

Kaczynski, A. T., Robertson-Wilson, J., & Decloe, M. (2012). Interaction of perceived neighborhood walkability and self-efficacy on physical activity. *Journal of Physical Activity and Health, 9*(2), 208-217.

Kang, Y., O'Donnell, M., Strecher, V., & Falk, E. (2017). Dispositional mindfulness predicts adaptive affective responses to health messages and increased exercise motivation. *Mindfulness, 8*(2), 387-397.

Kangasniemi, A., Lappalainen, R., Kankaanpää, A., & Tammelin, T. (2014). Mindfulness skills, psychological flexibility, and psychological symptoms among physically less active and active adults. *Mental Health and Physical Activity, 7*(3), 121-127.

Kangasniemi, A. M., Lappalainen, R., Kankaanpää, A., Tolvanen, A., & Tammelin, T. (2015). Towards a physically more active lifestyle based on one's own values: The results of a randomized controlled trial among physically inactive adults. *BMC Public Health, 15*(1), 1-14.

Katterman, S. N., Goldstein, S. P., Butryn, M. L., Forman, E. M., & Lowe, M. R. (2014a). Efficacy of an acceptance-based behavioral intervention for weight gain prevention in young adult women. *Journal of Contextual Behavioral Science, 3*(1), 45-50.

Katterman, S. N., Kleinman, B. M., Hood, M. M., Nackers, L. M., & Corsica, J. A. (2014b). Mindfulness meditation as an intervention for binge eating, emotional eating, and weight loss: A systematic review. *Eating behaviors, 15*(2), 197-204.

Keng, S.-L., Smoski, M. J., & Robins, C. J. (2011). Effects of mindfulness on psychological health: A review of empirical studies. *Clinical Psychology Review, 31*(6), 1041-1056.

Kennedy, A. B., & Blair, S. N. (2014). Motivating people to exercise. *American Journal of Lifestyle Medicine, 8*(5), 324-329.

Kennedy, A. B., & Resnick, P. B. (2015). Mindfulness and physical activity. *American Journal of Lifestyle Medicine, 9*(3), 221-223.

Kenny, D. A., & McCoach, D. B. (2003). Effect of the number of variables on measures of fit in structural equation modeling. *Structural equation modeling, 10*(3), 333-351.

Kerrigan, D., Chau, V., King, M., Holman, E., Joffe, A., & Sibinga, E. (2017). There is no performance, there is just this moment: The role of mindfulness instruction in promoting health and well-being among students at a highly-ranked university in the United States. *Journal of Evidence-Based Complementary & Alternative Medicine, 22*(4), 909-918.

Khoury, B., Sharma, M., Rush, S. E., & Fournier, C. (2015). Mindfulness-based stress reduction for healthy individuals: A meta-analysis. *Journal of Psychosomatic Research, 78*(6), 519-528.

Kidd, P. S., & Parshall, M. B. (2000). Getting the focus and the group: Enhancing analytical rigor in focus group research. *Qualitative Health Research, 10*(3), 293-308.

Kiken, L. G., Garland, E. L., Bluth, K., Palsson, O. S., & Gaylord, S. A. (2015). From a state to a trait: Trajectories of state mindfulness in meditation during intervention predict changes in trait mindfulness. *Personality and Individual Differences, 81*, 41-46.

Kinnafick, F.-E., Thøgersen-Ntoumani, C., & Duda, J. (2016). The effect of need supportive text messages on motivation and physical activity behaviour. *Journal of Behavioral Medicine, 39*(4), 574-586.

Kinnafick, F.-E., Thøgersen-Ntoumani, C., & Duda, J. L. (2014). Physical activity adoption to adherence, lapse, and dropout: A self-determination theory perspective. *Qualitative Health Research, 24*(5), 706-718.

Kinnunen, M. I., Suihko, J., Hankonen, N., Absetz, P., & Jallinoja, P. (2012). Self-control is associated with physical activity and fitness among young males. *Behavioral Medicine, 38*(3), 83-89.

Kitzinger, J. (1994). The methodology of focus groups: The importance of interaction between research participants. *Sociology of Health and Illness, 16*(1), 103-121.

Kiyota, M. (1978). *Mahāyāna Buddhist meditation: Theory and practice*. Hawaii: University Press.

Klainin-Yobas, P., Cho, M. A. A., & Creedy, D. (2012). Efficacy of mindfulness-based interventions on depressive symptoms among people with mental disorders: A meta-analysis. *International Journal of Nursing Studies, 49*(1), 109-121.

Klatt, M. D., Sieck, C., Gascon, G., Malarkey, W., & Huerta, T. (2016). A healthcare utilization cost comparison between employees receiving a worksite mindfulness or a diet/exercise lifestyle intervention to matched controls 5 years post intervention. *Complementary Therapies in Medicine, 27*, 139-144.

Kline, R. B. (2015). *Principles and practice of structural equation modeling*: Guilford.

Kohl, H. W., Craig, C. L., Lambert, E. V., Inoue, S., Alkandari, J. R., Leetongin, G., . . . Group, L. P. A. S. W. (2012). The pandemic of physical inactivity: Global action for public health. *The Lancet, 380*(9838), 294-305.

Kok, G., Gottlieb, N. H., Peters, G.-J. Y., Mullen, P. D., Parcel, G. S., Ruiter, R. A., . . . Bartholomew, L. K. (2016). A taxonomy of behaviour change methods: An intervention mapping approach. *Health Psychology Review, 10*(3), 297-312.

Korkiakangas, E. E., Alahuhta, M. A., & Laitinen, J. H. (2009). Barriers to regular exercise among adults at high risk or diagnosed with type 2 diabetes: A systematic review. *Health Promotion International, 24*(4), 416-427.

Krane, V., Andersen, M. B., & Strean, W. B. (1997). Issues of qualitative research methods and presentation. *Journal of Sport & Exercise Psychology, 19*(2), 213-218.

Kredlow, M. A., Capozzoli, M. C., Hearon, B. A., Calkins, A. W., & Otto, M. W. (2015). The effects of physical activity on sleep: A meta-analytic review. *Journal of Behavioral Medicine, 38*(3), 427-449.

Kristeller, J., Wolever, R. Q., & Sheets, V. (2014). Mindfulness-based eating awareness training (MB-EAT) for binge eating: A randomized clinical trial. *Mindfulness, 5*(3), 282-297.

Kristeller, J. L., & Hallett, C. B. (1999). An exploratory study of a meditation-based intervention for binge eating disorder. *Journal of Health Psychology, 4*(3), 357-363.

Kristeller, J. L., & Wolever, R. Q. (2010). Mindfulness-based eating awareness training for treating binge eating disorder: The conceptual foundation. *Eating disorders, 19*(1), 49-61.

Kuyken, W., Warren, F. C., Taylor, R. S., Whalley, B., Crane, C., Bondolfi, G., . . . Schweizer, S. (2016). Efficacy of mindfulness-based cognitive therapy in prevention of depressive relapse: An individual patient data meta-analysis from randomized trials. *JAMA psychiatry, 73*(6), 565-574.

Kvale, S., & Brinkmann, S. (2009). *Interviews: Learning the craft of qualitative research interviewing*: Sage.

Kyu, H. H., Bachman, V. F., Alexander, L. T., Mumford, J. E., Afshin, A., Estep, K., . . . Moyer, M. L. (2016). Physical activity and risk of breast cancer, colon cancer, diabetes, ischemic heart disease, and ischemic stroke events: Systematic review and dose-response meta-analysis for the Global Burden of Disease Study 2013. *BMJ, 354*, i3857.

La Forge, R. (2005). Aligning mind and body: Exploring the disciplines of mindful exercise. *ACSM's Health & Fitness Journal, 9*(5), 7-14.

Lally, P., Van Jaarsveld, C. H., Potts, H. W., & Wardle, J. (2010). How are habits formed: Modelling habit formation in the real world. *European Journal of Social Psychology, 40*(6), 998-1009.

Lattimore, P., Fisher, N., & Malinowski, P. (2011). A cross-sectional investigation of trait disinhibition and its association with mindfulness and impulsivity. *Appetite, 56*(2), 241-248.

Lattimore, P. J., Malinowski, P., Mead, B. R., Irwin, L., Grice, L., & Carson, R. (2016). 'I can't accept that feeling': Relationships between interoceptive awareness, mindfulness and eating disorder symptoms in females with, and at-risk of an eating disorder. *Psychiatry Research, 247*, 163-171.

Lau, M. A., Bishop, S. R., Segal, Z. V., Buis, T., Anderson, N. D., Carlson, L., . . . Devins, G. (2006). The Toronto Mindfulness Scale: Development and validation. *Journal of Clinical Psychology, 62*(12), 1445-1467.

Leal, J., Luengo-Fernández, R., Gray, A., Petersen, S., & Rayner, M. (2006). Economic burden of cardiovascular diseases in the enlarged European Union. *European Heart Journal, 27*(13), 1610-1619.

Lee, A. C., Harvey, W. F., Price, L. L., Han, X., Driban, J. B., Wong, J. B., . . . Wang, C. (2017). Mindfulness is associated with treatment response from non-pharmacological exercise interventions in knee osteoarthritis. *Archives of Physical Medicine and Rehabilitation, 98*(11), 2265-2273.

Lee, I.-M., & Buchner, D. M. (2008). The importance of walking to public health. *Medicine and Science in Sports and Exercise, 40*(7 Suppl), S512-518.

Lee, I.-M., Hsieh, C.-C., & Paffenbarger, R. S. (1995). Exercise intensity and longevity in men: The Harvard alumni health study. *JAMA, 273*(15), 1179-1184.

Lee, I.-M., Rexrode, K. M., Cook, N. R., Manson, J. E., & Buring, J. E. (2001). Physical activity and coronary heart disease in women: Is no pain, no gain passé? *JAMA, 285*(11), 1447-1454.

Lee, I.-M., & Skerrett, P. J. (2001). Physical activity and all-cause mortality: What is the dose-response relation? *Medicine and Science in Sports and Exercise, 33*(6 Suppl), S459-S471.

Lee, P. H., Macfarlane, D. J., Lam, T. H., & Stewart, S. M. (2011). Validity of the international physical activity questionnaire short form (IPAQ-SF): A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 8*(1), 115-126.

Leigh, J., Bowen, S., & Marlatt, G. A. (2005). Spirituality, mindfulness and substance abuse. *Addictive Behaviors, 30*(7), 1335-1341.

Leitzmann, M. F., Brenner, A., Moore, S. C., Koebnick, C., Park, Y., Hollenbeck, A., . . . Ron, E. (2009). Prospective study of body mass index, physical activity and thyroid cancer. *International Journal of Cancer, 126*(12), 2947-2956.

Lemmens, V. E. P. P., Oenema, A., Klepp, K.-I., Henriksen, H. B., & Brug, J. (2008). A systematic review of the evidence regarding efficacy of obesity prevention interventions among adults. *Obesity Reviews, 9*(5), 446-455.

Leone, L. A., & Ward, D. S. (2013). A mixed methods comparison of perceived benefits and barriers to exercise between obese and nonobese women. *Journal of Physical Activity and Health, 10*(4), 461-469.

Levesque, C., & Brown, K. W. (2007). Mindfulness as a moderator of the effect of implicit motivational self-concept on day-to-day behavioral motivation. *Motivation and Emotion, 31*(4), 284-299.

Levinson, D. B., Stoll, E. L., Kindy, S. D., Merry, H. L., & Davidson, R. J. (2014). A mind you can count on: Validating breath counting as a behavioral measure of mindfulness. *Frontiers in Psychology, 5*, 1202.

Lewis, B. A., Williams, D. M., Frayeh, A., & Marcus, B. H. (2016). Self-efficacy versus perceived enjoyment as predictors of physical activity behaviour. *Psychology & Health, 31*(4), 456-469.

Lilja, J. L., Lundh, L.-G., Josefsson, T., & Falkenström, F. (2013). Observing as an essential facet of mindfulness: A comparison of FFMQ patterns in meditating and non-meditating individuals. *Mindfulness, 4*(3), 203-212.

Lillis, J., & Bond, D. S. (2019). Values-based and acceptance-based intervention to promote adoption and maintenance of habitual physical activity among inactive adults with overweight/obesity: A study protocol for an open trial. *BMJ open, 9*(1), e025115.

Lillis, J., Hayes, S. C., Bunting, K., & Masuda, A. (2009). Teaching acceptance and mindfulness to improve the lives of the obese: A preliminary test of a theoretical model. *Annals of Behavioral Medicine, 37*(1), 58-69.

Lindahl, J. R., Fisher, N. E., Cooper, D. J., Rosen, R. K., & Britton, W. B. (2017). The varieties of contemplative experience: A mixed-methods study of meditation-related challenges in Western Buddhists. *PloS One, 12*(5), e0176239.

Lindner, C., Nagy, G., & Retelsdorf, J. (2015). The dimensionality of the Brief Self-Control Scale: An evaluation of unidimensional and multidimensional applications. *Personality and Individual Differences, 86*, 465-473.

Loucks, E. B., Britton, W. B., Howe, C. J., Eaton, C. B., & Buka, S. L. (2015). Positive associations of dispositional mindfulness with cardiovascular health: The New England family study. *International Journal of Behavioral Medicine, 22*(4), 540-550.

Lucas, A. R., Focht, B. C., Cohn, D. E., Buckworth, J., & Klatt, M. D. (2016). A mindfulness-based lifestyle intervention for obese, inactive endometrial cancer survivors: A feasibility study. *Integrative Cancer Therapies, 16*(3), 263-275.

Lustyk, M. K., Chawla, N., Nolan, R., & Marlatt, G. A. (2009). Mindfulness meditation research: Issues of participant screening, safety procedures, and researcher training. *Advances in Mind-Body Medicine, 24*(1), 20-30.

Lutz, A., Jha, A. P., Dunne, J. D., & Saron, C. D. (2015). Investigating the phenomenological matrix of mindfulness-related practices from a neurocognitive perspective. *American Psychologist, 70*(7), 632-658.

Lutz, A., Slagter, H. A., Dunne, J. D., & Davidson, R. J. (2008). Attention regulation and monitoring in meditation. *Trends in Cognitive Sciences, 12*(4), 163-169.

Lykins, E. L. B., & Baer, R. A. (2009). Psychological functioning in a sample of long-term practitioners of mindfulness meditation. *Journal of Cognitive Psychotherapy, 23*(3), 226-241.

MacLean, K. A., Ferrer, E., Aichele, S. R., Bridwell, D. A., Zanesco, A. P., Jacobs, T. L., . . . Shaver, P. R. (2010). Intensive meditation training improves perceptual discrimination and sustained attention. *Psychological Science, 21*(6), 829-839.

Magnus, C. M. R., Kowalski, K. C., & McHugh, T.-L. F. (2010). The role of self-compassion in women's self-determined motives to exercise and exercise-related outcomes. *Self and identity, 9*(4), 363-382.

Malinowski, P. (2008). Mindfulness as psychological dimension: Concepts and applications. *Irish Journal of Psychology, 29*(1-2), 155-166.

Malinowski, P. (2013). Neural mechanisms of attentional control in mindfulness meditation. *Frontiers in Neuroscience, 7*, 8.

Malinowski, P. (2017). Mindfulness. In S. Schneider & M. Velmans (Eds.), *The Blackwell companion to consciousness* (pp. 203-216): John Wiley & Sons.
Malinowski, P., Moore, A. W., Mead, B. R., & Gruber, T. (2017). Mindful aging: The effects of regular brief mindfulness practice on electrophysiological markers of cognitive and affective processing in older adults. *Mindfulness, 8*(1), 78-94.
Malinowski, P., & Shalamanova, L. (2017). Meditation and cognitive ageing: The role of mindfulness meditation in building cognitive reserve. *Journal of Cognitive Enhancement, 1*(2), 96-106.
Mammen, G., & Faulkner, G. (2013). Physical activity and the prevention of depression: A systematic review of prospective studies. *American Journal of Preventive Medicine, 45*(5), 649-657.
Manson, J. E., Greenland, P., LaCroix, A. Z., Stefanick, M. L., Mouton, C. P., Oberman, A., . . . Siscovick, D. S. (2002). Walking compared with vigorous exercise for the prevention of cardiovascular events in women. *New England Journal of Medicine, 347*(10), 716-725.
Mantzios, M., Egan, H., Hussain, M., Keyte, R., & Bahia, H. (2018). Mindfulness, self-compassion, and mindful eating in relation to fat and sugar consumption: An exploratory investigation. *Eating and Weight Disorders-Studies on Anorexia, Bulimia and Obesity, 23*(6), 833-840.
Manuel, J. A., Somohano, V. C., & Bowen, S. (2017). Mindfulness practice and its relationship to the Five-Facet Mindfulness Questionnaire. *Mindfulness, 8*(2), 361-367.
Marcus, B. H., Forsyth, L. H., Stone, E. J., Dubbert, P. M., McKenzie, T. L., Dunn, A. L., & Blair, S. N. (2000). Physical activity behavior change: Issues in adoption and maintenance. *Health Psychology, 19*(Suppl 1), 32-41.
Markland, D., & Ingledew, D. K. (2007). The relationships between body mass and body image and relative autonomy for exercise among adolescent males and females. *Psychology of Sport and Exercise, 8*(5), 836-853.
Markland, D., & Tobin, V. (2004). A modification to the Behavioural Regulation in Exercise Questionnaire to include an assessment of amotivation. *Journal of Sport & Exercise Psychology, 26*(2), 191-196.
Marlatt, G. A., & Kristeller, J. L. (1999). Mindfulness and meditation. In W. R. Miller (Ed.), *Integrating spirituality into treatment: Resources for practitioners*. Washington DC: American Psychological Association.
Martin, E. C., Cox, M. G., Galloway-Williams, N., & Winett, R. A. (2015a). Pilot testing of a mindfulness- and acceptance-based intervention for increasing cardiorespiratory fitness in sedentary adults: A feasibility study. *Journal of Contextual Behavioral Science, 4*(4), 237-245.
Martin, E. C., Dick, A. M., Scioli-Salter, E. R., & Mitchell, K. S. (2015b). Impact of a yoga intervention on physical activity, self-efficacy, and motivation in women with PTSD symptoms. *Journal of Alternative and Complementary Medicine, 21*(6), 327-332.
Martin, R., Prichard, I., Hutchinson, A. D., & Wilson, C. (2013). The role of body awareness and mindfulness in the relationship between exercise and eating behavior. *Journal of Sport & Exercise Psychology, 35*(6), 655-660.
Masicampo, E. J., & Baumeister, R. F. (2007). Relating mindfulness and self-regulatory processes. *Psychological Inquiry, 18*(4), 255-258.
Massey, O. T. (2011). A proposed model for the analysis and interpretation of focus groups in evaluation research. *Evaluation and Program Planning, 34*(1), 21-28.
Matthews, C. E., Ainsworth, B. E., Thompson, R. W., & Bassett, J. D. R. (2002). Sources of variance in daily physical activity levels as measured by an accelerometer. *Medicine and Science in Sports and Exercise, 34*(8), 1376-1381.
McAuley, E., Katula, J., Mihalko, S. L., Blissmer, B., Duncan, T. E., Pena, M., & Dunn, E. (1999). Mode of physical activity and self-efficacy in older adults: A latent growth curve analysis. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 54*(5), P283-P292.
McBee, L. (2008). *Mindfulness-based elder care: A CAM model for frail elders and their caregivers*. New York, NY: Springer Publishing Co.
McBee, L. (2009). Mindfulness-based elder care: Communicating mindfulness to frail elders and their caregivers. In F. Didonna (Ed.), *Clinical handbook of mindfulness* (pp. 431-445). New York, NY: Springer.
McIntosh, C. N. (2007). Rethinking fit assessment in structural equation modelling: A commentary and elaboration on Barrett (2007). *Personality and Individual Differences, 42*(5), 859-867.

McIntosh, T., Hunter, D. J., & Royce, S. (2016). Barriers to physical activity in obese adults: A rapid evidence assessment. *Journal of Research in Nursing, 21*(4), 271-287.
McIver, S., O'Halloran, P., & McGartland, M. (2009). Yoga as a treatment for binge eating disorder: A preliminary study. *Complementary Therapies in Medicine, 17*(4), 196-202.
McLeod, J. (2011). *Qualitative research in counselling and psychotherapy*: Sage.
Medvedev, O. N., Krägeloh, C. U., Narayanan, A., & Siegert, R. J. (2017). Measuring mindfulness: Applying generalizability theory to distinguish between state and trait. *Mindfulness, 8*(4), 1036-1046.
Meiklejohn, J., Phillips, C., Freedman, M. L., Griffin, M. L., Biegel, G., Roach, A., . . . Saltzman, A. (2012). Integrating mindfulness training into K-12 education: Fostering the resilience of teachers and students. *Mindfulness, 3*(4), 291-307.
Metcalf, B., Henley, W., & Wilkin, T. (2012). Effectiveness of intervention on physical activity of children: Systematic review and meta-analysis of controlled trials with objectively measured outcomes (EarlyBird 54). *BMJ, 345*, e5888.
Meyer, J. D., Torres, E. R., Grabow, M. L., Zgierska, A. E., Teng, H. Y., Coe, C. L., & Barrett, B. P. (2018). Benefits of 8-wk mindfulness-based stress reduction or aerobic training on seasonal declines in physical activity. *Medicine and Science in Sports and Exercise, 50*(9), 1850-1858.
Michie, S., & Abraham, C. (2004). Interventions to change health behaviours: Evidence-based or evidence-inspired? *Psychology & Health, 19*(1), 29-49.
Michie, S., Abraham, C., Whittington, C., McAteer, J., & Gupta, S. (2009). Effective techniques in healthy eating and physical activity interventions: A meta-regression. *Health Psychology, 28*(6), 690-701.
Miles, J., & Shevlin, M. (2001). *Applying regression and correlation: A guide for students and researchers*. London: Sage.
Miller, C. K., Kristeller, J. L., Headings, A., Nagaraja, H., & Miser, W. F. (2012). Comparative effectiveness of a mindful eating intervention to a diabetes self-management intervention among adults with type 2 diabetes: A pilot study. *Journal of the Academy of Nutrition and Dietetics, 112*(11), 1835-1842.
Mirams, L., Poliakoff, E., Brown, R. J., & Lloyd, D. M. (2013). Brief body-scan meditation practice improves somatosensory perceptual decision making. *Consciousness and Cognition, 22*(1), 348-359.
Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology, 41*(1), 49-100.
Moffitt, R., & Mohr, P. (2015). The efficacy of a self-managed acceptance and commitment therapy intervention DVD for physical activity initiation. *British Journal of Health Psychology, 20*(1), 115-129.
Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & The Prisma Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine, 6*(7), e1000097.
Monninkhof, E. M., Elias, S. G., Vlems, F. A., van der Tweel, I., Schuit, A. J., Voskuil, D. W., & van Leeuwen, F. E. (2007). Physical activity and breast cancer: A systematic review. *Epidemiology*, 137-157.
Monteiro, L., & Musten, F. (2013). *Mindfulness starts here: An eight-week guide to skillful living*. Victoria: Friesen.
Monteiro, L., Nuttall, S., & Musten, F. (2010). Five skilful habits: An ethics-based mindfulness intervention. *Counselling and Spirituality, 29*(1), 91-103.
Monteiro, L. M., Musten, R. F., & Compson, J. (2015). Traditional and contemporary mindfulness: Finding the middle path in the tangle of concerns. *Mindfulness, 6*(1), 1-13.
Moor, K. R., Scott, A. J., & McIntosh, W. D. (2013). Mindful eating and its relationship to body mass index and physical activity among university students. *Mindfulness, 4*(3), 269-274.
Moore, A., & Malinowski, P. (2009). Meditation, mindfulness and cognitive flexibility. *Consciousness and Cognition, 18*, 176-186.
Moore, A. W., Gruber, T., Derose, J., & Malinowski, P. (2012). Regular, brief mindfulness meditation practice improves electrophysiological markers of attentional control. *Frontiers in Human Neuroscience, 6*, 18.
Morgan, D. L. (1996). *Focus groups as qualitative research* (Vol. 16). London: Sage.

Morgan, T. A., Dalrymple, K., Multach, M., & Zimmerman, M. (2017). Relations between mindfulness processes, psychiatric symptoms, and functioning in psychiatric and pre-bariatric surgery outpatients. *Mindfulness, 8*(2), 417-432.
Mothes, H., Klaperski, S., Seelig, H., Schmidt, S., & Fuchs, R. (2014). Regular aerobic exercise increases dispositional mindfulness in men: A randomized controlled trial. *Mental Health and Physical Activity, 7*(2), 111-119.
Mrazek, M. D., Franklin, M. S., Phillips, D. T., Baird, B., & Schooler, J. W. (2013). Mindfulness training improves working memory capacity and GRE performance while reducing mind wandering. *Psychological Science, 24*(5), 776-781.
Muraven, M., Baumeister, R. F., & Tice, D. M. (1999). Longitudinal improvement of self-regulation through practice: Building self-control strength through repeated exercise. *The Journal of social psychology, 139*(4), 446-457.
Murphy, C., & MacKillop, J. (2012). Living in the here and now: Interrelationships between impulsivity, mindfulness, and alcohol misuse. *Psychopharmacology, 219*(2), 527-536.
Murphy, M. J., Mermelstein, L. C., Edwards, K. M., & Gidycz, C. A. (2012). The benefits of dispositional mindfulness in physical health: A longitudinal study of female college students. *Journal of American College Health, 60*(5), 341-348.
Musial, F., Büssing, A., Heusser, P., Choi, K.-E., & Ostermann, T. (2011). Mindfulness-based stress reduction for integrative cancer care: A summary of evidence. *Research in Complementary Medicine, 18*(4), 192-202.
Nanamoli, B., & Bodhi, B. (1995). *The middle length discourses of the Buddha: A translation of the Majjhima Nikaya*. Somerville, MA: Wisdom Publication.
Napolitano, M. A., Papandonatos, G. D., Borradaile, K. E., Whiteley, J. A., & Marcus, B. H. (2011). Effects of weight status and barriers on physical activity adoption among previously inactive women. *Obesity, 19*(11), 2183-2189.
National Health Services. (2016a). Obesity. Retrieved from https://www.nhs.uk/conditions/obesity/
National Health Services. (2016b). Physical activity guidelines for adults. Retrieved from http://www.nhs.uk/Livewell/fitness/Pages/physical-activity-guidelines-for-adults.aspx
National Health Services. (2018). Benefits of exercise. Retrieved from https://www.nhs.uk/live-well/exercise/exercise-health-benefits/
Neff, K. D. (2003). The development and validation of a scale to measure self-compassion. *Self and identity, 2*(3), 223-250.
Neff, K. D., & Davidson, O. (2016). Self-compassion. In I. Ivtzan & T. Lomas (Eds.), *Mindfulness in Positive Psychology: The Science of Meditation and Wellbeing*: Routledge.
Neff, K. D., & Germer, C. K. (2013). A pilot study and randomized controlled trial of the mindful self-compassion program. *Journal of Clinical Psychology, 69*(1), 28-44.
Ng, J. Y. Y., Ntoumanis, N., Thøgersen-Ntoumani, C., Deci, E. L., Ryan, R. M., Duda, J. L., & Williams, G. C. (2012). Self-determination theory applied to health contexts: A meta-analysis. *Perspectives on Psychological Science, 7*(4), 325-340.
Nielsen, L., Riddle, M., King, J. W., Aklin, W. M., Chen, W., Clark, D., . . . Ferrer, R. (2018). The NIH Science of Behavior Change Program: Transforming the science through a focus on mechanisms of change. *Behaviour Research and Therapy, 101*, 3-11.
Niemiec, R. M., & Lissing, J. (2016). Mindfulness-based strengths practice (MBSP) for enhancing well-being, managing problems, and boosting positive relationships. In I. Ivtzan & T. Lomas (Eds.), *Mindfulness in Positive Psychology: The Science of Meditation and Wellbeing* (pp. 15-36). New York, NY: Routledge.
Noar, S. M., Benac, C. N., & Harris, M. S. (2007). Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions. *Psychological Bulletin, 133*(4), 673-693.
Ntoumanis, N. (2012). A self-determination theory perspective on motivation in sport and physical education: Current trends and possible future research directions. In G. C. Roberts & D. C. Treasure (Eds.), *Motivation in sport and exercise* (Vol. 3, pp. 91-128). Champaign, IL: Human Kinetics.
O'Reilly, G. A., Cook, L., Spruijt-Metz, D., & Black, D. S. (2014). Mindfulness-based interventions for obesity-related eating behaviours: A literature review. *Obesity Reviews, 15*(6), 453-461.
Oberle, E., Schonert-Reichl, K. A., Lawlor, M. S., & Thomson, K. C. (2012). Mindfulness and inhibitory control in early adolescence. *The Journal of Early Adolescence, 32*(4), 565-588.

Ohkawara, K., Tanaka, S., Miyachi, M., Ishikawa-Takata, K., & Tabata, I. (2007). A dose-response relation between aerobic exercise and visceral fat reduction: Systematic review of clinical trials. *International Journal of Obesity, 31*(12), 1786-1797.

Ojiambo, R. M. E. (2013). Physical activity and well-being: A review of the health benefits of physical activity on health outcomes. *Journal of Applied Medical Sciences, 2*(2), 69-78.

Olson, K. L., & Emery, C. F. (2015). Mindfulness and weight loss: A systematic review. *Psychosomatic Medicine, 77*(1), 59-67.

Ott, M. J., Norris, R. L., & Bauer-Wu, S. M. (2006). Mindfulness meditation for oncology patients: A discussion and critical review. *Integrative Cancer Therapies, 5*(2), 98-108.

Paffenbarger, J. R. S., Hyde, R. T., Wing, A. L., Lee, I.-M., Jung, D. L., & Kampert, J. B. (1993). The association of changes in physical-activity level and other lifestyle characteristics with mortality among men. *New England Journal of Medicine, 328*(8), 538-545.

Paffenbarger, J. R. S., Kampert, J. B., Lee, I.-M., Hyde, R. T., Leung, R. W., & Wing, A. L. (1994). Changes in physical activity and other lifeway patterns influencing longevity. *Medicine and Science in Sports and Exercise, 26*(7), 857-865.

Palmeira, L., Pinto-Gouveia, J., & Cunha, M. (2017). Exploring the efficacy of an acceptance, mindfulness and compassionate-based group intervention for women struggling with their weight (Kg-Free): A randomized controlled trial. *Appetite, 112*, 107-116.

Parfitt, G., Rose, E. A., & Burgess, W. M. (2006). The psychological and physiological responses of sedentary individuals to prescribed and preferred intensity exercise. *British Journal of Health Psychology, 11*(1), 39-53.

Pasco, J. A., Jacka, F. N., Williams, L. J., Brennan, S. L., Leslie, E., & Berk, M. (2011). Don't worry, be active: Positive affect and habitual physical activity. *Australian and New Zealand Journal of Psychiatry, 45*(12), 1047-1052.

Patton, J. H., & Stanford, M. S. (1995). Factor structure of the Barratt Impulsiveness Scale. *Journal of Clinical Psychology, 51*(6), 768-774.

Patton, M. Q. (1990). *Qualitative evaluation and research methods*: Sage.

Peacock, J. C., Sloan, S. S., & Cripps, B. (2014). A qualitative analysis of bariatric patients' post-surgical barriers to exercise. *Obesity Surgery, 24*(2), 292-298.

Peek, L., & Fothergill, A. (2009). Using focus groups: Lessons from studying daycare centers, 9/11, and Hurricane Katrina. *Qualitative Research, 9*(1), 31-59.

Penedo, F. J., & Dahn, J. R. (2005). Exercise and well-being: A review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry, 18*(2), 189-193.

Peters, J. R., Erisman, S. M., Upton, B. T., Baer, R. A., & Roemer, L. (2011). A preliminary investigation of the relationships between dispositional mindfulness and impulsivity. *Mindfulness, 2*(4), 228-235.

Peterson, C. (2014). Mindfulness-based art therapy. In L. Rappaport (Ed.), *Mindfulness and the art therapies: Theory and practice* (pp. 42-58): Jessica Kingsley Publishers.

Peterson, C., & Seligman, M. E. P. (2004). *Character strengths and virtues: A handbook and classification*. Oxford: Oxford University Press.

Piana, N., Battistini, D., Urbani, L., Romani, G., Fatone, C., Pazzagli, C., . . . De Feo, P. (2013). Multidisciplinary lifestyle intervention in the obese: Its impact on patients' perception of the disease, food and physical exercise. *Nutrition, Metabolism and Cardiovascular Diseases, 23*(4), 337-343.

Piet, J., & Hougaard, E. (2011). The effect of mindfulness-based cognitive therapy for prevention of relapse in recurrent major depressive disorder: A systematic review and meta-analysis. *Clinical Psychology Review, 31*(6), 1032-1040.

Pozuelos, J. P., Mead, B. R., Rueda, M. R., & Malinowski, P. (2019). Short-term mindful breath awareness training improves inhibitory control and response monitoring. *Progress in Brain Research, 244*, 137-163.

Preacher, K. J. (2010). Latent growth curve models. In G. R. Hancock, R. O. Mueller, & L. M. Stapleton (Eds.), *The reviewer's guide to quantitative methods in the social sciences* (Vol. 1, pp. 185-198). London: Routledge.

Prestwich, A., Perugini, M., & Hurling, R. (2009). Can the effects of implementation intentions on exercise be enhanced using text messages? *Psychology & Health, 24*(6), 677-687.

Prichard, I., & Tiggemann, M. (2008). Relations among exercise type, self-objectification, and body image in the fitness centre environment: The role of reasons for exercise. *Psychology of Sport and Exercise, 9*(6), 855-866.

Prochaska, J. O., Redding, C. A., & Evers, K. E. (2015). The transtheoretical model and stages of change. In K. Glanz, B. K. Rimer, & K. Viswanath (Eds.), *Health behaviour: Theory, research, and practice* (pp. 125-148). San Francisco, CA: John Wiley & Sons.

Quaglia, J. T., Braun, S. E., Freeman, S. P., McDaniel, M. A., & Brown, K. W. (2016). Meta-analytic evidence for effects of mindfulness training on dimensions of self-reported dispositional mindfulness. *Psychological Assessment, 28*(7), 803-818.

Quaglia, J. T., Brown, K. W., Lindsay, E. K., Creswell, J. D., & Goodman, R. J. (2015). From conceptualization to operationalization of mindfulness. In K. W. Brown, J. D. Creswell, & R. M. Ryan (Eds.), *Handbook of mindfulness: Theory, research, and practice* (pp. 151-170). New York; London: Guilford Press.

Raja-Khan, N., Agito, K., Shah, J., Stetter, C. M., Gustafson, T. S., Socolow, H., . . . Legro, R. S. (2017). Mindfulness-based stress reduction in women with overweight or obesity: A randomized clinical trial. *Obesity, 25*(8), 1349-1359.

Ratey, J. J., & Loehr, J. E. (2011). The positive impact of physical activity on cognition during adulthood: A review of underlying mechanisms, evidence and recommendations. *Reviews in the Neurosciences, 22*(2), 171-185.

Rau, H. K., & Williams, P. G. (2016). Dispositional mindfulness: A critical review of construct validation research. *Personality and Individual Differences, 93*, 32-43.

Rhodes, R. E., & Dickau, L. (2012). Experimental evidence for the intention–behavior relationship in the physical activity domain: A meta-analysis. *Health Psychology, 31*(6), 724-727.

Rhodes, R. E., Fiala, B., & Conner, M. (2009). A review and meta-analysis of affective judgments and physical activity in adult populations. *Annals of Behavioral Medicine, 38*(3), 180-204.

Rhodes, R. E., Janssen, I., Bredin, S. S., Warburton, D. E., & Bauman, A. (2017). Physical activity: Health impact, prevalence, correlates and interventions. *Psychology & Health, 32*(8), 942-975.

Rhodes, R. E., & Kates, A. (2015). Can the affective response to exercise predict future motives and physical activity behavior? A systematic review of published evidence. *Annals of Behavioral Medicine, 49*(5), 715-731.

Rhodes, R. E., & Pfaeffli, L. A. (2010). Mediators of physical activity behaviour change among adult non-clinical populations: A review update. *International Journal of Behavioral Nutrition and Physical Activity, 7*(1), 37.

Ridgers, N. D., Knowles, Z. R., & Sayers, J. (2012). Encouraging play in the natural environment: A child-focused case study of Forest School. *Children's Geographies, 10*(1), 49-65.

Riggs, N. R., Black, D. S., & Ritt-Olson, A. (2015). Associations between dispositional mindfulness and executive function in early adolescence. *Journal of Child and Family Studies, 24*(9), 2745-2751.

Rimer, J., Dwan, K., Lawlor, D. A., Greig, C. A., McMurdo, M., Morley, W., & Mead, G. E. (2012). Exercise for depression. *Cochrane Database of Systematic Reviews*(7).

Ritchie, T. D., & Bryant, F. B. (2012). Positive state mindfulness: A multidimensional model of mindfulness in relation to positive experience. *International Journal of Wellbeing, 2*(3), 150-181.

Roberts, K. C., & Danoff-Burg, S. (2010). Mindfulness and health behaviors: Is paying attention good for you? *Journal of American College Health, 59*(3), 165-173.

Robins, C. J., & Rosenthal, M. Z. (2011). Dialectical behavior therapy. In J. D. Herbert & E. M. Forman (Eds.), *Acceptance and mindfulness in Cognitive Behavior Therapy: Understanding and applying the new therapies* (pp. 164-192). Hoboken, NJ: John Wiley & Sons, Inc.

Rodgers, A., Corbett, T., Bramley, D., Riddell, T., Wills, M., Lin, R.-B., & Jones, M. (2005). Do u smoke after txt? Results of a randomised trial of smoking cessation using mobile phone text messaging. *Tobacco Control, 14*(4), 255-261.

Roesch, S. C., Norman, G. J., Adams, M. A., Kerr, J., Sallis, J. F., Ryan, S., . . . Patrick, K. (2009). Latent growth curve modeling of adolescent physical activity: Testing parallel process and mediation models. *Journal of Health Psychology, 14*(2), 313-325.

Rose, E. A., & Parfitt, G. (2007). A quantitative analysis and qualitative explanation of the individual differences in affective responses to prescribed and self-selected exercise intensities. *Journal of Sport & Exercise Psychology, 29*(3), 281-309.

Rosenbaum, S., Tiedemann, A., & Ward, P. B. (2014). Meta-analysis physical activity interventions for people with mental illness: A systematic review and meta-analysis. *Journal of Clinical Psychiatry, 75*(9), 964-974.

Rosenkranz, M. A., Dunne, J. D., & Davidson, R. J. (2019). The next generation of mindfulness-based intervention research: What have we learned and where are we headed? *Current opinion in psychology, 28*, 179–183.

Ross, A., & Thomas, S. (2010). The health benefits of yoga and exercise: A review of comparison studies. *Journal of Alternative and Complementary Medicine, 16*(1), 3-12.

Ruffault, A., Bernier, M., Juge, N., & Fournier, J. F. (2016a). Mindfulness may moderate the relationship between intrinsic motivation and physical activity: A cross-sectional study. *Mindfulness, 7*(2), 445-452.

Ruffault, A., Bernier, M., Thiénot, E., Fournier, J. F., & Flahault, C. (2017). Exploring the links between mindfulness skills, physical activity, signs of anxiety, and signs of depression among non-clinical participants. *Journal de Thérapie Comportementale et Cognitive, 27*(1), 16-24.

Ruffault, A., Czernichow, S., Hagger, M. S., Ferrand, M., Erichot, N., Carette, C., . . . Flahault, C. (2016b). The effects of mindfulness training on weight-loss and health-related behaviours in adults with overweight and obesity: A systematic review and meta-analysis. *Obesity Research & Clinical Practice, 11*(5), 90-111.

Ryan, R. M. (1995). Psychological needs and the facilitation of integrative processes. *Journal of Personality, 63*(3), 397-427.

Ryan, R. M., & Connell, J. P. (1989). Perceived locus of causality and internalization: Examining reasons for acting in two domains. *Journal of Personality and Social Psychology, 57*(5), 749-761.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68-78.

Ryan, R. M., Williams, G. C., Patrick, H., & Deci, E. L. (2009). Self-determination theory and physical activity: The dynamics of motivation in development and wellness. *Hellenic Journal of Psychology, 6*, 107-124.

Rzewnicki, R., Auweele, Y. V., & De Bourdeaudhuij, I. (2003). Addressing overreporting on the International Physical Activity Questionnaire (IPAQ) telephone survey with a population sample. *Public Health Nutrition, 6*(3), 299-305.

Sagui-Henson, S. J., Levens, S. M., & Blevins, C. L. (2018). Examining the psychological and emotional mechanisms of mindfulness that reduce stress to enhance healthy behaviours. *Stress and Health, 34*(3), 1-12.

Sahdra, B. K., Shaver, P. R., & Brown, K. W. (2010). A scale to measure nonattachment: A Buddhist complement to Western research on attachment and adaptive functioning. *Journal of Personality Assessment, 92*(2), 116-127.

Sala, M., Rochefort, C., Priscilla Lui, P., & Baldwin, A. S. (2019). Trait mindfulness and health behaviors: A meta-analysis. *Health Psychology Review*.

Sallis, J. F., & Owen, N. (2015). Ecological models of health behavior. In K. Glanz, B. K. Rimer, & K. Viswanath (Eds.), *Health behavior: Theory, research, and practice* (Vol. 5, pp. 43-64): Jossey-Bass.

Salmoirago-Blotcher, E., Druker, S., Frisard, C., Dunsiger, S. I., Crawford, S., Meleo-Meyer, F., . . . Pbert, L. (2018). Integrating mindfulness training in school health education to promote healthy behaviors in adolescents: Feasibility and preliminary effects on exercise and dietary habits. *Preventive Medicine Reports, 9*, 92-95.

Salmoirago-Blotcher, E., Hunsinger, M., Morgan, L., Fischer, D., & Carmody, J. (2013). Mindfulness-based stress reduction and change in health-related behaviors. *Journal of Evidence-Based Complementary & Alternative Medicine, 18*(4), 243-247.

Salmon, J., Owen, N., Crawford, D., Bauman, A., & Sallis, J. F. (2003). Physical activity and sedentary behavior: A population-based study of barriers, enjoyment, and preference. *Health Psychology, 22*(2), 178-188.

Salmon, P., Hanneman, S., & Harwood, B. (2010). Associative/dissociative cognitive strategies in sustained physical activity: Literature review and proposal for a mindfulness-based conceptual model. *Sport Psychology, 24*(2), 127-156.

Santos-Lozano, A., Marín, P. J., Torres-Luque, G., Ruiz, J. R., Lucía, A., & Garatachea, N. (2012). Technical variability of the GT3X accelerometer. *Medical Engineering and Physics, 34*(6), 787-790.

Sappington, R., & Longshore, K. (2015). Systematically reviewing the efficacy of mindfulness-based interventions for enhanced athletic performance. *Journal of Clinical Sport Psychology, 9*(3), 232-262.

Sasaki, J. E., John, D., & Freedson, P. S. (2011). Validation and comparison of ActiGraph activity monitors. *Journal of Science and Medicine in Sport, 14*(5), 411-416.

Sauer, S., Walach, H., Schmidt, S., Hinterberger, T., Lynch, S., Büssing, A., & Kohls, N. (2013). Assessment of mindfulness: Review on state of the art. *Mindfulness, 4*(1), 3-17.

Saxe, G. A., HÉbert, J. R., Carmody, J. F., Kabat-Zinn, J., Rosenzweig, P. H., Jarzobski, D., . . . Blute, R. D. (2001). Can diet in conjunction with stress reduction affect the rate of increase in prostate specific antigen after biochemical recurrence of prostate cancer? *Journal of Urology, 166*(6), 2202-2207.

Schermelleh-Engel, K., Moosbrugger, H., & Müller, H. (2003). Evaluating the fit of structural equation models: Tests of significance and descriptive goodness-of-fit measures. *Methods of psychological research online, 8*(2), 23-74.

Schneider, J., Malinowski, P., Watson, P. M., & Lattimore, P. (2018). The role of mindfulness in physical activity: A systematic review. *Obesity Reviews, 20*(3), 448-463.

Schneider, M., Dunn, A., & Cooper, D. (2009). Affect, exercise, and physical activity among healthy adolescents. *Journal of Sport & Exercise Psychology, 31*(6), 706-723.

Schöne, B., Gruber, T., Graetz, S., Bernhof, M., & Malinowski, P. (2018). Mindful breath awareness meditation facilitates efficiency gains in brain networks: A steady-state visually evoked potentials study. *Scientific Reports, 8*(1), 13687.

Schreiber, J. B., Nora, A., Stage, F. K., Barlow, E. A., & King, J. (2006). Reporting structural equation modeling and confirmatory factor analysis results: A review. *The Journal of educational research, 99*(6), 323-338.

Schwarzer, R. (2008). Modeling health behavior change: How to predict and modify the adoption and maintenance of health behaviors. *Applied psychology, 57*(1), 1-29.

Sedlmeier, P., Eberth, J., Schwarz, M., Zimmermann, D., Haarig, F., Jaeger, S., & Kunze, S. (2012). The psychological effects of meditation: A meta-analysis. *Psychological Bulletin, 138*(6), 1139-1171.

Sedlmeier, P., Loße, C., & Quasten, L. C. (2018). Psychological effects of meditation for healthy practitioners: An update. *Mindfulness, 9*(2), 371-387.

Segal, Z. V., Williams, J. M. G., & Teasdale, J. D. (2002). *Mindfulness-based cognitive therapy for depression: A new approach to relapse prevention*. New York, NY: Guilford.

Seligman, M. E. P., & Csikszentmihalyi, M. (2000). Positive psychology: An introduction. *American Psychologist, 55*(1), 5-14.

Semple, R. J. (2010). Does mindfulness meditation enhance attention? A randomized controlled trial. *Mindfulness, 1*(2), 121-130.

Sesso, H. D., Paffenbarger, J. R. S., & Lee, I.-M. (2000). Physical activity and coronary heart disease in men: The Harvard Alumni Health Study. *Circulation, 102*(9), 975-980.

Shapiro, D. H. (1992). A preliminary study of long-term meditators: Goals, effects, religious orientation, cognitions. *Journal of Transpersonal Psychology, 24*(1), 23-39.

Shapiro, S. L., & Carlson, L. E. (2009). *The art and science of mindfulness*. Washington, DC: American Psychological Association.

Shapiro, S. L., Carlson, L. E., Astin, J. A., & Freedman, B. (2006). Mechanisms of mindfulness. *Journal of Clinical Psychology, 62*(3), 373-386.

Shapiro, S. L., & Schwartz, G. E. (2000). Intentional systemic mindfulness: An integrative model for self-regulation and health. *Advances in Mind-Body Medicine, 16*(2), 128-134.

Sharf, R. H. (2015). Is mindfulness Buddhist? (and why it matters). *Transcultural psychiatry, 52*(4), 470-484.

Sharma, M., & Rush, S. E. (2014). Mindfulness-based stress reduction as a stress management intervention for healthy individuals: A systematic review. *Journal of Evidence-Based Complementary & Alternative Medicine, 19*(4), 271-286.

Shaya, F. T., Flores, D., Gbarayor, C. M., & Wang, J. (2008). School-based obesity interventions: A literature review. *Journal of School Health, 78*(4), 189-196.

Shennan, C., Payne, S., & Fenlon, D. (2011). What is the evidence for the use of mindfulness-based interventions in cancer care? A review. *Psycho-Oncology, 20*(7), 681-697.

Shields, S. A., Mallory, M. E., & Simon, A. (1989). The Body Awareness Questionnaire: Reliability and validity. *Journal of Personality Assessment, 53*(4), 802-815.

Shonin, E., & Van Gordon, W. (2015). Managers' experiences of meditation awareness training. *Mindfulness, 6*(4), 899-909.

Shonin, E., Van Gordon, W., & Griffiths, M. D. (2014). Do mindfulness-based therapies have a role in the treatment of psychosis? *Australian and New Zealand Journal of Psychiatry, 48*(2), 124-127.

Singh, N. N., Lancioni, G. E., Singh, A. N., Winton, A. S. W., Singh, J., McAleavey, K. M., . . . Joy, S. D. S. (2008). A mindfulness-based health wellness program for managing morbid obesity. *Clinical Case Studies, 7*(4), 327-339.

Singh, N. N., Lancioni, G. E., Winton, A. S., Karazsia, B. T., Myers, R. E., Latham, L. L., & Singh, J. (2014). Mindfulness-based positive behavior support (MBPBS) for mothers of adolescents with autism spectrum disorder: Effects on adolescents' behavior and parental stress. *Mindfulness, 5*(6), 646-657.

Singh, N. N., Lancioni, G. E., Winton, A. S., Singh, A. N., Singh, J., & Singh, A. D. (2011). Effects of a mindfulness-based smoking cessation program for an adult with mild intellectual disability. *Research in Developmental Disabilities, 32*(3), 1180-1185.

Singh, N. N., Lancioni, G. E., Winton, A. S., Wahler, R. G., Singh, J., & Sage, M. (2004). Mindful caregiving increases happiness among individuals with profound multiple disabilities. *Research in Developmental Disabilities, 25*(2), 207-218.

Sirois, F. M. (2015). A self-regulation resource model of self-compassion and health behavior intentions in emerging adults. *Preventive Medicine Reports, 2*, 218-222.

Sirois, F. M., Kitner, R., & Hirsch, J. K. (2015). Self-compassion, affect, and health-promoting behaviors. *Health Psychology, 34*(6), 661-669.

Slagter, H. A., Davidson, R. J., & Lutz, A. (2011). Mental training as a tool in the neuroscientific study of brain and cognitive plasticity. *Frontiers in Human Neuroscience, 5*, 17.

Slonim, J., Kienhuis, M., Di Benedetto, M., & Reece, J. (2015). The relationships among self-care, dispositional mindfulness, and psychological distress in medical students. *Medical Education Online, 20*(1), 27924.

Smallwood, J., McSpadden, M., & Schooler, J. W. (2007). The lights are on but no one's home: Meta-awareness and the decoupling of attention when the mind wanders. *Psychonomic Bulletin and Review, 14*(3), 527-533.

Smith, B. (2010). Narrative inquiry: Ongoing conversations and questions for sport and exercise psychology research. *International review of sport and exercise psychology, 3*(1), 87-107.

Smith, B., & McGannon, K. R. (2018). Developing rigor in qualitative research: Problems and opportunities within sport and exercise psychology. *International review of sport and exercise psychology, 11*(1), 101-121.

Smith, J. E., Richardson, J., Hoffman, C., & Pilkington, K. (2005). Mindfulness-based stress reduction as supportive therapy in cancer care: Systematic review. *Journal of Advanced Nursing, 52*(3), 315-327.

Smith, P. J., Blumenthal, J. A., Hoffman, B. M., Cooper, H., Strauman, T. A., Welsh-Bohmer, K., . . . Sherwood, A. (2010). Aerobic exercise and neurocognitive performance: A meta-analytic review of randomized controlled trials. *Psychosomatic Medicine, 72*(3), 239-252.

Sniehotta, F. F., Scholz, U., & Schwarzer, R. (2005). Bridging the intention–behaviour gap: Planning, self-efficacy, and action control in the adoption and maintenance of physical exercise. *Psychology & Health, 20*(2), 143-160.

Solloway, S. G., & Fisher, W. P. (2007). Mindfulness practice: A Rasch variable construct innovation. *Journal of Applied Measurement, 8*(4), 359-372.

Sparkes, A. C., & Smith, B. (2009). Judging the quality of qualitative inquiry: Criteriology and relativism in action. *Psychology of Sport and Exercise, 10*(5), 491-497.

Spector, D., Battaglini, C., Alsobrooks, A., Owen, J., & Groff, D. (2012). Do breast cancer survivors increase their physical activity and enhance their health-related quality of life after attending community-based wellness workshops? *Journal of Cancer Education, 27*(2), 353-361.

Spence, J. C., & Lee, R. E. (2003). Toward a comprehensive model of physical activity. *Psychology of Sport and Exercise, 4*(1), 7-24.

Spijkerman, M. P. J., Pots, W. T. M., & Bohlmeijer, E. T. (2016). Effectiveness of online mindfulness-based interventions in improving mental health: A review and meta-analysis of randomised controlled trials. *Clinical Psychology Review, 45*, 102-114.

Spinella, M. (2007). Normative data and a short form of the Barratt Impulsiveness Scale. *International Journal of Neuroscience, 117*(3), 359-368.

Stadler, G., Oettingen, G., & Gollwitzer, P. M. (2009). Physical activity in women: Effects of a self-regulation intervention. *American Journal of Preventive Medicine, 36*(1), 29-34.

Standage, M., Gillison, F. B., Ntoumanis, N., & Treasure, D. C. (2012). Predicting students' physical activity and health-related well-being: A prospective cross-domain investigation of motivation across school physical education and exercise settings. *Journal of Sport & Exercise Psychology, 34*(1), 37-60.

Standage, M., Sebire, S. J., & Loney, T. (2008). Does exercise motivation predict engagement in objectively assessed bouts of moderate-intensity exercise?: A self-determination theory perspective. *Journal of Sport and Exercise Psychology, 30*(4), 337-352.

Stanford, M. S., Mathias, C. W., Dougherty, D. M., Lake, S. L., Anderson, N. E., & Patton, J. H. (2009). Fifty years of the Barratt Impulsiveness Scale: An update and review. *Personality and Individual Differences, 47*(5), 385-395.

Stanley, E. A., Schaldach, J. M., Kiyonaga, A., & Jha, A. P. (2011). Mindfulness-based mind fitness training: A case study of a high-stress predeployment military cohort. *Cognitive and Behavioral Practice, 18*(4), 566-576.

Stokols, D. (1996). Translating social ecological theory into guidelines for community health promotion. *American Journal of Health Promotion, 10*(4), 282-298.

Streiner, D. L. (2006). Building a better model: An introduction to structural equation modelling. *The Canadian Journal of Psychiatry, 51*(5), 317-324.

Ströhle, A. (2009). Physical activity, exercise, depression and anxiety disorders. *Journal of Neural Transmission, 116*(6), 777.

Strowger, M., Kiken, L. G., & Ramcharran, K. (2018). Mindfulness meditation and physical activity: Evidence from 2012 National Health Interview Survey. *Health Psychology, 37*(10), 924-928.

Sundquist, J., Lilja, Å., Palmér, K., Memon, A. A., Wang, X., Johansson, L. M., & Sundquist, K. (2015). Mindfulness group therapy in primary care patients with depression, anxiety and stress and adjustment disorders: Randomised controlled trial. *British Journal of Psychiatry, 206*(2), 128-135.

Swain, D. P. (2005). Moderate or vigorous intensity exercise: Which is better for improving aerobic fitness? *Preventive Cardiology, 8*(1), 55-58.

Tabachnik, B. G., & Fidell, S. L. (2007). *Using multivariate statistics* (Vol. 201). Boston: Pearson Education Inc.

Tanaka, J. S. (1987). " How big is big enough?": Sample size and goodness of fit in structural equation models with latent variables. *Child Development, 58*(1), 134-146.

Tanay, G., & Bernstein, A. (2013). State Mindfulness Scale (SMS): Development and initial validation. *Psychological Assessment, 25*(4), 1286-1299.

Tang, Y.-Y., Hölzel, B. K., & Posner, M. I. (2015). The neuroscience of mindfulness meditation. *Nature Reviews Neuroscience, 16*(4), 213-225.

Tang, Y.-Y., Ma, Y., Wang, J., Fan, Y., Feng, S., Lu, Q., . . . Fan, M. (2007). Short-term meditation training improves attention and self-regulation. *Proceedings of the national Academy of Sciences, 104*(43), 17152-17156.

Tang, Y.-Y., & Posner, M. I. (2014). Training brain networks and states. *Trends in Cognitive Sciences, 18*(7), 345-350.

Tang, Y.-Y., Yang, L., Leve, L. D., & Harold, G. T. (2012). Improving executive function and its neurobiological mechanisms through a mindfulness-based intervention: Advances within the field of developmental neuroscience. *Child Development Perspectives, 6*(4), 361-366.

Tangney, J. P., Baumeister, R. F., & Boone, A. L. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality, 72*(2), 271-324.

Tapper, K., & Ahmed, Z. (2018). A mindfulness-based decentering technique increases the cognitive accessibility of health and weight loss related goals. *Frontiers in Psychology, 9*, 587-594.

Tapper, K., Shaw, C., Ilsley, J., Hill, A. J., Bond, F. W., & Moore, L. (2009). Exploratory randomised controlled trial of a mindfulness-based weight loss intervention for women. *Appetite, 52*(2), 396-404.

Tate, D. F., Jeffery, R. W., Sherwood, N. E., & Wing, R. R. (2007). Long-term weight losses associated with prescription of higher physical activity goals. Are higher levels of physical activity protective against weight regain? *The American journal of clinical nutrition, 85*(4), 954-959.

Teasdale, J. D., Moore, R. G., Hayhurst, H., Pope, M., Williams, S., & Segal, Z. V. (2002). Metacognitive awareness and prevention of relapse in depression: Empirical evidence. *Journal of Consulting and Clinical Psychology, 70*(2), 275-287.

Teasdale, J. D., Segal, Z. V., & Williams, J. M. G. (2003). Mindfulness training and problem formulation. *Clinical Psychology: Science and Practice, 10*(2), 157-160.

Teasdale, J. D., Segal, Z. V., Williams, J. M. G., Ridgeway, V. A., Soulsby, J. M., & Lau, M. A. (2000). Prevention of relapse/recurrence in major depression by mindfulness-based cognitive therapy. *Journal of Consulting and Clinical Psychology, 68*(4), 615-623.

Teixeira, P. J., Carraça, E. V., Markland, D., Silva, M. N., & Ryan, R. M. (2012). Exercise, physical activity, and self-determination theory: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 9*(1), 78-108.

Teixeira, P. J., Carraça, E. V., Marques, M. M., Rutter, H., Oppert, J.-M., De Bourdeaudhuij, I., . . . Brug, J. (2015). Successful behavior change in obesity interventions in adults: A systematic review of self-regulation mediators. *BMC Medicine, 13*, 84.

Teper, R., & Inzlicht, M. (2012). Meditation, mindfulness and executive control: The importance of emotional acceptance and brain-based performance monitoring. *Social Cognitive and Affective Neuroscience, 8*(1), 85-92.

Teper, R., Segal, Z. V., & Inzlicht, M. (2013). Inside the mindful mind: How mindfulness enhances emotion regulation through improvements in executive control. *Current Directions in Psychological Science, 22*(6), 449-454.

Teychenne, M., Ball, K., & Salmon, J. (2008). Physical activity and likelihood of depression in adults: A review. *Preventive Medicine, 46*(5), 397-411.

Thera, N. (2005). *The heart of buddhist meditation: Satipaṭṭhāna: A handbook of mental training based on the Buddha's way of mindfulness, with an anthology of relevant texts translated from the Pali and Sanskrit*: Buddhist Publication Society.

Thomas, B. H., Ciliska, D., Dobbins, M., & Micucci, S. (2004). A process for systematically reviewing the literature: Providing the research evidence for public health nursing interventions. *Worldviews on Evidence-Based Nursing, 1*(3), 176-184.

Thomas, S. L., Hyde, J., Karunaratne, A., Kausman, R., & Komesaroff, P. A. (2008). "They all work... when you stick to them": A qualitative investigation of dieting, weight loss, and physical exercise, in obese individuals. *Nutrition Journal, 7*(1), 34.

Thompson, B. L., & Waltz, J. (2007). Everyday mindfulness and mindfulness meditation: Overlapping constructs or not? *Personality and Individual Differences, 43*(7), 1875-1885.

Tice, D. M., Baumeister, R. F., Shmueli, D., & Muraven, M. (2007). Restoring the self: Positive affect helps improve self-regulation following ego depletion. *Journal of Experimental Social Psychology, 43*(3), 379-384.

Toivonen, K. I., Zernicke, K. J., & Carlson, L. E. (2017). Web-based mindfulness interventions for people with physical health conditions: Systematic review. *Journal of Medical Internet Research, 19*(8).

Tomarken, A. J., & Waller, N. G. (2005). Structural equation modeling: Strengths, limitations, and misconceptions. *Annual Review of Clinical Psychology, 1*, 31-65.

Treanor, M. (2011). The potential impact of mindfulness on exposure and extinction learning in anxiety disorders. *Clinical Psychology Review, 31*(4), 617-625.

Trost, S. G., Mciver, K. L., & Pate, R. R. (2005). Conducting accelerometer-based activity assessments in field-based research. *Medicine and Science in Sports and Exercise, 37*(11 Suppl), S531-543.

Trost, S. G., Owen, N., Bauman, A. E., Sallis, J. F., & Brown, W. (2002). Correlates of adults' participation in physical activity: Review and update. *Medicine and Science in Sports and Exercise, 34*(12), 1996-2001.

Tsafou, K.-E., De Ridder, D. T. D., Van Ee, R., & Lacroix, J. P. W. (2016a). Mindfulness and satisfaction in physical activity: A cross-sectional study in the Dutch population. *Journal of Health Psychology, 21*(9), 1817-1827.

Tsafou, K.-E., Lacroix, J. P. W., van Ee, R., Vinkers, C. D. V., & De Ridder, D. T. D. (2016b). The relation of trait and state mindfulness with satisfaction and physical activity: A cross-sectional study in 305 Dutch participants. *Journal of Health Psychology, 22*(10), 1221-1232.

Tudor-Locke, C., Brashear, M. M., Johnson, W. D., & Katzmarzyk, P. T. (2010). Accelerometer profiles of physical activity and inactivity in normal weight, overweight, and obese US men and women. *International Journal of Behavioral Nutrition and Physical Activity, 7*(1), 60-71.

Tull, M. T., Gratz, K. L., Latzman, R. D., Kimbrel, N. A., & Lejuez, C. (2010). Reinforcement sensitivity theory and emotion regulation difficulties: A multimodal investigation. *Personality and Individual Differences, 49*(8), 989-994.

Turner, T., & Hingle, M. (2017). Evaluation of a mindfulness-based mobile app aimed at promoting awareness of weight-related behaviors in adolescents: A pilot study. *JMIR Research Protocols, 6*(4), e67.

Ulmer, C. S., Stetson, B. A., & Salmon, P. G. (2010). Mindfulness and acceptance are associated with exercise maintenance in YMCA exercisers. *Behaviour Research and Therapy, 48*(8), 805-809.

Vago, D. R., & Silbersweig, D. A. (2012). Self-awareness, self-regulation, and self-transcendence (S-ART): A framework for understanding the neurobiological mechanisms of mindfulness. *Frontiers in Human Neuroscience, 6*, 296.

Vallerand, R. J., & Ratelle, C. F. (2002). *Intrinsic and extrinsic motivation: A hierarchical model* (Vol. 128).

van Aalderen, J. R., Breukers, W. J., Reuzel, R. P., & Speckens, A. E. (2014). The role of the teacher in mindfulness-based approaches: A qualitative study. *Mindfulness, 5*(2), 170-178.

van Berkel, J., Boot, C. R. L., Proper, K. I., van der Beek, A. J., & Bongers, P. M. (2014). Effectiveness of a worksite mindfulness-based multi-component intervention on lifestyle behaviors. *International Journal of Behavioral Nutrition and Physical Activity, 11*(1), 9.

Van Dam, N. T., Bilgrami, Z. R., & Eisenlohr-Moul, T. (2018a). Development and validation of the Balanced Inventory of Mindfulness-Related Skills (BIMS). *Perspectives on Psychological Science, 13*, 36-61.

Van Dam, N. T., Earleywine, M., & Borders, A. (2010). Measuring mindfulness? An item response theory analysis of the Mindful Attention Awareness Scale. *Personality and Individual Differences, 49*(7), 805-810.

Van Dam, N. T., Earleywine, M., & Danoff-Burg, S. (2009). Differential item function across meditators and non-meditators on the Five Facet Mindfulness Questionnaire. *Personality and Individual Differences, 47*(5), 516-521.

Van Dam, N. T., Hobkirk, A. L., Danoff-Burg, S., & Earleywine, M. (2012). Mind your words: Positive and negative items create method effects on the Five Facet Mindfulness Questionnaire. *Assessment, 19*(2), 198-204.

Van Dam, N. T., van Vugt, M. K., Vago, D. R., Schmalzl, L., Saron, C. D., Olendzki, A., . . . Gorchov, J. (2018b). Mind the hype: A critical evaluation and prescriptive agenda for research on mindfulness and meditation. *Perspectives on Psychological Science, 13*(1), 36-61.

Van Gordon, W., Shonin, E., & Griffiths, M. D. (2015a). Towards a second generation of mindfulness-based interventions. *Australian and New Zealand Journal of Psychiatry, 49*(7), 591-592.

Van Gordon, W., Shonin, E., Griffiths, M. D., & Singh, N. N. (2015b). There is only one mindfulness: Why science and Buddhism need to work together. *Mindfulness, 6*(1), 49-56.

Van Gordon, W., Shonin, E., Zangeneh, M., & Griffiths, M. D. (2014). Work-related mental health and job performance: Can mindfulness help? *International Journal of Mental Health and Addiction, 12*(2), 129-137.

VanBuskirk, K., Roesch, S., Afari, N., & Wetherell, J. L. (2014). Physical activity of patients with chronic pain receiving acceptance and commitment therapy or cognitive behavioural therapy. *Behaviour Change, 31*(2), 131-143.

Vandenberg, R. J. (2006). Introduction: Statistical and methodological myths and urban legends: Where, pray tell, did they get this idea? *Organizational Research Methods, 9*(1), 194-201.

Vanhelst, J., Mikulovic, J., Bui-Xuan, G., Dieu, O., Blondeau, T., Fardy, P., & Béghin, L. (2012). Comparison of two ActiGraph accelerometer generations in the assessment of physical activity in free living conditions. *BMC Research Notes, 5*(1), 187.

Verburgh, L., Konigs, M., Scherder, E. J. A., & Oosterlaan, J. (2014). Physical exercise and executive functions in preadolescent children, adolescents and young adults: A meta-analysis. *British Journal of Sports Medicine, 48*(12), 973-979.

von Soest, T., & Hagtvet, K. A. (2011). Mediation analysis in a latent growth curve modeling framework. *Structural equation modeling, 18*(2), 289-314.

Vuori, I. M. (2001). Dose-response of physical activity and low back pain, osteoarthritis, and osteoporosis. *Medicine and Science in Sports and Exercise, 33*(6 Suppl), S551-586; discussion 609-510.

Walach, H., Buchheld, N., Buttenmüller, V., Kleinknecht, N., & Schmidt, S. (2006). Measuring mindfulness - the Freiburg Mindfulness Inventory (FMI). *Personality and Individual Differences, 40*(8), 1543-1555.

Wanden-Berghe, R. G., Sanz-Valero, J., & Wanden-Berghe, C. (2010). The application of mindfulness to eating disorders treatment: A systematic review. *Eating disorders, 19*(1), 34-48.

Wankel, L. M. (1993). The importance of enjoyment to adherence and psychological benefits from physical activity. *International Journal of Sport Psychology, 24*(2), 151-169.

Wannamethee, S. G., & Shaper, A. G. (2001). Physical activity in the prevention of cardiovascular disease. *Sports Medicine, 31*(2), 101-114.

Warburton, D. E. R., Nicol, C. W., & Bredin, S. S. D. (2006). Health benefits of physical activity: The evidence. *Canadian Medical Association Journal, 174*(6), 801-809.

Watson, P., Dugdill, L., Murphy, R., Knowles, Z., & Cable, T. (2012). Moving forward in childhood obesity treatment: A call for translational research. *Health Education Journal, 72*(2), 230-239.

Wheaton, B., Muthen, B., Alwin, D. F., & Summers, G. F. (1977). Assessing reliability and stability in panel models. *Sociological Methodology, 8*, 84-136.

Wheeler, M. S., Arnkoff, D. B., & Glass, C. R. (2016). What is being studied as mindfulness meditation? *Nature Reviews Neuroscience, 17*(1), 59-60.

Wiklund, M., Olsén, M. F., & Willén, C. (2011). Physical activity as viewed by adults with severe obesity, awaiting gastric bypass surgery. *Physiotherapy Research International, 16*(3), 179-186.

Williams, D. M. (2008). Exercise, affect, and adherence: An integrated model and a case for self-paced exercise. *Journal of Sport & Exercise Psychology, 30*(5), 471-496.

Williams, D. M., Dunsiger, S., Ciccolo, J. T., Lewis, B. A., Albrecht, A. E., & Marcus, B. H. (2008). Acute affective response to a moderate-intensity exercise stimulus predicts physical activity participation 6 and 12 months later. *Psychology of Sport and Exercise, 9*(3), 231-245.

Williams, D. M., Dunsiger, S., Emerson, J. A., Gwaltney, C. J., Monti, P. M., & Miranda Jr, R. (2016). Self-paced exercise, affective response, and exercise adherence: A preliminary investigation using ecological momentary assessment. *Journal of Sport and Exercise Psychology, 38*(3), 282-291.

Williams, J. M. G., Crane, C., Barnhofer, T., Brennan, K., Duggan, D. S., Fennell, M. J., . . . Von Rohr, I. R. (2014). Mindfulness-based cognitive therapy for preventing relapse in recurrent depression: A randomized dismantling trial. *Journal of Consulting and Clinical Psychology, 82*(2), 275.

Williams, M. J., McManus, F., Muse, K., & Williams, J. M. G. (2011). Mindfulness-based cognitive therapy for severe health anxiety (hypochondriasis): An interpretative phenomenological analysis of patients' experiences. *British Journal of Clinical Psychology, 50*(4), 379-397.

Wills, T. A., Isasi, C. R., Mendoza, D., & Ainette, M. G. (2007). Self-control constructs related to measures of dietary intake and physical activity in adolescents. *Journal of Adolescent Health, 41*(6), 551-558.

Wilson, P. M., & Rodgers, W. M. (2004). The relationship between perceived autonomy support, exercise regulations and behavioral intentions in women. *Psychology of Sport and Exercise, 5*(3), 229-242.

Wilson, P. M., Rodgers, W. M., Loitz, C. C., & Scime, G. (2006). 'It's who I am...really!' The importance of integrated regulation in exercise contexts. *Journal of Applied Biobehavioral Research, 11*(2), 79-104.

Wing, R. R., & Hill, J. O. (2001). Successful weight loss maintenance. *Annual Review of Nutrition, 21*(1), 323-341.
Wipfli, B. M., Rethorst, C. D., & Landers, D. M. (2008). The anxiolytic effects of exercise: A meta-analysis of randomized trials and dose-response analysis. *Journal of Sport & Exercise Psychology, 30*(4), 392-410.
Wolf, E. J., Harrington, K. M., Clark, S. L., & Miller, M. W. (2013). Sample size requirements for structural equation models: An evaluation of power, bias, and solution propriety. *Educational and Psychological Measurement, 73*(6), 913-934.
World Health Organisation. (2010). Prevalence of insufficient physical activity. Retrieved from http://www.who.int/gho/ncd/risk_factors/physical_activity_text/en/
World Health Organisation. (2012). Global recommendations on physical activity for health. Retrieved from http://www.who.int/dietphysicalactivity/factsheet_adults/en/
World Health Organisation. (2018). Global action plan on physical activity 2018–2030: More active people for a healthier world. Retrieved from https://www.who.int/ncds/prevention/physical-activity/global-action-plan-2018-2030/en/
Yang, C.-H., & Conroy, D. E. (2019). Mindfulness and physical activity: A systematic review and hierarchical model of mindfulness. *International Journal of Sport and Exercise Psychology*, 1-24.
Younge, J. O., Wery, M. F., Gotink, R. A., Utens, E. M. W. J., Michels, M., Rizopoulos, D., . . . Roos-Hesselink, J. W. (2015). Web-based mindfulness intervention in heart disease: A randomized controlled trial. *PloS One, 10*(12), e0143843.
Yusainy, C., Chan, D. K. C., Hikmiah, Z., & Anggono, C. O. (2019). Physical activity in Indonesian University students: The contradictory roles of dispositional mindfulness and self-control. *Psychology, Health & Medicine, 24*(4), 446-455.
Zabatiero, J., Ng, L., Clayton, R., Middlemiss, S., Kang, K., Harrold, M., & Cavalheri, V. (2018). Effectiveness of interventions aiming at reducing sedentary behaviour in a non-surgical population with overweight or obesity: A systematic review and meta-analysis. *Obesity Research & Clinical Practice*.
Zainal, N. Z., Booth, S., & Huppert, F. A. (2013). The efficacy of mindfulness-based stress reduction on mental health of breast cancer patients: A meta-analysis. *Psycho-Oncology, 22*(7), 1457-1465.
Zajac, A. U., & Schier, K. (2011). Body image dysphoria and motivation to exercise: A study of Canadian and Polish women participating in yoga or aerobics. *Archives of Psychiatry and Psychotherapy, 4*, 67-72.
Zeidan, F., Grant, J. A., Brown, C. A., McHaffie, J. G., & Coghill, R. C. (2012). Mindfulness meditation-related pain relief: Evidence for unique brain mechanisms in the regulation of pain. *Neuroscience Letters, 520*(2), 165-173.
Zgierska, A., Rabago, D., Chawla, N., Kushner, K., Koehler, R., & Marlatt, A. (2009). Mindfulness meditation for substance use disorders: A systematic review. *Substance Abuse, 30*(4), 266-294.
Zschucke, E., Gaudlitz, K., & Ströhle, A. (2013). Exercise and physical activity in mental disorders: Clinical and experimental evidence. *Journal of Preventive Medicine & Public Health, 46*(Supplement 1), S12-S21.

Appendices

Appendix 2A – Systematic review search strategy

Table 2A.1. Systematic review search terms and strategy.

Key search terms:
mindful* OR “dispositional mindfulness” OR “cultivated mindfulness” OR “mindful* meditat*” OR “acceptance and commitment therapy” OR “dialectical behaviour therapy” OR “mindfulness-based stress reduction” OR “mindfulness-based cognitive therapy” OR “mindfulness-based strengths practice” OR Vipassana OR Zen AND exercis* OR “physical activit*” OR “physical health” OR fitness

Appendix 2B – Studies excluded from systematic review

Table 2B.1. Excluded studies with reasons for exclusion.

Authors (year)	Design	Reason for exclusion
Bodenlos, Wells, Noonan, & Mayrsohn (2015)	CS	No analysis of the relationship between DM and PA
Moor, Scott, & McIntosh (2013)	CS	No DM measure
Cox et al. (2016)	LGT	No DM measure
Berman, Morton, & Hegel (2016)	COH	PA is component of MBI with no PA-based control group
Forman, Butryn, Hoffman, & Herbert (2009)	COH	No PA measure
Fuller et al. (2017)	COH	No PA measure
Klatt, Sieck, Gascon, Malarkey, & Huerta (2016)	COH	No PA measure
Martin, Cox, Galloway-Williams, & Winett (2015a)	COH	PA is component of MBI with no PA-based control group
Singh et al. (2008)	COH	PA is component of MBI with no PA-based control group
Spector, Battaglini, Alsobrooks, Owen, & Groff (2012)	COH	PA is component of MBI with no PA-based control group
Turner & Hingle (2017)	COH	No PA measure
Daubenmier et al. (2016)	RCT	No PA measure
Gould, Dariotis, Mendelson, & Greenberg (2012)	RCT	No PA measure
Hawkes, Pakenham, Chambers, Patrao, & Courneya (2014)	RCT	No PA measure
Ingraham, Harbatkin, Lorvick, Plumb, & Minnis (2017)	RCT	PA is component of MBI with no PA-based control group
Kangasniemi et al. (2015)	RCT	PA is component of MBI with no PA-based control group
Lee et al. (2017)	RCT	No PA measure
Lillis, Hayes, Bunting, & Masuda (2009)	RCT	No PA measure
Raja-Khan et al. (2017)	RCT	No PA measure
van Berkel, Boot, Proper, van der Beek, & Bongers (2014)	RCT	PA is component of MBI with no PA-based control group

Note. CS, cross-sectional study; COH, cohort study; DM, dispositional mindfulness; LGT, longitudinal study; MBI, mindfulness-based intervention; PA, physical activity; RCT, randomised controlled trial.

Appendix 3A – Walking challenge instructions

Liverpool John Moores University
Walking challenge instructions

We encourage you to **walk briskly** for at **least 30 minutes per day on 5 days per week for the next 2 weeks**.

Walking briskly requires walking at a tempo that slightly raises your heart rate (e.g., when you're trying to catch the bus), but not so fast that you feel out of breath.

You can achieve the walking challenge by, for example:

- Walking to and from work/school
- Walking with friends
- Walking your dog

Please only count brisk walking that you do for **at least 10 minutes at a time**.

You will receive a very short (5-minute) follow-up survey **after 1 week** and again **after 2 weeks**, asking you to tell us how much walking and physical activity you have done. To remember how much you have walked, you can use notes on your phone, a paper diary, or other ways to keep track of your walking.

Good luck and thank you for taking part!

You may keep these instructions throughout the challenge. If you prefer to watch the walking challenge video, please use the following YouTube link: https://youtu.be/wMp0CWvZMrA

Appendix 3B – Indices of model fit

Table 3B.1. Descriptions and cut-off points of commonly used fit indices.

Measure	Name	Description	Cut-off for good fit
χ^2	Model Chi-Square	Assesses overall fit of the data to the model and the discrepancy between the sample and the fitted covariance matrices (Hu & Bentler, 1999).	$p \geq .05$
χ^2/df	Relative Chi-Square	Chi-Square/degrees of freedom ratio is often used as an alternative to the χ^2, as it is less sensitive to sample size (Hooper et al., 2008).	Good ≤ 2 Acceptable ≤ 3
TLI	Tucker Lewis Index	Also known as the Non-Normed Fit Index (NNFI), which is preferable for smaller samples and simpler models and assesses the model by comparing the χ^2 value of the model to the χ^2 of the null model (Hooper et al., 2008).	≥ .95, can be 0 > TLI > 1 for acceptance
CFI	Comparative Fit Index	A revised form of the Normed Fit Index (NFI) and performs well even with small sample sizes and compares the sample covariance matrix with the null model (Hooper et al., 2008).	Good ≥ .95 Acceptable ≥ .90
RMSEA	Root Mean Square Error of Approximation	A parsimony-adjusted index, which informs how well the model would fit the populations covariance matrix (Byrne, 2013).	Good ≤ .06 Acceptable ≤ .08
SRMR	Standardized Root Mean Square Residual	Square-root of difference between residuals of the sample covariance matrix and the hypothesized model (Hooper et al., 2008). Used when varying item levels (scales) are used in a model.	Good ≤ .08 Acceptable ≤ .10

Appendix 3C – Comparison of study two baseline sample

Table 3C.1. Comparison of completer and dropout means on key variables at baseline.

	Opted in (n = 160)		Opted out (n = 36)		t-test
Measure	Mean	Std. Error	Mean	Std. Error	Sig. (2-tailed)
Age	37.23	.97	40.06	2.72	.332
Body mass index	26.24	.57	25.95	.83	.821
Physical activity	2761.33	175.92	3094.53	420.35	.430
Mindfulness	46.86	.72	46.26	1.57	.725
PA acceptance	44.42	.95	42.31	1.81	.335
Autonomous motivation	9.95	.60	8.44	1.22	.280
Self-control	42.86	.66	41.54	1.46	.397
Impulsivity	30.64	.48	32.75	1.17	.071

Note. PA, physical activity.

Appendix 3D – Latent growth curve model of change in physical activity

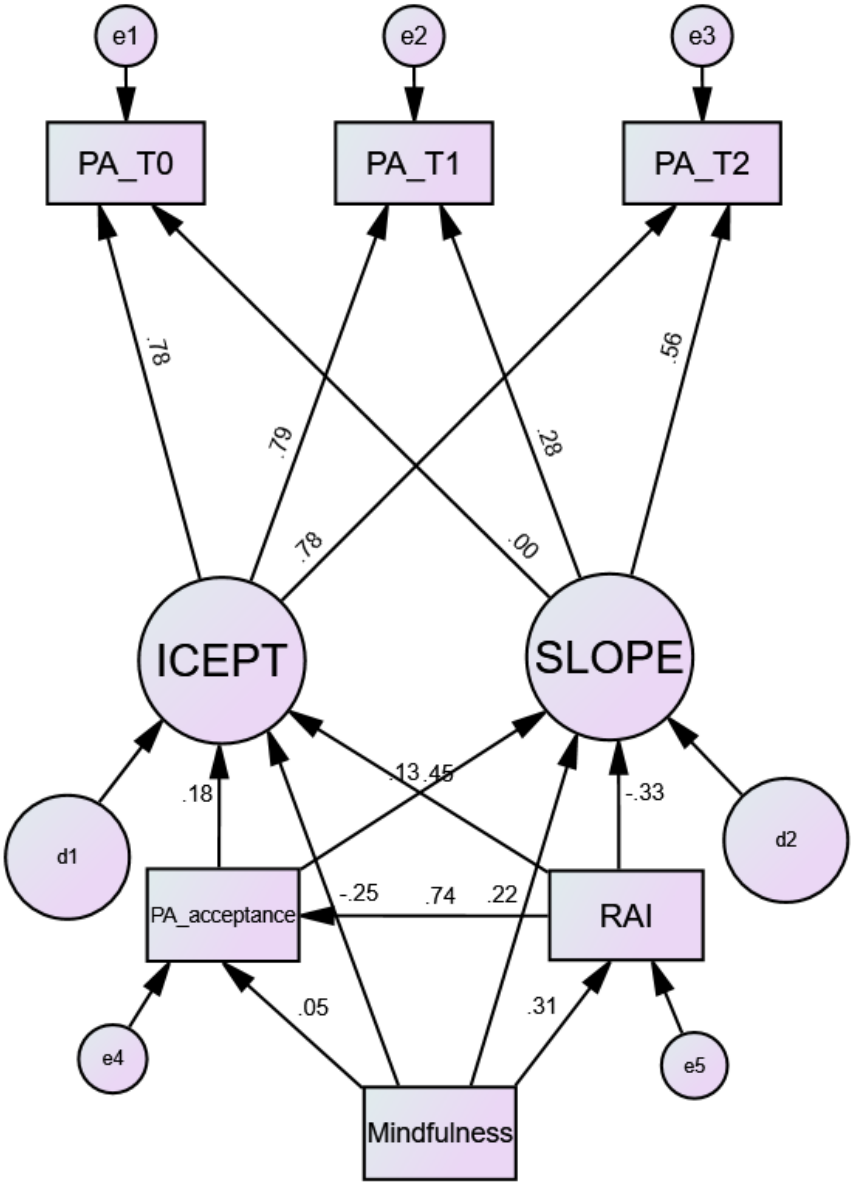

Figure 3D.1. Latent growth curve model depicting dispositional mindfulness as a predictor of change in physical activity, mediated by physical activity acceptance and autonomous exercise motivation (N = 116).
Note. PA, physical activity; RAI, Relative Autonomy Index. Beta coefficients ≥ .25 represent significant paths.

Appendix 4A – Accelerometer instructions

Physical Activity Monitor Instructions

- The physical activity monitor measures your physical activity levels.
- It should be worn like a belt and should sit on the right hip (see picture below).
- It may be worn underneath clothes.
- It should be worn during all waking hours for at least 7 consecutive days.
- Please record the times when you put on and take off your monitor during the day in the activity diary that can be found in your envelope.
- At the end of the 7-day period, please return your monitor and the activity diary to the researcher.

NOTE: The physical activity monitor is splash proof, but you MUST take it off for water-based activities (e.g., showering/swimming, etc.). You may remove it for contact sports such as rugby if you wish.

If you have any questions, please do not hesitate to contact Jekaterina Schneider, email: J.Schneider@2016.ljmu.ac.uk.

Appendix 4B – MfPA course home practice recording sheet

Your practice **Participant number:_____**

Thank you for taking part in the Mindfulness for Physical Activity course! We are interested in how much you have engaged with your workbook and your practice over the last 6 weeks. This is so that we can evaluate engagement with the course and work on improving and adapting the course content and structure if needed.

Please use your workbook to complete the table below. You do not need to write down any notes about your feelings and experiences – that is just for you! Please try to be as accurate and honest as possible when you complete the table. We want to know even if you did not do any practice.

Once you are done, please hand in this sheet to one of the researchers.

Week	**How many days did you meditate?**	**What meditations did you try?**	**What type of activity did you do?**
Example:	*5*	*Body scan* *Mindful movement*	*Yoga* *Taking the stairs*
1			
2			
3			
4			
5			

Appendix 4C – MfPA course evaluation form

Led by **Paul Lattimore**

We like to monitor outcomes to make sure what we are offering is of use to people and we are continually aiming to improve, so it would be very helpful to get your feedback on how you have found this course. If you would take the time to answer the following questions, we would be grateful.

For each item listed below, please circle the number which best describes how useful and beneficial that aspect of the course was for you. (If you didn't do one of the practices, just put an X beside it).

	1 means no use									**10 means very useful**
Idea of "autopilot"	1	2	3	4	5	6	7	8	9	10
Idea of "primary & secondary experience"	1	2	3	4	5	6	7	8	9	10
Mindfulness of body & breath meditation (body scan)	1	2	3	4	5	6	7	8	9	10
Idea of "doing & being"	1	2	3	4	5	6	7	8	9	10
Idea of "coming to our senses" (two triangles)	1	2	3	4	5	6	7	8	9	10
Mindfulness of breath meditation	1	2	3	4	5	6	7	8	9	10
Mindful movement	1	2	3	4	5	6	7	8	9	10
Mindfulness in Action tasks	1	2	3	4	5	6	7	8	9	10
Working with thoughts and letting go of unhelpful thoughts	1	2	3	4	5	6	7	8	9	10
Thoughts & sounds meditation	1	2	3	4	5	6	7	8	9	10
Idea of "negativity bias"	1	2	3	4	5	6	7	8	9	10
Idea of "3 major emotion systems"	1	2	3	4	5	6	7	8	9	10
Idea of "self-critic vs self-compassion"	1	2	3	4	5	6	7	8	9	10
Kindness meditations	1	2	3	4	5	6	7	8	9	10
3-minute breathing space meditation	1	2	3	4	5	6	7	8	9	10
Emails (reading, reminders, etc.)	1	2	3	4	5	6	7	8	9	10
MP3s	1	2	3	4	5	6	7	8	9	10

On the scale below, please rate how important the course has been for you, where 1 means not important at all and 10 means very important.

1 2 3 4 5 6 7 8 9 10

Do you feel you have gained something of lasting value from taking the course?

yes no not sure

If yes, please state what you feel you got from it:

If not, why do you think it has not really been beneficial to you?

Are there any aspects of the course you think could be improved?

Any comments about the student teacher Paul Lattimore **and his ability to communicate the material in the course?**

Any other comments:

Thank you for taking the time to complete this form.

Appendix 4D – Focus group discussion guide

Introduction *[10 minutes]*:

Welcome and thank you for agreeing to take part. I really appreciate your time that you have devoted to this study. This focus group is the last part of the Mindfulness for Physical Activity study.

The information sheet that you have received at the start of this study is here, so you are welcome to have another read of this and ask any questions you may have. We also ask that you sign a consent form before we get started.

[Hand out and collect consent forms]

You were invited to take part in this focus group so that we can have some qualitative feedback about your experience of the Mindfulness for Physical Activity course and to get some insight into how it may have affected your daily life and physical activity. There are two parts to this focus group. First, we will discuss your overall experience of the course, such as what you liked and what you did not like, and this should take about 15 minutes. Then we will have opportunity to discuss your experience of physical activity during and after the course, which should take about 20 minutes.

The focus group is expected to take no more than 45 minutes, and there are no right or wrong answers. We simply want to encourage a discussion where everyone can feel included.

The session will be audio recorded to allow us to transcribe and analyse the data for my thesis. I will start recording now.

[Turn on recording devices]

Please say your name so that I can check that the device is recording.

[Get participants to say their names to ensure recording device works and so that their name can be matched with their voice]

Despite this session being recorded, all information you provide will be anonymised. The recordings will be transcribed and stored securely, and all transcriptions will be treated confidentially and anonymously, so you will not be identified in any reproduction of this study. The recordings will only be used for the purposes of this research and then deleted. We cannot ensure full confidentiality, so you do not have to answer any questions you don't want to answer or disclose sensitive information about yourself, but we ask that you please not share anything said during the focus group outside of this room. Any names you mention in your answers will also be anonymised or deleted. We want to make sure everyone feels comfortable to share their true experience of the programme.

Can we all agree to not share identifying information about each other outside of this room?

[Wait and see that they are listening/nodding]

We encourage the guidelines that we together agreed upon at the start of the mindfulness course and I have put these up on this flipchart for your reference.

[Refer to flipchart]

Do you have any questions? Ok, let's begin!

Main session *[35-45 minutes]*:

Research title	Research questions	Focus group questions	Probes
Adapting a mindfulness-based programme to facilitate physical activity uptake in underactive participants: A feasibility study	1. What was participants' experience of the overall course?	1. How did you find the course?	What did you enjoy about the course? What could have been done differently? How did you feel during/after course?
		2. Did you gain anything of value from the course?	What? What aspects of the course did you engage in? Meditation? Why/why not?
	2. How has the Mindfulness for Physical Activity course impacted participants' relationship with physical activity?	3. How is your relationship with physical activity now compared to before the course?	Did it change? What changed? How did it change? Why did it not change? What do you think was the reason for this? Or why not? What could have been done differently?
		4. What aspects of the course did you find most useful for your physical activity?	How often did you engage with these aspects/practices? How/why do you think they helped? What practices did you use/did you not use? What about the course has helped you? How can the course be improved to help you with this?
		Do you think you will keep up with meditation and/or physical activity aspects taught in this course in the future? Does anyone have anything else to add that hasn't already been said?	

Conclusion *[5 minutes]*:

Thank you very much for participating. We hope you have found the discussion interesting and your opinions will be very valuable in our evaluation of the Mindfulness for Physical Activity course. I would like to remind you that any comments that you have made today will be treated confidentially and anonymously.

Before you leave, you will receive a £10 [shopping] voucher. You will also be emailed a debrief sheet about the study later in the week that will explain the study in more detail. If you have any questions or concerns or if you want to be informed about the outcomes of this study, please do not hesitate to get in touch with me. My email will be on the debrief sheet.

Thanks again for taking part in our project!

Appendix 4E – MfPA course workbook sample

Introduction to the course

This course is about using mindfulness techniques to help improve your experiences of physical activity. The mindfulness teaching will help you identify and overcome obstacles to physical activity and to experience the pleasure that can be gained through physical activity – whether you are at home, outside, or in the gym. You will have the opportunity to tailor the programme to meet your own needs, by setting personal goals to help you integrate physical activity into your daily life.

The Mindfulness for Physical Activity (MfPA) course involves attendance at, and participation in, 6 weekly 2-hour classes. The course is group-based with a maximum class size of 15. Typically, each class will involve some tutor-guided discussion and explanation, meditation practice, mindful movement, working in pairs or threes to share experiences, and reviews of the events of the week. There is no need for any special equipment, but a yoga mat and a soft cushion can be helpful in some classes.

In the week between each class, participants are encouraged to complete some home practice activities to learn the skills taught in class and to incorporate them into their daily living routines. The home practice also includes some brief self-monitoring exercises and brief diary keeping. Useful readings about mindfulness referred to in class are optional.

Inquiry is a central part of the type of learning that will take place. Inquiry in this context means identification of and discussion of personal experiences related to physical activity and mindfulness exercises. Participants are encouraged to be open to discussion of experiences in a kind, understanding, and confidential class environment.

Please note that this is not an exercise class. The activities will be classroom-based and tailored to help you use mindfulness techniques during your own physical activity. If you are currently physically inactive or have any health conditions or concerns, you are advised to see your GP or an exercise professional before increasing your level of physical activity. You can read more about physical activity guidelines and different types of physical activity that you can do at the back of this booklet.

What this workbook contains

This practice workbook is to help you make the most of your course. It includes:

A list of your home practice, including meditation and Mindfulness in Action

Week by week meditation diary sheets so that you can track your progress

Week by week physical activity diary sheets so that you can record your activity

Throughout the course, you will also gain access to audio of guided meditation practice. The course teacher will provide you with a Dropbox link from where you can download the MP3 files of the audio to your device.

This workbook is for your own personal use, but we encourage you to engage with both the workbook and the audio recordings of the guided meditation practice as often as you would like and to take any notes of your experiences so that you may discuss them in class or revisit them at any point.

Week 1 – Mindfulness: Learning to Choose

Key concepts:
Mindfulness
Autopilot
Primary and secondary experience
Reacting and responding
Choice

Home practice

Meditation:
Aim to practice the 10-minute Body Scan each day. If you feel like it, try it twice a day.

Reading/Web:
Explore different types of physical activity that you can do using the NHS website (https://www.nhs.uk/live-well/exercise/) and the Live Well Directory (https://www.thelivewelldirectory.com/).

Mindfulness in Action: Do one routine activity and one physical activity mindfully each day

A routine activity: Choose an activity, something you normally do at least once every day, such as cleaning your teeth, having a shower, drinking a cup of tea or coffee, etc. Whatever activity you choose, try not to do it on autopilot, pay full attention to it. The main principles to follow are:

Do just the activity and nothing else.
Pay attention to the physical sensations of doing it.
Bring your mind back whenever it wanders.

A physical activity: Choose one type of physical activity and aim to do it once each day. It could be taking the stairs instead of the lift, walking to the shops, lifting heavy shopping, going for a walk in the evening, swimming, jogging, etc. Do this safely; do not over-exert yourself.

Use your workbook to record anything you think or feel about these activities and/or anything you want to record about your attempts to practice the meditation for this week.

Meditation

What meditation practice did you do?	How long did you meditate for?	What did you notice? How did you feel before/after the practice? If you did not do the practice, what were your reasons?

Physical activity

Day/Date	What activity did you do?	What thoughts/feelings/sensations did you notice?

Appendix 4F – Initial iteration of focus group themes

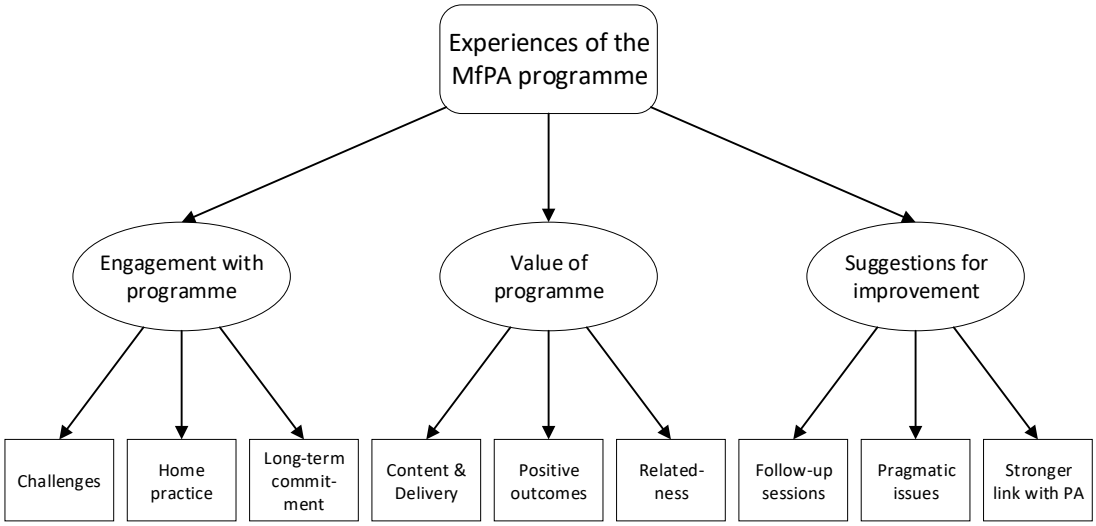

Figure 4F.1. Map depicting the first iteration of thematic analysis of participants' experiences of the Mindfulness for Physical Activity (MfPA) programme.
Note. The overarching research question is depicted at the top, the themes are presented as ellipses, and the subthemes are presented as rectangles.

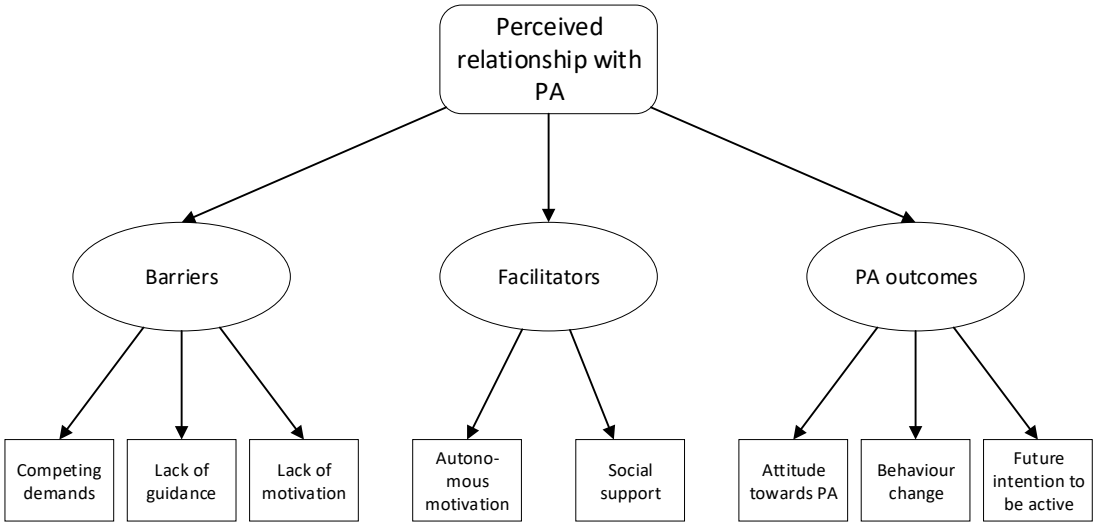

Figure 4F.2. Map depicting the first iteration of thematic analysis of participants' perceived relationship with physical activity (PA) after the Mindfulness for Physical Activity (MfPA) programme.
Note. The overarching research question is depicted at the top, the themes are presented as ellipses, and the subthemes are presented as rectangles.