The effect of a multi-component intervention with and without height-adjustable workstations on vascular and behavioural outcomes in contact centre call agents

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Abstract

Background: In modern society, despite the health-enhancing benefits of physical activity (PA), the number of adults meeting the PA guidelines is low, with physical inactivity presented as the fourth leading cause of death globally. High sedentary behaviour (SB) levels are a risk factor for numerous chronic diseases and all-cause mortality. Furthermore, there is evidence that SB is associated with health independent of PA levels. In the UK, up to 4% of the UK population are employed within contact centres, and call agents sit for 90% of their working day. In comparison to traditional office workers, contact centre call agents have less autonomy over their working practices due to high call volumes and the need to be connected to their computer via a headset. This study evaluated the effect of a 12-week multicomponent PA and SB intervention with and without the provision of a sit-stand workstation on behavioural, vascular, and anthropometric outcomes in call centre workers. **Methods**: A two-arm, parallel-group, pilot randomised control trial was implemented in one contact centre in the North West of England. Participants were divided into two groups: i) a multi-level intervention group with the use of a sit-stand workstation (sit less and move more plus; (SLAMM+), and ii) a multi-level intervention group without a sit-stand workstation (SLAMM). Both groups received organisational, intrapersonal, and interpersonal support to sit less and move more, while the SLAMM+ group received the additional environmental component of a height-adjustable workstation. Data was collected at baseline (0 weeks) and 12 weeks. Assessments included flow-mediated dilation, blood pressure and anthropometrics and behavioural outcomes. **Results**: While no significant between-group differences were observed for vascular, behavioural or anthropometric outcomes after 12 weeks of intervention, the direction and magnitude of the adjusted change scores were favourable for the SLAMM+ group compared to the SLAMM group for total and prolonged occupational and daily sitting time, and occupational and daily standing time. **Conclusion**: The findings of this study suggest the provision of a sit-stand workstation may be important for eliciting more favourable changes in behavioural outcomes in call centre workers with no changes in vascular outcomes. Future studies should aim to assess if replacing sitting with standing in call agents provides an adequate physiological stimulus to improve endothelial function in call agents.

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I didn't think I would be writing this paragraph at the start of my MPhil. My late mother was my biggest fan, I miss her infectious smile, laugh and down-to-earth advice. She was always on hand to tell me 'It'll be grand' in tough times.

This thesis is dedicated to you, Ma.

Declaration

I declare that the work within this thesis is entirely my own.

Publications

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Table of Content

List of Tables

List of Figures

Abbreviations

Sedentary Behaviour	SB
Physical Activity	PA
Body Mass Index	BMI
Metabolic Equivalent of Task	MET
Nitric Oxide	NO
Cardiovascular Disease	CVD
Flow-Mediated Dilation	FMD
Blood Pressure	BP
Systolic Blood Pressure	SBP
Diastolic Blood Pressure	DBP
Region of Interest	ROI
Shear Rate Area-Under-the-Curve	SRAUC
Analysis of Covariance	ANCOVA

CHAPTER 1

LITERATURE REVIEW

1.1 Physical Activity and Sedentary Behaviour Definitions, Guidelines and Prevalence

1.1.1 Definitions

Physical activity (PA) is defined as "any bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen et al., 1985, p129). PA can be classified into three categories, depending on the activity intensity, using the metabolic equivalent of task (MET) model (Pate et al., 2005). A person sitting quietly is equal to 1 MET, as activity intensity increases, a behaviour can be categorised as light intensity, > 1.5-2.9 METs; moderate intensity, 3–5.9 METs; and vigorous intensity, > 6 METs. Though widely used, the METs model has been challenged due to certain sitting (i.e., sedentary) behaviours increasing above the 1.5 MET threshold for light PA, such as driving (Henson et al., 2013). That said, characteristics that help distinguish PA and sedentary behaviour (SB) are both posture and intensity. SB is defined as "any waking behaviour in a sitting, reclining, or lying posture with an energy expenditure of fewer than 1.5 METs" (Tremblay et al., 2017). SB differs from physical inactivity, which is defined as the failure to meet the minimum amount of PA prescribed in national/international guidelines (Hallal et al., 2003).

1.1.2 Guidelines

The current UK guidelines for PA state that adults aged 19-64 years old should aim to acquire 150 minutes of moderate-intensity PA per week; or 75 minutes of vigorous-intensity PA per week, or an equivalent combination of both intensities (Department of Health, 2019).

Recommendations from the government also include advice to reduce the amount of time spent in SB, and where possible to break up prolonged periods of SB with at least light activity (Department of Health, 2019).

Opportunities to participate in PA are becoming increasingly difficult due to a variety of domains that require people to engage in SB such as the workplace (Dugdill et al., 2008). Therefore, attention has grown to provide recommendations to reduce SB at work (Buckley et al., 2015). The recommendations are that desk-based workers should aim to accumulate at least 2 hours a day of standing and light activity (light walking) during working hours, with a view to achieving a total of 4 hours of standing or light activity during working hours (Buckley et al., 2015). Additionally, desk-based workers should aim to break up prolonged seated work with standing and light activity throughout the day (Buckley et al., 2015).

1.1.3 Prevalence

In modern society, despite the health enhancing benefits of PA, the number of adults meeting the PA guidelines is low, with physical inactivity presented as the fourth leading cause of death globally (Kohl 3rd et al., 2012). Public Health England (2021) stated that 28% of adults are inactive while recent figures have shown 64% of adults aged >16 meet the PA guidelines in England (Active Lives Survey, 2022). Although, national data is often based on self-reported data and these measures tend to provide inaccurate representations of total PA as poor recall or social desirability bias leads to over-reporting (Sallis and Saelens, 2000). This may mean that the number of people in England meeting the PA guidelines is lower.

Physical inactivity is reported to cause more than 5 million deaths worldwide and is considered to be pandemic (Nes et al., 2017). Lee et al. (2012) suggested that 6-10% of global deaths from non-communicable diseases are caused by being physically inactive, while 1 in 6 deaths are caused by physical inactivity (Public Health England, 2015). There has been a plethora of evidence that indicates PA is important for health, and more recently, interest has grown in the benefits of reducing the amount of time people spend in SB. This has been, in part, due to observations of high levels of SB in adults. In 2021, it was reported that adults in the UK spend up to 30 hours a week in SB (BHF, 2021). Further, on average, adults spend 5 hours per/day sedentary in the UK, while 30% spend an average of 6 hours per/day during weekdays, rising to 37% on the weekend (BHF, 2021).

1.1.4 Assessment of physical activity and sedentary behaviour

In research, there are various approaches to analyse PA and SB, which are usually broken down into subjective and objective methodologies. Typically, subjective measures of PA and SB are usually measured via a questionnaire, self-reported log or diary which are vulnerable to recall bias and place a higher burden on participants (Sylvia et al., 2014, Graves et al., 2015). This is consequently less than ideal for providing an accurate picture of participants' PA and SB. The use of an accelerometer (such as

ActiGraph), which is a valid method to objectively assess time spent sedentary and in light, moderate and vigorous intensity PA is likely more precise.. It is not very accurate at measuring postures (Wu et al., 2022). The activPAL can measure PA (walking mainly) but it is primarily used to measure postures (sitting, standing, lying). (Pfister et al., 2017, Steeves et al., 2015). Therefore, to assess outcomes such as sitting, standing, and walking, an accelerometer is best, and activPAL is an example of a valid accelerometer suitable for this in free-living across multiple days, in office workers (Wu et al., 2022).

1.2 Office and call centre working

In recent decades, PA levels have steadily been declining and SB levels have been increasing (Hallal et al., 2012, Ng and Popkin, 2012, Bull et al., 2020). A likely root cause of these recent observations was the industrial revolution in the 1800s, which catalysed changes in technology (such as machines removing physical effort needed for a wide range of tasks, especially at work), transportation (which reduced the need for active transport), and an increase in the quantity of desk-based vocations (Mansoubi et al., 2015, Woessner et al., 2021). Adults spend up to 2/3 of waking hours at work (Thorp et al., 2014) and in recent decades, light PA jobs have become more sedentary while desk-based employment has become one of the most prevalent modes of vocation throughout the UK (Owen et al., 2011; Bureau of Labour Statistics, 2010). Desk-based workers engage in prolonged periods of SB at work (Graves et al., 2015, Alkhajah et al., 2012) with 70-85% of workplace activities reported as predominately seated (O'Connell et al., 2015).

In the UK, just over 4% of the population is employed in call centres (Contact Babel, 2020). In call centres, call agents are line managed by team leaders who report to senior managers (Morris et al., 2019). Call centre environments tend to have demanding targets to deal with high levels of inbound calls. Call agents are required to remain at their desks for long periods and answer calls consecutively to achieve key performance indicators. Due to the restrictive environments in call centres, call agents are reported to sit up to 90% of their time at work, often in prolonged bouts of > 30mins (Straker et al., 2013, Toomingas et al., 2012, Morris et al., 2018). Accordingly, the nature of call agents' work hinders their ability to move more at work and break up their SB. Toomingas and colleagues (2005) highlighted that call agents deal with high levels of customer service activity that require the use of a computer and telephone. As a result, call agents have less autonomy over their working practices than traditional office workers. Therefore, call agents may struggle to improve their PA and SB behaviours at work due to high call volumes and the need to be connected to a phone via a wired headset (Morris et al., 2018). As a consequence of these high levels of total and prolonged sitting time, call agents are at increased risk for negative health consequences (Bennie et al., 2015).

1.2.2 Impact on health

In adults, higher levels of PA are associated with lower risks of premature cardiovascular disease (CVD) mortality, all-cause mortality, and incidence of hypertension, type 2 diabetes, site specific cancers, and poor mental and cognitive health, and poor sleep (Bull et al., 2020). Lower levels of SB are also linked with better health, including reduced risks of all-cause mortality, CVD mortality, cancer mortality and type 2 diabetes incidence (Bull et al., 2020). Accordingly, there is a substantial reduction in premature mortality when higher levels of PA are attained in conjunction with less time spent in SB (Ekelund et al., 2020). Ekelund and colleagues (2016) who proposed that 60-75 minutes of daily moderate to vigorous intensity PA can offset but not eradicate the negative health consequences associated with high levels of SB. These findings were supported by another study that showed individuals with higher sedentary time, 30-40 minutes of MVPA per day can attenuate the relationship between sedentary time and mortality, but not eliminate it (Chastin et al., 2021).

In the UK, CVD causes 25% of deaths each year (BHF, 2022). Atherosclerosis is a known predictor for future cardiovascular events in asymptomatic adults (Green et al., 2011). Early subclinical markers of atherosclerosis are vascular function which can be measured through flow-mediated dilation (FMD) (Green et al., 2011). Atherosclerosis is the key cause of CVD, it involves the build-up of fatty deposits in the artery walls which reduces function and narrows the artery reducing blood flow (Frostegård, 2013). PA and SB are some of the leading modifiable risk factors for CVD (Lavie et al., 2019). Evidence has shown that highly active adult men and women have lower incidents of CVD (WHO, 2016). Dunstan and colleagues (2010) reported that high television viewing time (as a surrogate for sitting time) was associated with an increased risk profile for both all-cause and CVD mortality. Compared to participants who sat for <2 hours/day, participants sitting for >4 hours/day had an increased risk of all-cause (46%) and CVD (80%) mortality, which was independent from other traditional risk factors (Dunstan et al., 2010).

Many risk factors are associated with CVD, including those that are modifiable (such as smoking, obesity, physical inactivity, SB, hypertension) and non-modifiable (such as increasing age, male sex, ethnicity, and family history). Concerning obesity, call agents are reported to have higher levels of obesity compared to traditional office workers (Thorp et al., 2011). The increasing prevalence of obesity is a serious global issue (World Health Organisation, 2017). In 2015, one study showed a causal association between higher body mass index (BMI) and the incidence of CVD (Hägg et al., 2015). This paper postulated that for every increase in BMI standard deviation, coronary heart disease risk increased by 20% (Hägg et al., 2015). Boger and colleagues (2007) reported that after controlling for traditional risk factors, obesity was still associated with coronary heart disease. Call agents' higher levels of obesity than traditional office workers may be, in part, due to the higher levels of SB, which has been identified to negatively affect BMI and waist circumference (Healy et al., 2008). Therefore, call agents who sit for prolonged periods are likely to be at an increased risk for undesirable body composition and CVD.

A further modifiable risk factor for CVD is hypertension, also known as high blood pressure. Hypertension is an important risk factor for CVD, with an estimated 28% of adults in the UK reported having hypertension (BHF, 2020). Hypertension is recognised as the major risk factor for CVD worldwide, an estimated 50% CVD events are attributed to hypertension

(Lawes et al., 2008). The World Health Organisation reports that hypertension causes almost 9 million deaths each year globally (World Health Organisation, 2013). One meta-analysis stated that for every 10-mmHg reduction in systolic blood pressure (SBP) toward healthy levels, the risk of a CVD event was reduced by 20% (Ettehad et al., 2016). With call agents sitting for long periods during the workday, they are placed at a higher risk for hypertension. Previous research suggests that sitting for prolonged periods acts negatively on traditional and novel CV risk factors, and mainly desk-based workers, and especially contact centre workers, sit for prolonged periods (Carter et al., 2019, Healy et al., 2008, Thosar et al., 2015). Consequently, the workplace, and especially contact centres, have been identified as key target settings for the introduction of health-promoting interventions to reduce SB and increase PA in mainly desk-based workers (Buman et al., 2017, Thorp et al., 2011).

1.3 The cardiovascular system

The cardiovascular system consists of the heart, arteries, veins, capillaries, and blood. The cardiovascular system is responsible for circulating blood around the body to allow for rapid delivery of nutrients to the tissues, while also removing waste products (Aird, 2011). The heart is a muscular organ around the size of a fist located in the middle of the chest behind the sternum. The heart is responsible for pumping blood, while the arteries act as a complex transport system, transporting oxygenated blood to the tissues of the body and returning deoxygenated blood back to the heart and lungs. The heart consists of four chambers, two atria and two ventricles. Arteries and veins are attached to the heart in a circulation system.

1.3.1 The role of the vascular endothelium in conduit vessels

The arteries are made up of three layers, the tunica externa, the tunica media, and the tunica intima (Figure 1).

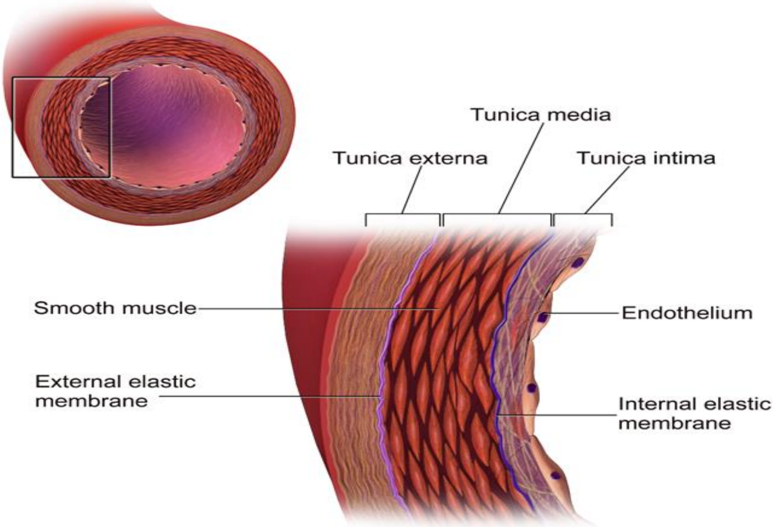

Figure 1 Anatomy of an artery (Used with permission from anatomytool.org).

The outermost layer of arteries, the tunica externa mainly consists of connective tissue. The tunica media is the middle layer of the artery wall, which is made up of smooth muscle that constricts and dilates to regulate blood flow. The inner layer of the artery is the intima, where the endothelial cells are located. The vascular endothelium is the innermost layer in conduit arteries and acts as a barrier between blood and the tissue of the body, although its main function is to regulate vascular tone (Ghiadoni et al., 2003). A healthy endothelium is imperative for maintaining vascular function. There are numerous substances released by the endothelium to regulate vascular tone, which is largely mediated by the bioavailability of nitric oxide (NO) (Sun et al., 2020). Further, NO has protective properties for the vascular system against atherosclerosis by inhibiting leukocyte adhesion and smooth muscle cell proliferation (da Silva et al., 2021). The endothelium is sensitive to shear stress as a result of blood flow inside arteries, which is the main stimulus for dilation. One way of increasing shear stress is PA, and moderate to high levels of PA has been identified to have cardiovascular protective properties (Joyner and Green, 2009). This may be because consistent PA exposure maintains or enhances endothelial function and contributes to improved peripheral barometer function. As a consequence of these improvements, arteries experience enhanced vasodilation along with delaying age related and risk factor arterial stiffness (Joyner and Green, 2009). In response to vasodilation, vasoconstriction is the other side of the coin where the artery is narrowed (Bruno et al., 2012). One of the two divisions of the autonomic nervous system, the sympathetic nervous system, is well known to have a significant role in maintaining cardiovascular homeostasis. Sympathetic nerve activity aids constriction of large artery which is equally important for healthy arteries so that vessel diameter can return to baseline following dilation (Bruno et al., 2012).

1.4 Measurement of conduit artery endothelial function

Endothelial function can be measured non-invasively using ultrasound through a widely accepted technique called Flow Mediated Dilation (FMD) (Thijssen et al., 2019). FMD assesses the ability of conduit arteries to release NO in response to 5 minutes of occlusion in the artery with a cuff

(Flammer et al., 2012). Cuff placement has been reported to be important to elicit the desired response, which is distal to the image site (Green et al., 2017). Once the cuff is deflated, blood flow and artery diameter is measured for another 3 minutes (Thijssen et al., 2011). FMD is calculated as the change in diameter from baseline to peak dilation expressed as a percentage (Thijssen et al., 2019).

1.5 Prognostic value of FMD

Endothelial dysfunction is associated with increased risk for CVD (de Jager et al., 2006), and is known to be an early contributor to the atherosclerotic pathway (Matsuzawa et al., 2015). Importantly, FMD predicts future cardiovascular events in humans (Matsuzawa et al., 2015) and can be modified by PA levels (Pahkala et al., 2011). A 2010 meta-analysis reported that for every 1% increase in FMD, the risk of future CV event was reduced by 13% (Inaba et al., 2010, Thijssen et al., 2019). One study revealed that the low muscular activity associated with SB reduces blood flow, as well as regular variations in blood flow, resulting in reduced vascular function (Thosar et al., 2012). A further study also reported that 3 hours of sitting induced a decline in endothelial function of the superficial femoral artery from 4.72% at baseline to 2.2% (Thosar et al., 2015). Similar results were found in that 6 hours of sitting induced popliteal artery dysfunction while brachial artery remained unchanged (Thosar et al., 2015, Restaino et al., 2015). This identifies a potential CVD risk for call agents, due to reduced lower limb muscle activation present during periods of prolonged occupational sitting.

1.6 Interventions to help workers move more and sit less at work.

In recent times, research into PA and SB interventions within the workplace has increased (Peachey et al., 2018). Chu and colleagues (2016) published a systematic review and meta-analysis and reported that multi-component interventions (focusing on interpersonal, intrapersonal organisational, environmental components) reported greater reductions in sitting (-88.8 min/8h workday) in desk-based workers. Environmental interventions showed substantial reductions in sitting (-72.8 min/8h workday), where educational/ behavioural strategies elicited only minor reductions in sitting (-15.5 min/8h workday) (Chu et al., 2016). Similar reductions in sitting were observed in a further review, where using a sit-stand workstation with or without an information/counselling component produced reductions in sitting time of -100 min/workday in comparison to information/counselling alone (-19 min/8h workday), computer prompts (-14 min/8h workday) and policy changes (-15 min/8h workday) (Shrestha et al., 2018). Shrestha and colleagues (2018) reported that the PA and SB intervention studies in their review were of very low to low quality due to inadequate sample sizes and weak methodological quality including failure to blind outcome accessors and the use of self-reported methods for activity outcomes (Shrestha et al., 2018).

The evidence suggests that implementing sit-stand workstations in workplaces are generally effective in reducing sitting time at work, although these interventions have been unsuccessful in increasing PA at work (Shrestha et al., 2018). Interestingly, interventions that focused on reducing SB and increasing PA were less effective in reducing SB than interventions that focused solely on SB (Prince et al., 2014). Numerous interventions in workplaces have failed to replace sitting with PA, as most reported standing increases similar to the reduction in sitting time. Shrestha and colleagues (2018) found a 1-minute per/day increase in stepping time across nine studies that tried to increase PA. This highlights the failure across workplace interventions in changing PA levels. The office/ call centre setting may be set up in a way where increasing PA may prove difficult due to the ergonomic design and work demands placed on workers (Hadgraft et al., 2016). Further, increasing PA in call agents specifically would require the agents to be away from their workstation for longer periods, which is a concern of team leaders and managers, who previously reported decreased productivity levels as a barrier to supporting call agents to be more active and less sedentary at work (Morris et al., 2018).

The current workplace intervention evidence base reports findings in more traditional office workers, with little known about intervention effects in call centres. The call centre is a unique working environment that places additional restraints on call agents' ability to move more throughout the working day. Morris and colleagues (2018) reported feedback from call agents in a qualitative study using multi-stakeholder focus groups and interviews to explore the barriers to moving more at work. Continuous monitoring of performance metrics and personal time during work, along with low autonomy over working practices were all identified as barriers to moving more during the working hours (Morris et al., 2018). In an 8-week feasibility intervention study, through the utility of focus groups and interviews, call agents perceived education sessions, height adjustable workstations and emails (containing information on importance of moving more and strategies to move more at work) as the most effective strategies to influence SB and PA at work (Morris et al., 2019). The Morris paper, however, did not evaluate changes in PA and SB, or health outcomes, across the intervention, which is an opportunity for future research.

The restrictive nature of call centres makes it tough to promote PA at work, but some studies have reported reductions in sitting time. The 'Opt to Stand' quasi-experimental study was a multilevel intervention in call centres that compared the effect of implementing a sit-stand workstation on PA and SB compared to a control group (Chau et al., 2016). Due to issues with objective monitoring of behavioural data, self-reported data was used. Chau and colleagues (2016) reported a reduction in sitting of -100 min/workday at 19 weeks compared to a control group of usual practice. A further study in call agents demonstrated no significant changes in self-reported sitting time over a 6-month period (Pickens et al., 2016). Pickens and colleagues (2016) reported that a total of 91 participants were allocated to a sit-stand workstation or a stand-biased group and which resulted in no changes in self-reported sitting time at 3- and 6-months. A limitation highlighted was the high dropout rate, where attrition was 30% and 45% at 3 and 6-months respectfully. To date, behavioural data in call centres is self-reported, with no studies measuring cardiovascular outcomes. Due to the negative effects SBs has on cardiovascular health, measuring cardiovascular outcomes in environments with high sitting time provides insight into the possible health benefits. More studies are needed in call centres, as call agents have more restrictive conditions placed on them than traditional office workers and are likely to sit for prolonged periods of time placing them at higher risk for cardiovascular disease. Future studies should aim to obtain objective data on behavioural outcomes to gain an accurate and comprehensive insight into the behavioural alterations multi-component PA and SB interventions have in call centres.

The aim of this study was to evaluate the effect of a 12-week multi-component intervention, with and without the use of a sit-stand workstation, on vascular, behavioural, and anthropometric outcomes in call centre agents. Both groups received organisational, intrapersonal, and interpersonal support to alter behaviours, while the SLAMM+ group received an environmental component in the form of a high-adjustable workstation. It was hypothesised that the multi-component intervention that included provision of height-adjustable workstations for call agents, would lead to greater improvements in vascular, behavioural, and anthropometric outcomes in comparison to the multi-component intervention that did not include the provision of height-adjustable workstations.

CHAPTER 2

METHODS

2.1 Trial Design

The present thesis was part of a larger two-arm, parallel-group, pilot randomised control trial (RCT; clinical trials number: NCT03733288) conducted in a call centre in North West England (Figure 2). The project involved two PhD students and me, whom all contributed to the trial design, implementation, and evaluation. My primary role focused on FMD data collection and analysis. The larger RCT duration was 10 months. This thesis reports on the project from organisational recruitment (January 2018) through to baseline (July 2018) and 12-week (October 2018; follow up 1) data collection. Data collected at 10 months (follow-up 2) is not included in this thesis but is presented elsewhere (Morris et al., 2021).

Participants were divided into two groups: i) a multi-level intervention group with the use of a sit-stand workstation (sit less and move more plus; (SLAMM+), and ii) a multi-level intervention group without a sit-stand workstation (SLAMM). Data was collected at baseline (0 weeks) and 12 weeks. Ethical approval was obtained from Liverpool John Moores University research ethics committee (ethics number: 18/SPS/001).

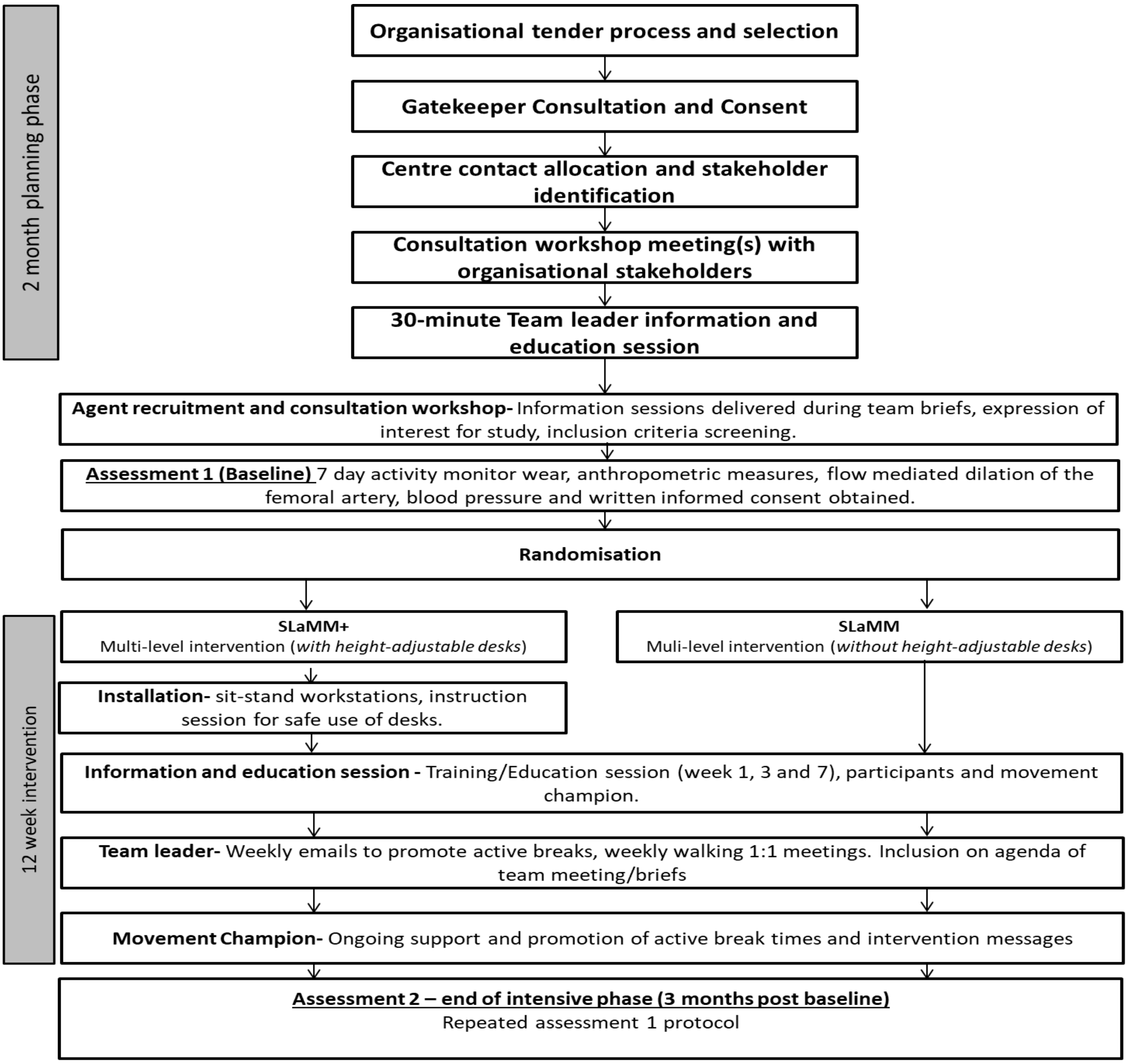

Figure 2 CONSORT flowchart detailing overview of study recruitment, randomisation, and intervention components

2.2 Recruitment and planning

2.2.1 Organisation level call centre recruitment

A tender process was utilised to recruit organisations. The tender outlined the research objectives, aims, and expected timeframes for the study. The tender package, including an infographic (which highlighted the benefits of reducing SB and increasing PA for a healthier workforce) and application form, were emailed on our behalf by Call North West (with researchers copied in) to call centres affiliated with the Call North West Forum. Call North West forum is a support network that provides initiatives and events to over 700 call centres (https://callnorthwest.org.uk/). Their role is to share best practice and develop close partnerships with call centres in the North West. The tender package was sent to call centres with ≥100 call agents. Organisations were requested to submit an expression of interest to the research team, by email, detailing their suitability based on the tenders essential and desirable organisational requirements (Table 1) within 3-weeks of receiving the email.

Table 1. Organisational eligibility criteria.

Essential

1. The organisation can meet the proposed key dates for the research study.
2. The organisation has one or more branches/worksites in the North West of England.
3. Call agents have access to a work telephone, desktop computer with internet, are ≥18 years.
4. Organisations with only one branch/worksite in the North West of England house call agents across;
    a) Two or more buildings in the branch/worksite, and/or,
    b) Two or more office floors in the branch/worksite, and/or,
    c) Two or more clearly defined areas on the same office floor within the branch/worksite.

Desirable

1. The organisation has one or more branches/worksites within 50 miles of Liverpool city centre.
2. The organisation has >50% of call agents employed as full-time staff (22.5 h or more).
3. Call agents have access to wireless headsets.

Three applications were received from the tender process, of which none met the fourth essential criteria in Table 1. Despite this, the applications received were considered as the project timeline and funding period were limited, and the research team followed up with the organisations accordingly. Onsite meetings were conducted with each organisation to discuss their suitability. The relevant centres were notified of the outcome by telephone and email, with feedback supplied to those centres that were not deemed appropriate for inclusion. Informed consent (using a gatekeeper participant information sheet) was obtained from a gatekeeper (senior manager) from the successful organisation before participant recruitment. Consent was provided for recruitment, data collection, and intervention delivery onsite, during work hours.

2.2.2 Planning phase

During the planning phase, the research team worked with the organisation to plan the logistics of delivering the trial. A member of the management team agreed to act as the ‘centre contact’ for the research team throughout the duration of the study. This involved supporting recruitment, data collection, and intervention delivery. Face-to-face meetings were conducted with the centre contact and key stakeholders (senior management, team leaders and members of the planning team), to discuss the research process and delivery of the intervention including logistical considerations, recruitment, data collection, installation of sit/stand desks, and “offline time” for call agents to attend the education and data collection sessions.

2.2.3 Team leader recruitment and engagement

A recruitment email (drafted by the research team) was sent to team leaders by the centre contact, inviting them to take part in a 30-minute researcher-led information session. Team leaders were authorised by senior management if they wished to attend the recruitment session, which explained in detail the study aim, design, and timescale. The researcher highlighted the role of the team leader, which involved enabling and encouraging their teams (call agents) to engage with the intervention. Strategies to help the team leaders encourage and aid the agents throughout the study were discussed. Importantly, team leaders were advised that call agents should not be pressured or coerced to engage in the intervention.

2.2.4 Call agent recruitment

The call centre distributed/displayed researcher-designed recruitment posters throughout the centre in the weeks prior to call agent recruitment. Direct contact with employees in the call centre was initiated via a recruitment email that was drafted by the research team and distributed by the centre contact. The email invited call agents to attend a 10–15minute non-compulsory researcher-led study information session. Researchers' contact details were also placed on the posters for call agents that did not want to or could not attend the recruitment session. The session explained the study aims, protocol, objectives, assessments, and eligibility criteria (Table 2). Participants were informed that participation in the study would involve random allocation at the individual level to an intervention group [SLAMM (without sit-stand workstation) or SLAMM+ (with sit-stand workstation)]. At the end of the information session, participants were provided with an expression of interest form that included an option to be a 'stand-up champion' (described below). Call agents could email the research team to inform them of their interest in the study or give the hardcopy completed interest form to the centre contact. Call agents were given one week to express formal interest. A member of the research team used telephone screening to determine if call agents met the eligibility criteria.

Table 2. Participant (call agent) eligibility criteria

1. Full-time member of staff (≥0.6 full time or part-time equivalent worker in a permanent or temporary/agency position)
2. Call agent job role
3. Based onsite throughout the trial period
4. Access to a work telephone and desktop computer with internet
5. Aged ≥18 years
6. Ambulatory
7. No health problems that would impact the ability to stand for 10 minutes at a time
8. No planned absence >3 weeks during first 12-weeks of the trial
9. No planned relocation to another workplace/site during the first 12-weeks of the intervention
10. Not pregnant

2.2.5 Stand Up Champion recruitment

Call agents were advised during the recruitment sessions that they could become a 'stand-up champion'. This role involved promoting the intervention message through their working practices, encouraging call agents to sit less and move more. Importantly, champions were advised that call agents should not be pressured or coerced to engage in the intervention.

2.3 Randomisation

A random number generator was used to allocate call agents to either the SLAMM or SLAMM+ group after baseline. This was performed by an independent researcher, not involved in the recruitment phase. Participants and researchers were not blinded to group allocation. The participants were notified by email if they were in the SLAMM+ or SLAMM group.

2.4 Intervention Procedures

2.4.1 Organisational strategies

To highlight organisational buy-in at recruitment, call agents and team leaders were informed that the senior management team had approved the installation of the sit-stand desks, offline time for education/training sessions and data collection for call agents, and the appointment of stand-up champions and a centre contact. Recruited agents were co-located in an open plan office that operated a hot desk policy, therefore senior management agreed to assign SLAMM+ agents an individual desk throughout the trial.

2.4.2 Environmental strategies

Following randomisation, only call agents in the SLAMM+ group had a sit-stand workstation installed on their desk (VARIDESK ProPlus or Posturite DeskRite 100). The desk models were randomly assigned to SLAMM+ call agents by a researcher not involved in recruitment using a random number generator. The sit-stand workstations enabled the call agents to change their posture throughout the day, while allowing the call agents to continue their working practices. During the first education and training session, researchers brought a sit-stand workstation to demonstrate how to use the workstation safely. Call agents could practice using the workstation during this session and ask questions. An A5 laminate was attached to the top of each workstation and indicated safe and effective use.

2.4.3 Interpersonal strategies

Team leaders and stand-up champions were requested to encourage call agents to sit less and move more and were informed on the importance of call agents being free to engage with the intervention without persuasion. During the face-to-face meetings with call agents, team leaders were advised to include the intervention aims as part of their discussions. During the 12-week intervention, the centre contact was asked to forward an email (drafted by the research team) to call agents and team leaders on a weekly basis. These emails comprised ideas and strategies from call agents to sit less and move more. The ideas and strategies were informed by an activity with participants in the first education and training session (described below) and previous research (Buckley et al., 2015, Morris et al., 2019). Topics included posture changes, desk-based exercises, and active breaks.

2.4.4 Intrapersonal strategies

An invitation to call agents was disseminated via email by the centre contact, to attend three 30-minute researcher-led education and training sessions during work hours at intervention weeks 1, 3 and 9. During these sessions, researchers covered the aims of the intervention and the benefits of frequent posture changes, sitting less, moving more and active breaks. During the first session (week 1), call agents worked in groups to identify ways they could sit less and move more. A goal setting and self-monitoring strategy was introduced in week 1, with each call agent receiving a stopwatch and goal diary. Call agents were encouraged to monitor their time standing at their desk and walking at work and record daily totals in their diary. The diary included suggested incremental goals to encourage call agents to increase their stand and walking time at work. All intervention messages from week 1 were reinforced in the week 3 and 9 education and training sessions. Call agents received paper-based individual feedback (Appendix 1), and group-level feedback via presentations during the education sessions on cardiometabolic and anthropometric (week 1) and behavioural outcomes (week 9). The feedback was referred to as ‘health check feedback’ in the trial.

2.5 Data Collection

At baseline and 12 weeks (follow-up 1), participants attended a health check in the morning, conducted by appropriately trained researchers. Data collection was conducted in two quiet, temperature-controlled rooms at the call centre’s offices. One room was used for cardiovascular data collection (FMD; blood pressure [BP]) and the second room for anthropometric measurements and the fitting of activPAL monitors.

Partition screens were utilised to ensure privacy. At the two data collection points, participants were allocated a time between 8:00 am – 12:00 noon. This time window was selected as call agents had to fast overnight to control for diurnal variation. Call agents received a text message from researchers the day before to remind them about data collection and the requirement to arrive having completed an overnight fast and wearing light clothing suitable for data collection. Call agents were emailed a food and fluid diary prior to baseline assessments. They were required to record all food and fluid intake for the 24h period prior to the assessment, in order to replicate their food and fluid intake for the 24h prior to the 12-week assessment. Call agents were requested to avoid alcohol and caffeine consumption for 12 hours and avoid smoking and strenuous exercise for 24 hours before assessments. Females were asked to record the number of days since their last menstrual cycle.

2.6 Outcome Measures

Sociodemographic and occupational outcomes were measured at baseline only. The remaining outcomes in this section were measured at baseline and 12 weeks.

2.6.1 *Sociodemographic and Occupational*

Sociodemographic and occupational characteristics were assessed using an adapted survey (Graves et al., 2015). Participants self-reported ethnicity, gender identity, age, educational and marital status, employment status/history, hours worked per week, work tasks, number of people in their workplace, and transportation mode to and from work.

2.6.2 Anthropometrics

Stature was measured in a free-standing position to the nearest 0.1 cm using a Leicester Height Measure (Seca Ltd, Birmingham, UK) and body mass to the nearest 0.1 kg using a calibrated mechanical flat scale (Seca Ltd, Birmingham, UK). From this, body mass index (BMI; mass Kg / height m^2) was calculated. Participants wore light clothing and no shoes. Waist and hip circumferences were measured in duplicate at the level of the umbilicus and greater trochanter, respectively, and waist: hip ratio (WHR; waist circumference (cm) / hip circumference (cm)) was calculated. For all outcomes, two measurements were performed. If a >1% difference occurred between the two measures, a third measure was taken.

2.6.3 Cardiometabolic

A 10-minute supine rest period was implemented prior to the assessment of BP and FMD. Participant's BP was recorded at the end of the 10-minute time point on the right arm, and the 1 minute FMD baseline measurement followed immediately on the right leg.

2.6.4 Blood pressure

Resting brachial artery SBP, DBP and heart rate (beats/min) were determined from an average of two measurements using an automated sphygmomanometer on a bare arm (Omron Healthcare, Kyoto, Japan). If the difference between the 2 measurements was >1%, a third measurement was taken and an average of all three measurements was used.

2.6.5 *Endothelial function*

B-mode images of the superficial femoral artery (Figure 3) were obtained using high-resolution ultrasonography (Terason, t3000, Teratech) and a 10–12 MHz probe. Femoral artery FMD was acquired using expert consensus guidelines (Thijssen et al., 2019). Once a clear image was obtained, a 1-minute baseline measurement was acquired (Figure 2). A rapid cuff inflator (Hokanson, Bellevue, U.S.A.), placed around the distal third of the thigh, proximal to the patella, was inflated to create a local ischemic stimulus (220 mmHg) for 5 minutes (Thijssen et al., 2011). Artery diameter and blood flow velocity recordings were paused during cuff inflation but resumed 30 second prior to cuff deflation and continued for 3 minutes thereafter (Thijssen et al., 2011).

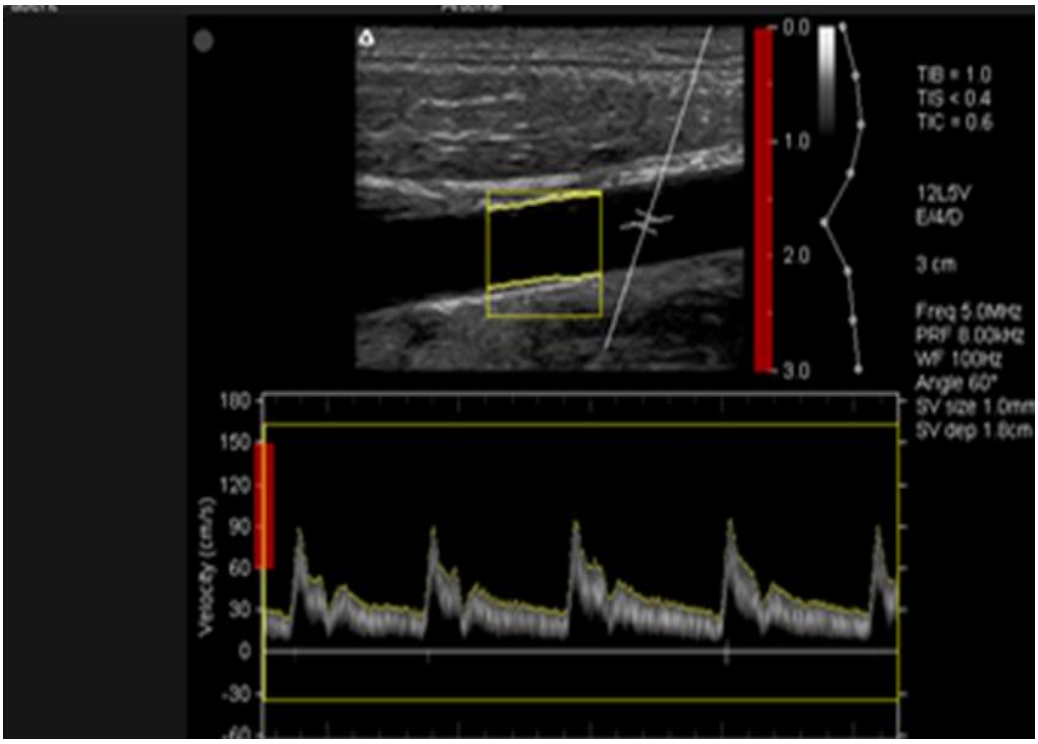

Figure 3 Custom software analysing flow-mediated dilation data. Yellow boxes show regions of interest for analysis of the artery walls and Doppler waveform.

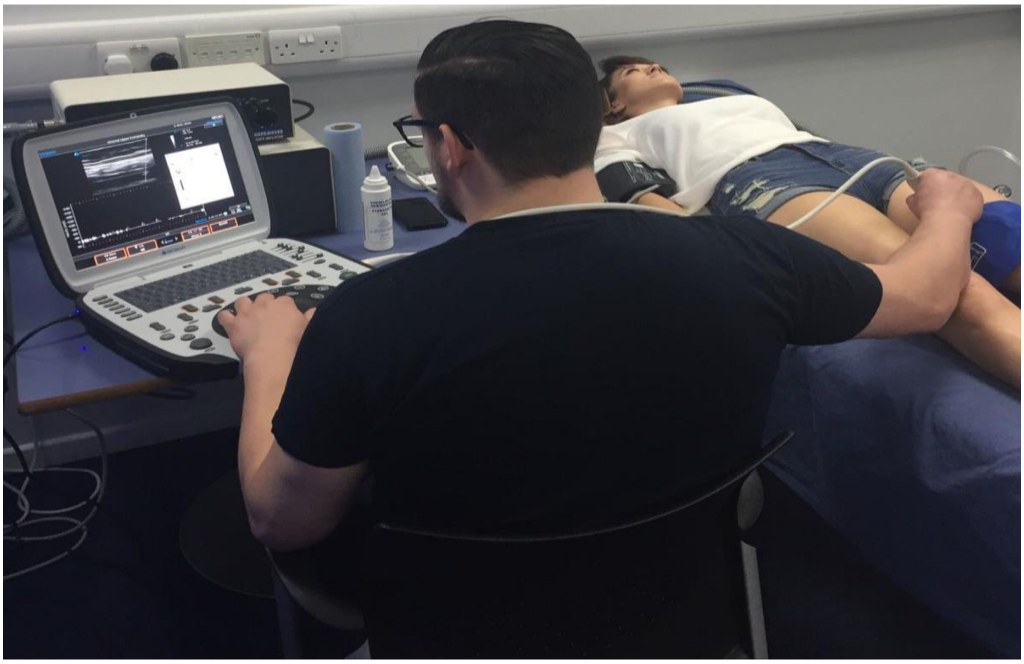

Figure 4 Assessment of femoral artery endothelial function using the flow-mediated dilation method.

Post-test analysis of femoral artery diameter was undertaken using custom-designed automated edge-detection and wall-tracking software (Dicom Encoder), which is for the most part independent of researcher bias (Woodman et al., 2001). Three validation studies illustrated the reproducibility and validity of the software (Woodman et al., 2001). Based on the quality of the image, an optimal region of interest (ROI) was selected for analysis by the researcher where there was clear distinction between the artery walls and lumen. After the ROI was selected, a pixel-density algorithm automatically identified the angle-corrected near and far-wall e-lines for every pixel column (Black et al., 2008) (Figure 2). An additional ROI was selected around the Doppler waveform, which automatically tracks the waveform (Black et al., 2008) (Figure 2). The edge detection software calculated diameter changes from baseline to peak diameter, time to peak following cuff release, and shear rate area-under-the-curve (SRAUC). The peak artery FMD was defined as the peak percentage change in artery diameter from baseline to post cuff release.

2.6.6 Behavioural outcomes and analysis

Using an activPAL monitor (PAL Technologies, Glasgow, UK) worn on the anterior midline of the right thigh (Figure 5), waking wear time, sitting time, standing time, total stepping time, number of steps and time accrued in sitting bouts ≥30 minutes were assessed continuously for 24 hours/day across a 7-day monitoring period at baseline and 12-weeks. The activPAL monitor has demonstrated excellent reliability and validity in measuring PA and SB (Edwardson et al., 2017). The monitor was placed in a flexible waterproof sleeve (PAL Technologies, Glasgow, UK) and attached to the thigh using a hypoallergenic waterproof adhesive strip (Tegaderm 3M, Bracknell, UK). Researchers familiarised participants with the monitor and supported them to attach the monitor. Instruction manuals detailing how to change and reattach their activity monitor during the wear period were provided.

Figure 5 ActivPAL monitor worn on the anterior midline of the right thigh.

Additional dressings and a leaflet with instructions on changing the dressing were provided so that participants could change this during their wear period. On each day of monitoring, participants were asked to complete a wear diary to record the time they started and finished work, the time they went to bed, went to sleep, woke up and got out of bed each day (Edwardson et al., 2017). The work diary enabled researchers to identify what behaviours occurred at work in addition to whole day behaviours. At the end of the monitoring period, the activPAL was returned to the research team or dropped in a box at the centre contact's desk. Data was downloaded using manufacturer software (PAL Technologies, Glasgow, UK).

ActivPAL data was downloaded and prepared for analysis using manufacturer software (PAL Technologies, Glasgow, UK). The software package was configured to identify and separate sleep, non-wear and invalid data from valid waking wear data. A day was classified as a non-wear day based on the following criteria: limited variations in activities (>95% of waking wear in any one activity); <500 steps; or <10hrs waking wear time (Winker et al., 2016).

Settings were applied in the software package to remove the first and last day, as these were not full days due to the monitor being issued and collected, respectively. A quality check was completed where heat maps were cross-checked with call agents' diaries to make sure the data was aligned (Edwardson et al., 2017). A file was prepared and added to the software that outlined working days and hours for all call agents, which allowed the calculation of the behavioural outcomes during work hours.

2.7 Sample Size

The sample size was dictated by the number of available height-adjustable workstations (*n*=30).

2.8 Statistical Analysis

Data was analysed using SPSS (IBM, New York, USA) with the alpha level set at $P \leq 0.05$. The primary aim of the full trial was to develop and evaluate a multi-component intervention to reduce call agents sitting time and increase PA in a call centre setting. The primary focus of this thesis was to test the effect of a 12-week multi-component intervention, with and without height-adjustable workstations, on vascular, behavioural and anthropometric outcomes in call centre agents. Analysis of covariance (ANCOVA) was utilised to compare intervention effects between groups at 12-weeks from baseline. The dependent variable was the change score, calculated as 12-week value minus baseline value. The independent variable was the treatment arm SLAMM and SLAMM+. Baseline values for all variables were entered as covariates to control for difference between groups at baseline (Vickers and Altman, 2001). Potentially confounding variables were added to the ANCOVA analysis if there was evidence to suggest they may influence the outcome variable. These included possible anthropometric, sociodemographic and job characteristics that were included in the analysis as covariates if a significant association ($P \leq 0.05$) was observed.

Shapiro-wilk tests were employed to identify if the un-standardised residuals were normally distributed. If residuals were not normally distributed, log and square root transformations of change scores were attempted. If these transformations worked in normalising the data, ANCOVA tests were then re-run on the recalculated change scores. If the residuals were still not normally distributed following transformations, log transformations were not used and ANCOVA was run on the raw change scores data (un-controlled for covariates) to determine if there were changes between groups.

CHAPTER 3

RESULTS

3.1 Trial Recruitment, Retention and Randomisation

3.1.1 Organisational recruitment

A total of 16 call centres were approached during the tender process, of which three expressed an interest in the study (response rate = 18%). One company from North West England was recruited. The call centre had 6 contracts staffed by 6 separate teams stationed independently across a large open-plan worksite. The call centre approved one contract/team for the trial. Within the selected contract, team leaders led a team of up to 16 call agents, who were largely non-permanent agency staff (Table 3).

3.1.2 Call agent recruitment, randomisation, and retention

A recruitment email was sent to 215 call agents, of which 213 attended recruitment sessions. A total of 107 call agents expressed an interest in the study, and 87 were screened; 59 call agents were identified to be eligible for the study, completed baseline assessments and were randomised. Of the 59 call agents at baseline, 39 completed 12-week assessments (retention rate = 66%). The main cause of attrition was company leavers (60%), of which 10% had spent less than <90 day in the company. Attrition for the SLAMM group was 27.5%, and SLAMM+ was 33.3%.

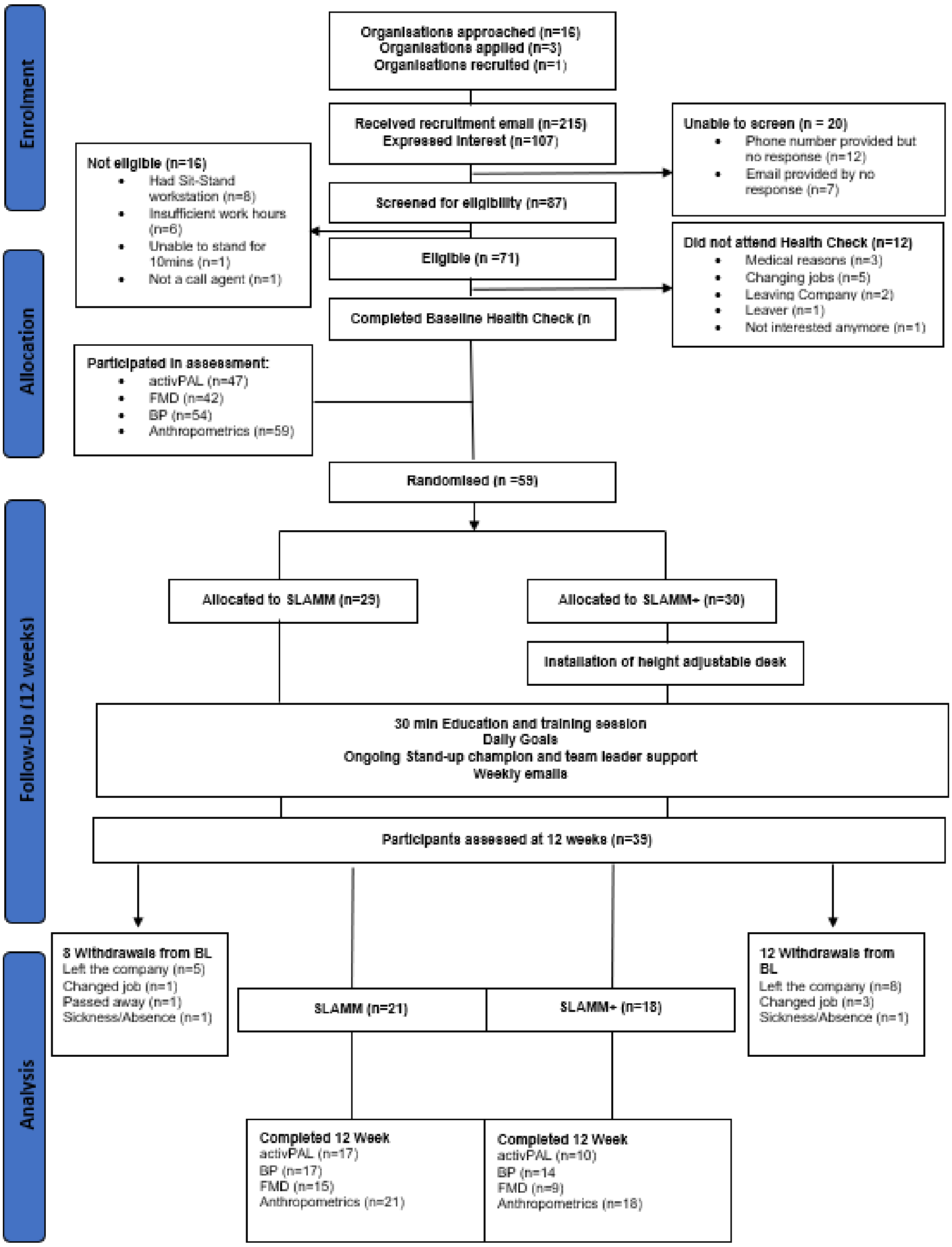

Figure 6 CONSORT flow diagram of enrolment, allocation, follow up and analysis.

3.2 Baseline Characteristics

Participants were typically white British, female, single, tertiary educated and mainly employed full-time on agency contracts (Table 3). Participants were generally overweight (BMI >25 kg/m^2;(Di Angelantonio et al., 2016) [Table 3]) and exhibited a healthy SBP

(<120mmHg) and DBP (<80mmHg) (Table 4) (Carey et al., 2018). There were no significant between-group differences between SLAMM and SLAMM+ at baseline for gender identity, age, ethnicity, marital status, or education. The SLAMM+ group had a significantly higher number of smokers than the SLAMM group (*P* = 0.036).

Table 3. Baseline characteristics presented as means ± SD or *n* (%).

	Total (*n*=59)	**SLAMM (*n*=29)**	**SLAMM+ (*n*=30)**	***P*-value**
Female	40 (67.8)	23 (73.0)	17 (56.7)	.063
Age (years)	30.6 ± 11.5	32.0 ± 11.0	29.2 ± 11.6	.438
White British	55 (93.2)	26 (89.7)	29 (96.6)	.206
Single	49 (83.1)	27 (93.1)	22 (73.3)	.318
Current smoker	28 (47.5)	10 (35.7)	18 (64.3)	.036*
Tertiary educated	34 (57.6)	15 (51.7)	19 (63.3)	.394
Body Mass Index (kg/m^2)	29.2 ± 7.2	28.7 ± 6.9	29.8 ± 7.4	.188
Worker Status				
Full Time	49 (83.1)	25 (86.2)	24 (80)	.717
Agency [a]	45 (76.3)	24 (82.8)	21 (70)	.345
Hours worked per week (h/week)	35.9 ± 3.8	35.4 ± 4.5	36.4 ± 2.8	.365
Hours worked per day (h/day)	7.2 ± 0.9	7.1 ± 1.0	7.4 ± 0.8	.384

* Indicates a significant difference between SLAMM and SLAMM+ at baseline (*P* < 0.05).
a Agency refers to staff members that were employed on a contract basis from a 3rd party agency, and not directly employed by the company.

For the SLAMM and SLAMM+ participants combined, sitting occupied 80% (381.1 ± 75.0 min/8-h workday) of their time at work, and 42% (199.2 ± 121.7 min/8-h workday) of sitting time was accrued in prolonged periods of >30 minutes. Standing accounted for 15% (72.2 ± 72.8 min/8-h workday) of agents' time at work, and stepping time accounted for 5% (26.2 ± 11.4 min/8-h workday).

3.3 Intervention Effects

3.3.1 Vascular Outcomes

Vascular data is presented in Table 4. There was no significant difference between groups for the changes in SBP (F1, 28 = .910, *P* = .348), DBP (F1, 28 = .989, *P* = .329), FMD (F1, 21 = .097, *P* = .758), baseline femoral diameter (F1, 22 = .203, *P* = .657), time to peak diameter (F1, 13 = .269, *P* = .613) or SR_{AUC} (F1, 28 = .212, P = .754) at 12 weeks.

3.3.2 Anthropometric Outcomes

Anthropometric data is presented in Table 5. There was no significant difference between groups for body mass (F1, 35 = 2.08, P = .508), BMI (F1, 35 = 1.48, P = .315), waist circumference (F1, 36 = 5.02, P = .393), hip circumference (F1, 36 = 14.2, P = .322) or waist to hip ratio (F1, 36 = 4.83, P = .981) at 12 weeks.

Table 4. Vascular outcomes with adjusted between-group differences.

	SLAMM (BP *n*=17) (Vascular n=15)[c]		SLAMM+ (BP *n*=14) (Vascular n=9)[c]		Between Group adjusted change baseline to 12 weeks (95% CI) [a]	*P*-value
	Baseline	**12 weeks**	**Baseline**	**12 Week**		
Systolic BP (mmHg)	113 (17)	115 (20)	115 (14)	122 (16)	5.2 (-6.0, 16.3)	.348
Diastolic BP (mmHg)	76 (10)	78 (12)	78 (9)	84 (15)	0.5 (-0.5, 1.5)	.329
FMD (%)	5.6 (5.2)	8.0 (5.4)	9.1 (5.6)	7.3 (2.9)	-0.6 (-4.9, 3.7)	.758
Baseline Femoral Diameter (cm)	0.58 (0.08)	0.58 (0.10)	0.58 (0.08)	0.57 (0.07)	-0.01 (-0.1, 0.0)	.657
Time to Peak (Sec)	62.5 (43.3)	63.3 (41.4)	83.3 (45.2)	71.6 (43.2)	-0.9 (-4.6, 2.8)	.613
SR_{AUC}	12216 (11954)	14082 (12960)	15337 (6767)	15902 (8661)	-0.1 (-0.5, 0.4)	.754

[a] Change scores and 95% Cis are after adjustment by ANCOVA for baseline value and confounders.
[b] Baseline and 12-week values are unadjusted mean (SD).
[C] Vascular = FMD, baseline femoral diameter, time to peak and SRauc
P-value refers to the statistical significance of the between-group differences from the ANCOVA
BP – blood pressure; FMD – flow-mediated dilation; SR_{AUC} – Shear rate area under the curve.

Table 5. Anthropometric outcomes with adjusted between-group differences.

	SLAMM (*n*=21)		SLAMM+ (*n*=18)		Between group adjusted change baseline to 12 weeks (95% CI) [a]	*P*-value
	Baseline	**12 weeks**	**Baseline**	**12 Week**		
Body Mass (kg)	76 (22)	76 (22)	85 (25)	87 (25)	0.5 (-0.97, 1.94)	.508
Body Mass Index (kg/m2)	28 (7)	28 (7)	31 (9)	32 (9)	0.3 (-0.31, 0.93)	.315
Waist Circumference (cm)	84 (16)	83 (16)	92 (21)	92 (21)	0.7 (-0.1, 2.5)	.393
Hip Circumference (cm)	104 (15)	104 (15)	113 (15)	114 (21)	0.8 (-1.0, 2.7)	.322
Waist-to-hip ratio	0.8 (0.1)	0.8 (0.1)	0.8 (0.1)	0.8 (0.1)	0.0 (-0.0, 0.0)	.981

[a] Change scores and 95% Cis are after adjustment by ANCOVA for baseline value and confounders.
[b] Baseline and 12-week values are unadjusted mean (SD)

P-value refers to the statistical significance of the between-group differences from the ANCOVA

Table 6. Behavioural outcomes with adjusted between-group differences.

	SLAMM (*n*=17)		SLAMM+ (*n*=10)		Between group adjusted change baseline to 12 weeks (95% CI) [a]	*P*=value
Occupational minutes (min/day)	**Baseline**	**12 Week**	**Baseline**	**12 Week**		
Sitting time	403.8 (34.2)	376.6 (69.4)	382.1 (49.3)	325.7 (30.7)	-23.1 (-76.7, 30.5)	.383
Standing time	50.1 (30.2)	76.8 (65.5)	71.5 (44.4)	127.9 (96.8)	17.6 (-32.9, 68.0)	.480
Stepping Time	26.0 (8.5)	26.6 (9.8)	26.4 (11.6)	26.4 (8.3)	0.27 (-8.4, 8.9)	.950
Number of Steps (steps/day)	2472.4 (821.5)	2474.3 (796.7)	2512.5 (1106.8)	2450.6 (743.6)	100.4 (-557.2, 778.2)	.763
Sitting time (> 30-minute bouts)	227.3 (94.5)	241.2 (112.3)	172.0 (146.1)	152.4 (41.3)	-52.0 (-129.8, 25.8)	.181
Daily minutes (min/day)	**SLAMM (*n*=14)**		**SLAMM+ (*n*=8)**			
Sitting time [c]	617.9 (183.8)	674.8 (75.3)	690.0 (50.7)	629.4 (48.4)	-51.7 (-102.0, 1.4)	.094
Standing time	175.4 (67.0)	188.8 (66.6)	176.8 (39.5)	234.1 (49.8)	44.4 (-5.6, 94.5)	.088
Stepping Time	102.7 (46.4)	96.4 (26.1)	93.2 (18.7)	96.6 (21.0)	8.68 (-4.8, 22.2)	.194
Number of Steps (steps/day)	9484.6 (3668.4)	8346.4 (2509.1)	7852.9 (1251.1)	8033.5 (1716.1)	723.0 (433.5, 1879.5)	.206
Sitting time (> 30-minute bouts)	322.7 (128.9)	385.0 (109.0)	346.4 (104.7)	303.7 (90.7)	-73.3 (-155.2, 8.8)	.077

[a] Change scores and 95% Cis are after adjustment by ANCOVA for baseline value and confounders.
[b] Baseline and 12-week values are unadjusted mean (SD)

[c] Results data shown are back-transformed to original units following square root transformations.

P-value refers to the statistical significance of the between-group differences from the ANCOVA

3.3.3 Behavioural Outcomes

Behavioural data is presented in Table 6. There were no significant differences between groups for occupational sitting time ($F_{1, 24} = 0.79$, $P = .383$), prolonged sitting time ($F_{1, 25} = 1.90$, $P = .181$), standing time ($F_{1, 25} = 0.51$, $P = .480$), stepping time ($F_{1, 25} = 0.00$, $P = .950$) or number of steps taken ($F_{1, 25} = 0.09$, $P = .763$) at 12 weeks. There were no significant differences between groups for daily sitting time ($F_{1, 26} = 2.72$, $P = .094$), prolonged sitting time ($F_{1, 14} = 1.36$, $P = .077$), standing time ($F_{1, 16} = 2.36$, $P = .088$), stepping time ($F_{1, 19} = 1.81$, $P = .194$) or number of steps taken ($F_{1, 19} = 1.71$, $P = .206$) at 12 weeks.

CHAPTER 4

DISCUSSION

This study evaluated the effect of a 12-week multicomponent PA and SB intervention with and without provision of a sit-stand workstation on vascular, behavioural and anthropometric outcomes in call centre workers. While no significant between group differences were observed for vascular, behavioural or anthropometric outcomes after 12 weeks of intervention, the direction and magnitude of the adjusted change scores were favourable for SLAMM+ participants compared to SLAMM participants for total and prolonged occupational and daily sitting time, and occupational and daily standing time. The findings suggest the provision of a sit-stand workstation may be important for eliciting more favourable changes in behavioural outcomes in call centre workers within multi-component interventions.

SLAMM (-27 min/8h) and SLAMM+ (-56 min/8h) participants reduced occupational sitting time at 12 weeks compared to baseline. Despite this, SLAMM participants (+57 min/8h) exhibited an increase in daily sitting time at 12 weeks compared to baseline, while SLAMM+ participants (-61min/8h) reduced their daily sitting time. Though the adjusted change score between groups for occupational and daily sitting time was not statistically significant, the direction and magnitude of change may suggest that the provision of a sit-stand workstation may have contributed to these positive findings for the SLAMM+ group. The reduction in occupational sitting time observed at 12 weeks in SLAMM+, and to a lesser extent SLAMM participants, is lower than the average 100 min/8h workday reduction reported in a review of previous workplace interventions using sit-stand workstations alone or in combination with information and counselling (Shrestha et al., 2018). This difference may be due to specific components of call agents' job roles that hinder their ability to alter their sitting in contrast to more traditional office workers. Call agents' have longer call times, lower autonomy over their working practices and the need to achieve KPIs reduce opportunities to change behaviours during working hours (Morris et al., 2018). An intervention in call agents showed a mean reduction in self-reported sitting time of 100 minutes using a sit-stand workstation compared to a control group at 19 weeks (Chau et al., 2016). Due to the absence of a control group, it is not possible to compare the present findings with those of Chau et al. (2016), though similar beneficial effects for the SLAMM+ intervention may have been observed in the present study compared to a control group.

In the present study, both groups increased occupational (SLAMM = +26.7 min/8h, SLAMM+ = +56.4 min/8h) and daily (SLAMM = +13.4 min/8h, SLAMM+ = +57.3 min/8h) standing time from baseline to 12 weeks, although the SLAMM+ group exhibited greater increases in standing which may be due to the utility of the sit-stand workstation. Occupational sitting time was replaced by standing at 12-weeks. These findings are comparable to other studies over a 12-week period in office workers, in which sitting was largely replaced by standing (Edwardson et al., 2018, Bodker et al., 2021). Edwardson and colleagues (2018) reported a reduction in sitting time of 62 min/workday and an increase in standing time of 58 min/workday at 12 weeks. Similarly, a further study showed that a reduction in sitting time (-88 min) was largely replaced with standing (+93 min) at 12 weeks (Bodker et al., 2021). The present study found similar findings for standing time as SLAMM+ reduced sitting time by 56 min/8h workday and increased standing time by 56 min/8h workday. This highlights the potential importance for the use of sit-stand workstations in replacing sitting with standing in desk-based workers, and more importantly call centre agents.

Occupational, and daily prolonged sitting reduced for SLAMM+ participants from baseline to 12 weeks and increased for SLAMM participants. This suggests that the environmental adaptation of the sit-stand workstation may have enabled SLAMM+ participants to alter their postures more frequently throughout the day than SLAMM participants, leading to less time spent in prolonged sitting. This is potentially meaningful for this setting, as recent evidence suggests that seated postures for prolonged periods of 1 hr significantly impairs endothelial function in lower limb arteries (Thosar et al., 2015, Restaino et al., 2016). Environmental interventions focused on reducing sitting time in workplaces using sit-stand workstations have shown reductions in prolonged (>30mins) occupational sitting time, compared to a traditional control group (Shrestha et al., 2018, Bodker et al., 2021). Despite this seemingly consistent finding, caution is warranted when interpreting this literature as the available evidence to date is low quality due to inadequate sample sizes and weak methodological quality (Shrestha et al., 2018). This may extend to the present trial, which was likely not powered to detect significant between-group changes for the behavioural outcomes. However, there are some multi-component studies that were adequately powered and found similar results in traditional office workers to what this study found in call centre agents (Healy et al., 2008, Edwardson et al., 2017). Accordingly, the findings suggest that multi-component interventions with provision of a sit-stand workstation have promise for reducing total and prolonged occupational and daily sitting time and increasing occupational and daily standing time in call agent workers.

There were minimal changes in occupational and daily stepping time within and between SLAMM and SLAMM+ groups from baseline to 12 weeks. Similar to the present study, other studies were unable to alter stepping time following the introduction of a sit-stand workstation. Edwardson et al. (2018) reported a 2.41-minute/per workday increase in stepping for the intervention group at 12 weeks, while a more recent study showed an increase in 12 minute/per work week (Mon to Fri 9am-5pm) at 12 weeks relative to baseline (Bodker et al., 2021). These findings suggest that these collective interventions have so far failed to promote PA at work in mainly desk-based workers. The ergonomic setup for desk-based vocations is restrictive in nature against increasing PA. Office environments, and more so call agent job roles, promote inactivity by needing to be seated to perform computer-based tasks and receive a large volume of calls (Morris et al., 2018). Therefore, opportunities to acquire more PA at work is a real challenge. More research is needed to identify strategies that allow call agents to increase their PA at work. Strategies may include the use of treadmills at desks, walking breaks, or call agents using their lunch break to achieve more PA (Carter et al., 2019, MacEwen et al., 2015). Policy changes in organisations may be key to delivering opportunities to increase PA in call centre agents during work hours and may be more likely to be sustained over time. In 2004, a call centre charter stated that call centre agents should receive a 10-minute screen break at least every 2 hours (Broughton, 2004). If adopted, this policy would help reduce call agents' time at their desk and provide more opportunities to reduce sitting time and engage in PA during work hours. As a consequence of the recent COVID pandemic, hybrid working was introduced to limit staff numbers in call centres. Accordingly, future research should try to identify the feasibility of these strategies for agents working not only onsite in a call centre but also remotely, and in a hybrid manner (I.e., partly at work and partly in an office).

Although the results were not significant for reducing total and prolonged sitting time, the findings are potentially meaningful, as recent evidence suggests that seated postures for prolonged periods of 1-hour significantly impair endothelial function in lower limb arteries (Thosar et al., 2015, Restaino et al., 2016). Previous lab-based studies found that reducing prolonged sedentary time during a typical working day can prevent a reduction in shear stress due to prolonged periods of sitting and improve endothelial function (Restaino et al., 2015, Thosar et al., 2015). The present study was the first to examine if attempts to reduce sitting time and increase standing and PA in highly sedentary call centre workers improves endothelial function. It was hypothesised that greater reductions in total and prolonged sitting time and improvements in endothelial function would occur in the SLAMM+ group compared to the SLAMM group, owing to the additional behavioural changes achieved from the provision of a sit-stand workstation for 12 weeks. Despite this, there were no between group differences for SFA FMD at 12 weeks, and within-group changes were -1.8% for SLAMM+ and +2.4% for SLAMM at 12 weeks compared to baseline. SLAMM+ exhibited the greater reduction in sitting time and replaced it predominantly with standing. As a consequence of this, improvements for FMD in the SLAMM+ group were expected. The unexpected results in the SLAMM+ group may have been due to participants potentially not adhering to the request to not smoke, and refrain from drinking coffee or exercising prior to the assessments which may have skewed the data. Another potential explanation relates to the scan site for the vascular assessment being the femoral artery. The collection of FMD data was somewhat limited due to many of the participants carrying excess fat mass in the upper legs, which made it difficult to obtain a clear image. This led to missing data and reduced the number of participants with usable images at 12-weeks, which depleted the available data for FMD at 12-weeks. The use of a lower frequency probe may have improved the image quality in the current study with this cohort and should be considered for future studies.

The findings contrast with other intervention studies that showed favourable increases in FMD in desk-based office workers using sit-stand workstations with various levels of sitting reductions. A study in desk-based office workers showed meaningful results in SFA FMD

(+1.2%) when sitting was reduced using a sit-stand workstation over an 8-week period relative to a control group of usual practice (Graves et al., 2015). Additionally, a recent intervention used a sit-stand workstation in overweight and obese desk-based workers and reported a significant reduction in sitting time and improvement in femoral artery endothelial function (Bodker et al., 2021). These findings may have been from the significant reduction in sitting time at 12 weeks, as stepping time was not significantly altered at 12 weeks. Bodker and colleagues (2021) reported that endothelial function in the SFA was significantly improved at 12-weeks and sustained at 24 weeks with no changes found in brachial artery FMD using a repeated measures design with no control group. Endothelial function is governed by the blood flow in the arteries and preventing the reduction in blood flow halts the impairment of endothelial function in lower limb arteries (Restaino et al., 2016). An increase for FMD in SLAMM along with a reduction for SLAMM+ conflicts with other studies reporting that reductions in sitting through the utility of a sit-stand workstation benefit endothelial function at 12 weeks. (Bodker et al., 2021). There are several factors that may have contributed to the findings of the present study. With little changes in stepping time, it has been proposed that simply substituting sitting with standing may not be adequate to attenuate the decline in endothelial function in the lower limbs and that a focus on PA or resistance activities may result in improved FMD measures (Paterson et al., 2020). A recent lab-based study showed that interrupting prolonged sitting with walking prevented a decline in FMD when the duration of walking was longer, rather than shorter more frequent bouts (Carter et al., 2019). Carter et al. (2019) showed 8 minutes of walking in 120-minute intervals maintained lower leg blood flow for longer in comparison to 2 minutes of walking every 30 minutes. This may suggest a change in approach in call centres to prevent this decline in FMD from prolonged sedentariness, by aiming for longer periods of walking less frequently, which seems to be more effective than more frequent short periods of walking. Using walking breaks to acquire longer stepping time, coupled with sit-stand workstations, could result in preserved endothelial function in call agents at work, although the feasibility of this intervention approach needs considering and evaluating.

Both SLAMM and SLAMM+ participants presented with mean values for SBP and DPB that were in the healthy range at baseline and did not change at 12-weeks (Carey et al., 2018). At baseline, the mean BMI for SLAMM (28.7 kg/m^2) and SLAMM+ (29.8 kg/m2) participants were unfavourable, in the overweight and obese categories respectively. There were no significant changes across all anthropometric measurements for either group at 12-weeks. Prolonged bouts of sitting are associated with higher BP and high SBP is linked with a lower FMD response (Benjamin et al., 2004, Thorp et al., 2011). Call centre agents are therefore at risk for higher BP due to spending 80% (present study) to 90% of their time at work in seated postures (Toomingas et al., 2012). Hadgraft and colleagues (2021) conducted a meta-analysis and reported that interventions targeting SB with or without PA are showing beneficial changes in anthropometric and BP measures. Pooled effects show small but significant effects on SBP (–1.1 mmHg), body mass (–0.6 kg), and waist circumference (–0.7 cm) (Hadgraft et al., 2021). A further systematic review found that workplace interventions that focused on reducing SB found promising results for SBP (Brierley et al., 2019). A study on desk-based workers demonstrated that short-term use of a sit-stand workstation in office workers likely had beneficial effect on DBP (Graves et al., 2015). Graves and colleagues (2015) however did not find anthropometric changes at 12 weeks, although both groups in this study were in the healthy ranges for BMI at baseline. Another study displayed a significant reduction in mean arterial pressure in desk-based workers following a 13-week e-health intervention aimed at disrupting prolonged occupational sitting (Mainsbridge et al., 2014). Evidence suggests that endothelial dysfunction signifies an early step in the development of hypertension through the impairment of nitric oxide pathway (Taddei et al., 2006). Importantly for the call centre environment, breaking up sitting with standing and activity breaks can have beneficial effects on blood pressure (Larsen et al., 2014) and waist circumference (Neuhaus et al., 2014).

In the current intervention, high attrition rates make it difficult to draw conclusions for BP, as 47% of participants did not complete follow-up data collection for BP which resulted in large mean changes detected. A lack of significant changes in prolonged sitting and a failure to increase stepping time may indicate that the behavioural changes were insufficient to elicit physiological adaptations and changes in body mass and BP outcomes over a relatively short 12-week period. Further, BP measurements were in the healthy ranges at the start of the intervention, which makes it unlikely that the intervention would have changed BP significantly. Across most studies, the short-term durations (<12 weeks) of interventions may be inadequate to elicit changes across anthropometric and BP measures in call agents who sit for long periods of their working day (Bailey, 2021). Future interventions should aim to design longer term RCTs as physiological adaptations may need longer than 12 weeks to occur. Further studies should also be adequately powered to detect changes in health markers while also controlling for diet, as diet can affect the results observed for anthropometric, FMD and BP outcomes (Bailey, 2021).

4.1 Strengths and limitations

This study used novel cardiovascular measurements with ultrasound techniques to determine endothelial function. FMD is considered the gold-standard for non-invasive assessment of vascular function. Another strength was the objective measurement of PA and SB over a 7-day period, which provided a valid and reliable measurement of call agent's occupational and daily PA and SB. By measuring activity with accelerometery, this reduced the risk of recall bias associated with self-reported measures (Welk et al., 2014). The intervention and evaluation in the current study was informed by formative research, which was another strength (Morris et al., 2018, Morris et al., 2019).

A limitation in this study was the failure to control for diet. As diet can affect many outcomes in the analysis, this limitation could explain some of the unexpected results seen in this study. The lack of clear segregation between intervention arms was another potential limitation in this study. Steps were taken to mitigate the risk of selection and detection bias, although an open-label trial was necessary due to the presence of sit-stand workstations within an open plan office. The risk of contamination however was considered low as the sit-stand workstation could not be transferred between agents and hence intervention groups. Cluster randomised approaches are recommended in future trials, as it is possible that the presence of SLAMM+ participants could have motivated SLAMM participants to reduce their sitting time and vice versa. Further, it may be possible that greater behavioural changes may have been observed if the intervention arm SLAMM+ was compared to a traditional control arm. Due to the intervention being delivered in a single call centre, this may reduce external validity. A further limitation is the low ability to generalise the results to other working groups outside of call centre agents. Attrition rates in the study was a limitation as the turnover of staff was high in the organisation. Annual attrition rates in call centres are reported to be 21%, with most call centre staff leaving in the first 3 months of employment (Contact Babel, 2017). Future research is needed that focuses on recruitment strategies that aid the reduction in attrition rates in the call centre setting.

4.2 Conclusion

This study evaluated the effect of a 12-week multicomponent PA and SB intervention with and without provision of a sit-stand workstation on vascular, behavioural, and anthropometric outcomes in call centre workers. While no significant between group differences were observed for behavioural, vascular, or anthropometric outcomes after 12 weeks of intervention, the direction and magnitude of the within group mean changes were favourable for SLAMM+ participants compared to SLAMM participants for total and prolonged occupational and daily sitting time, and occupational and daily standing time. High attrition rates make it difficult to draw conclusions from the results in this study. Attrition rates in the study seem consistent with previous interventions in call centres, and this should be considered when planning to deliver interventions in this setting. The sit-stand workstation did appear to provide more meaningful reductions in occupational sitting time for SLAMM+ compared to the SLAMM group. The environmental component was the single difference between the groups, and recent analysis have shown multicomponent and environmental interventions produce significant improvements in sitting habits at work. While it is clear that call centre agents have excessive amounts of sitting, further research is needed to establish if multi-component interventions, including sit-stand workstations, provide a feasible way of reducing sitting time by replacing it with standing in this cohort. Additionally, these studies should aim to assess if replacing sitting with standing in call agents provides an adequate physiological stimulus to alter and improve endothelial function and should explore how beneficial changes in PA levels can be achieved in this population.

CHAPTER 5

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