Title: A systematic review investigating the behaviour change strategies in interventions to prevent misuse of anabolic steroids.

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Astract:

This review aimed to examine strategies applied in interventions to prevent image and performance enhancing drug use in the context of intervention effectiveness. Comprehensive searches identified 14 interventions that met review inclusion criteria. Interventions were predominantly educational and delivered within school sport settings, but targeted a wide range of mediating factors. Identification of effective components was limited across studies by brief or imprecise descriptions of intervention content, lack of behavioural outcome measures and short-term follow up times; however studies with components in addition to information provision may be more promising. Interventions are required outside of sport settings to reflect the transition of this form of substance use to the general population.

Introduction

Anabolic steroids

Anabolic steroids (AS) are the most prominent of a range of substances used to modify appearance and performance known as image and performance enhancing drugs (IPEDs). Globally the lifetime prevalence of AS has been estimated at 3.3%, with higher prevalence amongst males (6.4%) (Sagoe et al., 2014b), and it is suggested that nearly one third of AS users will develop a form of dependence (Pope et al., 2014a). Although AS can be used without adverse consequences, such as when used therapeutically, risk of harm increases with the far greater doses observed when AS are used outside of clinical settings (Harmer, 2010). Additionally, the quality of illicitly produced AS cannot be controlled and those using them frequently do so as part of complex IPED regimens. This misuse of AS is associated with a range of acute and chronic adverse consequences (Pope et al., 2014b) that range greatly from cosmetic (e.g. acne) to critical (e.g. cardiovascular disease, liver function) with evidence of potential psychological harms (e.g. increased aggression, mania) (ACMD, 2010b). Harms appear to increase with long-term use, which may be characterised by polypharmacy, long or continuous cycles of use, body image disturbance and obsession with training and diet (Kanayama et al., 2009).

The majority of those using AS inject their drugs and are exposed to risks such as injection site injury, infection and blood-borne viruses (BBV)(ACMD, 2010b). In the UK, HIV prevalence amongst IPED users has been identified as similar to those who inject psychoactive drugs (Hope et al., 2013) and there is evidence of risky sexual behaviour (Hope et al., 2013; Bates and McVeigh, 2016) and sharing of injection equipment (ACMD, 2010a) that highlights the possibility of BBV transmission within and beyond this population. In sport the harms of drug use to competition itself and to the sense of fair play has long been a topic of debate (Fraleigh, 1984; Todd, 1987). Use of AS and other IPEDs are prohibited in accordance with the World Anti-Doping Agency's Prohibited List (WADA, 2017) with consequences to athletes from using banned substances including lengthy bans from competition which impacts upon reputations, careers and future earnings.

That interventions to prevent use of AS are required has long been recognised (Council on Scientific Affairs, 1988; Nutter, 1993). Historically, use of these substances has been most strongly associated with 'doping' to enhance sporting performance amongst athletes and concerns over use in sports continues. However, misuse amongst the wider population has been

reported since the 1980s (Buckley et al., 1988; Johnson et al., 1989) and evidence suggests that globally the use of AS is increasingly widespread outside of sports environments (Sagoe et al., 2014b; Pope et al., 2014a; McVeigh and Begley, 2016). Participation in sport may not be the primary risk factor for AS use (Harmer, 2010) and outside of sport common motivations include supporting an attractive and healthy physique and enhancing muscle growth and physical strength (Sagoe et al., 2014a; Brennan et al., 2016). Further, use of AS in some individuals has been associated with body image disorders such as muscle dysmorphia and high drive for muscularity (Kanayama et al., 2006; Rohman, 2009). Interventions are therefore required to prevent use of these substances amongst a range of populations.

Behaviour change interventions

Interventions that aim to change behaviour are likely to be complex. In order to develop effective interventions, it is therefore necessary to understand which intervention components work, or do not work. Over the past decade developments in the field of behaviour change science support researchers to unpick interventions and to systematically examine intervention components (Michie and Prestwich, 2010; Michie et al., 2013; Michie et al., 2011). For interventions to be effective, appropriate behaviour change mechanisms must be identified and the application of theory in their development is recommended to guide this (Craig et al., 2008). Examining the components and the application of theory in interventions provides insight into the nature of these interventions and it may be possible to identify approaches that are likely to be effective or ineffective.

Review aims

While useful summaries of the evidence base exist, previous examinations of prevention approaches (Backhouse et al., 2014; Bahrke, 2012) have not examined the content of AS prevention efforts. Additionally, there are a number of recent evaluations of relevant interventions that require consideration. This review therefore aimed to systematically identify the behaviour change strategies applied in interventions that have sought to prevent the misuse of drugs to enhance muscularity, performance or appearance. This included the characteristics and components of interventions and their settings and target populations, and the utilisation of theory in intervention development, delivery and evaluation. Additionally the review aimed to identify whether particular behaviour change strategies are associated with reducing use of these drugs.

Methods

Development and reporting of the review was guided by the statement of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2009). The review followed methods described in the review protocol registered on the PROSPERO International Register of Systematic Review (ID CRD42016051204).

Search strategy

A comprehensive search for relevant studies was undertaken in December 2016 in the following databases: the Cochrane Library, MEDLINE, PsycINFO, Sports Discus, the Social Science Citation Index and Conference Proceedings Citation Index. Search strategies were developed based on combinations of free text and controlled vocabulary terms adapted to each database but included variations of: *anabolic steroid, performance enhancing, doping, muscle enhancing, IPED, PIED, PED, sport, athletes, gym, fitness, school, bodybuilding, weight training and prison.* A full sample search strategy is available in the online supplementary material and from the authors. The publication lists of organisations including the Advisory Council on the Misuse of Drugs, US Anti-Doping Agency, UK Anti-Doping, Druginfo and the US National Institute on Drug Abuse, and of key literature reviews relevant to this review (Backhouse et al., 2014; Petróczi et al., 2014; Bahrke, 2012) were reviewed.

Inclusion criteria and study selection

Studies published from 1990-2016 were eligible for inclusion to include the time period since early calls for AS prevention interventions (Council on Scientific Affairs, 1988; Nutter, 1993). Inclusion criteria were controlled studies of interventions published in English or French that aimed to prevent misuse of drugs taken to enhance muscularity, performance or appearance. This included studies focussing on the use of specific drugs such as AS, but also studies that applied broader terms to the substances they focussed on such as prevention of 'performance enhancing drugs', or 'doping'. These terms are strongly associated with AS, but can also include other drugs used alone or alongside AS, so are referred to here under the umbrella of IPEDs. Universal interventions and those targeted to any populations including, but not restricted to, young people, gym users, bodybuilders, athletes and men who have sex with men were eligible for inclusion. Studies were included where an intervention was compared with no intervention or a control intervention, and outcomes relating to the use of IPEDs or

intentions, attitudes, norms or knowledge relating to IPED use, were reported. One reviewer screened titles and abstracts of identified articles, with a sample of 10% screened independently by a second reviewer to determine eligibility for inclusion against pre-determined criteria. The full text of articles included at this stage were downloaded and screened for eligibility in the same way. Reviewer agreement on inclusion and exclusion was 100%.

Data extraction and quality assessment

The methodological quality of studies was assessed using criteria set out in the Effective Public Health Practice Project (EPHPP) quality assessment tool (Thomas et al., 2004). This tool is appropriate to use in systematic reviews of effectiveness interventions (Deeks et al., 2003) evaluated using a range of methodologies (Jackson and Waters, 2005). Study strengths and weaknesses were considered alongside discussion of study findings. The data extraction process was developed to gather as much information as possible on the nature of interventions. Data relating to study design, population and methodology, intervention characteristics, study outcomes and process outcomes were extracted using a form in Microsoft Access designed for this review. Two reviewers undertook study quality and data extraction independently. Discrepancies at all stages were resolved through discussion.

Identification of behaviour change strategies

The theoretical basis of interventions were examined using the coding scheme developed by Michie and Prestwich (Michie and Prestwich, 2010) designed to identify the extent to which theory is used in the development, implementation and evaluation of interventions. Behaviour change techniques (BCTs) were grouped according to the revised Behaviour Change Technique Taxonomy (Michie et al., 2013), a hierarchically structured taxonomy of 93 BCTs. BCTs are defined as the smallest components of an intervention and were recorded when explicitly reported by article authors (Behaviour Change Technique Taxonomy v1). The Taxonomy has been applied in systematic reviews to identify BCTs associated with effective approaches designed to influence a variety of behaviours including obesity management, physical activity, sexual health, alcohol use and cardiac rehabilitation (Martin et al., 2013; Burns et al., 2016; Heron et al., 2016; Prestwich et al., 2016; Bird et al., 2013). To help understand behaviour change strategies the Behaviour Change Wheel (Michie et al., 2011) was used to identify the behaviour change function(s) in each intervention. The tool includes nine distinct functions that interventions can perform in order to change behaviour (education, persuasion, incentivisation, coercion, training, restriction, environmental

restructuring, modelling and enablement). Where further information on intervention content was required, authors of studies published since 2000 were contacted. Five of six authors contacted responded with additional information not included in published articles. Initially, two reviewers independently applied the Taxonomy, Behaviour Change Wheel and theory coding scheme to all identified interventions to identify BCTs, intervention functions and theoretical background. There was agreement between reviewers on 10/14 interventions for BCTs, on 12/14 interventions for intervention functions and 12/14 interventions for theoretical background. Findings were then compared and all disagreements were resolved through discussion between the two reviewers.

Analysis

Results relating to identification of behaviour change approaches, theoretical constructs and behaviour change techniques are presented in structured tables and as a narrative summary. Findings relating to intervention effectiveness on relevant outcomes are summarised in tables. For the outcome of intervention impact on IPED use, effect sizes are reported and where not available in articles these were calculated where possible. Due to a combination of factors including variation between studies in design, intervention approach and outcome measures, meta-analysis was not appropriate to examine intervention effectiveness.

Results

After deduplication 12,857 articles were identified through database and supplementary searches. The study selection process is summarised in Figure 1, with 23 articles eligible for inclusion in the review. These 23 articles covered 17 studies that evaluated 14 distinct interventions (two interventions were evaluated at pilot and full study stage, and one intervention was trialled and evaluated with two populations).

[Insert figure 1 here]

Summary of identified studies

The characteristics of the 14 interventions are summarised in Table 1. The interventions were predominantly delivered in educational settings to young athletes and sought to influence behaviour by providing messages about IPEDs and associated harms. A range of other approaches were applied usually alongside IPED education including the development of skills

and knowledge to encourage healthy alternatives to IPED use, wider health promotion, changing of appearance norms, the development of positive morals and values, and drug testing. Only 2 of 14 interventions were delivered outside of educational settings, one that targeted adolescents in the community (Nilsson et al., 2004; Nilsson et al., 2001) and one that targeted adolescent and adult gym users (Jalilian et al., 2011). Further details on intervention characteristics and delivery are provided in the online supplemental material and are available from the authors.

[Insert Table 1 here]

In 11 of 14 interventions, the primary aim was to reduce risk factors for IPED use. In addition, ATHENA (Elliot et al., 2004) was a health promotion intervention aiming to reduce disordered eating and IPED use; and a university-based drug education programme (Tricker and Connolly, 1996) and the SATURN programme (Goldberg et al., 2003; Goldberg et al., 2007) aimed to reduce substance use (including IPEDs) amongst student athletes. The ATHENA and ATLAS programmes were evaluated at short- and long-term follow up (two and one years respectively) and the German anti-doping intervention (Wippert and Fließer, 2016) was evaluated up to two years following the intervention. All other studies included follow up at 3 months following intervention completion or less.

Summary of study quality

Overall ratings of study quality are presented in Table 1 with full details of the quality assessment available in the online supplementary materials and from the authors. Overall three studies were rated strong, five studies were rated moderate and nine studies were rated weak using the EPHPP tool. Across the studies, common areas of weakness were withdrawals and drop outs, particularly across studies that recruited from school sports teams; and potential for selection bias. Further, in seven studies important differences between groups identified at baseline measurements were not reported or addressed. Amongst nine studies that reported random allocation to groups, in only one study was the method of randomisation described (Elliot et al., 2004).

Behaviour change strategies

Five of the nine intervention functions in the Behaviour Change Wheel (Michie et al., 2011) were identified across the studies in different combinations, presented in Appendix 1. These interventions applied predominantly educational strategies to influence IPED use and risk factors. The most frequently identified functions were education (12 of 14 interventions), persuasion (7 of 14 interventions) and training (5 of 14 interventions) in different combinations. Training elements of interventions included information about weight training techniques (n=4) and skills to resist IPEDs (n=3). Two interventions included exercise sessions where weight lifting techniques were demonstrated and practiced in addition to an educational programme (Goldberg et al., 1996b; Goldberg et al., 1996a; Sagoe et al., 2016).

Across the interventions 18 BCTs were identified (range 1 to 7), applied in many different combinations as presented in Table 2. Identification of BCTs was often difficult due to brief and imprecise reporting of interventions. Therefore it is possible that further BCTs were applied that could not be verified here. The most frequently identified BCTs involved information provision ('Information on social and environmental consequences', n=9; 'Information about health consequences', n=8), followed by 'Instruction on how to perform the behaviour' (n=5), reflecting the educational function of interventions identified. Smaller numbers of studies additionally included BCTs to influence social norms (such as the use of credible sources to deliver talks, information about others' perceptions about AS use) or self-regulating behaviour (such as goal setting, and self-monitoring). Most studies included between two and four BCTs, with more than four BCTs identified in only the ATLAS (Goldberg et al., 1996b; Goldberg et al., 1996a) and ATHENA (Elliot et al., 2004) programmes.

[Insert Table 2 here]

Interventions with multiple intervention functions and those that included higher numbers of BCTs tended to be associated with more encouraging results. More promising studies appeared likely to include a combination of education through information provision about IPEDs with components designed to develop skills, change social norms, or encourage goal setting. Two interventions associated with reductions in IPED use (Elliot et al., 2004; Nilsson et al., 2004) were the only interventions where participants received information on other people's perceptions about healthy behaviours ('Information about others' approval'). Interventions associated with increases in undesirable attitudes (Elbe and Brand, 2016; Goldberg et al., 2003;

Goldberg et al., 2007) and perceived norms (Goldberg et al., 2003; Goldberg et al., 2007) were studies for which just one BCT was identified, and were not educational.

The theory coding tool (Michie and Prestwich, 2010) was applied to all papers. Generally theoretical constructs were poorly reported. The theoretical bases of six interventions were identified with specific theories including ethical reasoning theory (Elbe and Brand, 2016), the theory of planned behaviour (TPB) (Jalilian et al., 2011), social learning theory (SLT) (Goldberg et al., 1996b; Goldberg et al., 1996a) and a combination of SLT and the health belief model (Sagoe et al., 2016). In the mediation analysis of ATHENA, models of behaviour including the TPB, social cognitive theory and the information, motivation, behaviour model were described (Ranby et al., 2009). Although no specific theories were described, the Greek anti-doping education intervention (Barkoukis et al., 2016) was based upon establishing social norms and sporting values. For all other studies no theoretical bases were described, and it was therefore not possible to determine whether relevant constructs were used in the development or evaluation of interventions. The rationale or theoretical bases for control groups were not described in any study.

There was evidence for the six studies where a theoretical basis was identified that theory had been used to develop intervention techniques. All six studies measured theory relevant constructs at evaluation, and in four studies (Goldberg et al., 1996b; Sagoe et al., 2016; Jalilian et al., 2011; Barkoukis et al., 2016) outcomes were discussed, to at least some extent, in relation to theory. The ATLAS intervention had the most explicit links between theory and intervention development and evaluation, and mediation analysis further explored theoretical constructs underpinning the intervention (MacKinnon et al., 2001).

Intervention effectiveness

Evaluations of 5/15 interventions measured changes in IPED use, summarised in Appendix 2. Potential to reduce use was limited by low numbers of users at baseline and short-term follow-ups and, although positive intervention effects on IPED use were reported, effect sizes (where available) were small. Evaluation of the only intervention targeting adults alongside adolescents in a gym reported a reduction in AS use, but findings were limited by small sample size and short-term follow up (Jalilian et al., 2011). Evaluation of a community wide programme indicated that use of AS may have reduced slightly (Nilsson et al., 2004), but findings were limited by the cross-sectional study design. There were also indications that the

ATLAS and ATHENA interventions had positive impacts on IPED use. Short-term evaluation of ATHENA (Elliot et al., 2004) indicated fewer new users of 'body shaping drugs' amongst girls who received the intervention. However, this measure included supplements as well as AS, and there was no effect of the intervention on the similar long-term outcome of 'steroid and creatine use' (Ranby et al., 2009). Use of AS increased slightly following the ATLAS intervention, but at a lower rate than amongst controls (Goldberg et al., 1996b). Numbers reporting AS use were low throughout the evaluation however and the differences between groups were not statistically significant.

Evaluation of the pilot study of random drug testing in a small sample of school athletes was suggested to have had a positive impact upon past month IPED use (Goldberg et al., 2003). However, there was no impact on new users and evaluation of the pilot and follow up studies suggested risk factors increased (Goldberg et al., 2003; Goldberg et al., 2007). Across studies other outcomes commonly assessed included intentions to use IPEDs, and a range of measures of attitudes, knowledge and subjective norms (summarised in Table 1). Knowledge of IPEDs was generally improved following interventions, however impact was less clear on intentions, attitudes and subjective norms with small changes in the desired direction on some measures.

Intervention fidelity in delivery

Evaluation of ATHENA identified that, on average, teams included 81% of intended intervention content in each session (Elliot et al., 2004). In no other studies was any indication of intervention fidelity reported. As such, it was not possible to determine whether interventions were delivered or received in the intended manner, or using the BCTs and strategies identified.

Discussion

This review examines the nature and findings of interventions that have sought to prevent or reduce use of AS and other IPEDs over more than two decades. In 1996 the authors of one of these interventions noted that in comparison to other substances, there had been little research into AS prevention (Goldberg et al., 1996a). Over twenty years later, during which time prevalence in the general population has greatly increased (Pope et al., 2014a) and a substantial amount of research examining the topic has taken place (McVeigh and Begley, 2016), the findings of this review suggest that this statement still holds true. While there is a growing

body of evidence relating to AS regarding aetiology, epidemiology and related harms, it would appear that little is known on how to influence behaviour change, particularly outside of sporting environments. Interventions have been tested that attempt to induce change in AS or other IPED use through targeting many different behavioural risk and protective factors, such as focussing on ethics and values, harms, healthy alternatives, body image and social norms. Since the studies in the 1990s by Goldberg and colleagues, these interventions do not generally appear to have built upon what has preceded them and the evidence therefore largely consists of a series of 'one off' interventions that vary greatly in focus. There is no indication of the coherent development of a body of evidence since the first studies investigating AS prevention, and consequently there are no clear messages emerging on what approaches are likely to be effective or ineffective.

Interventions in this area have focussed predominantly on young athletes. There remains a need to develop effective interventions to respond to the use of AS in both professional and amateur sport, and the lack of studies evaluating interventions in these environments outside of schools suggests that any current approaches need to be evaluated using robust study designs. The evidence regarding prevention outside of the sporting domain is severely lacking. Interventions are required in response to increasing use of drugs, particularly AS, to enhance muscularity and appearance for non-sporting reasons, which are associated with a range of physical and psychological harms (Pope et al., 2014b; Hope et al., 2013; ACMD, 2010b). These interventions will likely require different strategies than those targeting athletes hoping to improve sporting performance and therefore the strategies applied within school sport settings may not be transferable to the wider population. For example, recent interventions that focus on influencing ethical decisions (Elbe and Brand, 2016) and creating a sense of fair play and morality (Barkoukis et al., 2016) make sense in the context of competitive sport, but seem less important outside of this environment. It should also be noted that despite the broad search terms applied in this review very little evidence on IPEDs other than AS was identified, indicating that research on approaches to tackle issues relating to misuse of drugs used alone or alongside AS such as melanotan and fat burning drugs is lacking.

It was intended to examine intervention effectiveness in the context of BCTs and theory applied. While some BCTs appeared to be associated with more effective interventions, interpretation of these findings was often made difficult by ambiguous or brief descriptions of intervention content and components. A limitation of this review may be the application of recent tools to

identify BCTs and theory application, as it is recognised that studies published before new guidance and tools were available may be less likely to meet these standards. However, use of these tools enabled the examination of studies in a consistent manner and identification of strengths and weaknesses of the evidence base. It is likely that additional BCTs were applied in these interventions that could not be identified with sufficient confidence. Interventions that appeared more promising typically included higher numbers of BCTs and multiple intervention functions. Establishing norms regarding others' perceptions of AS use, a concept further supported by mediation analyses of ATHENA and ATLAS interventions (Ranby et al., 2009; MacKinnon et al., 2001), and including an element of skills training, either weight training or imparting resistance skills alongside educational components, may be promising approaches.

The interventions in this review were primarily educational and based on the idea that people will make rational decisions, and therefore that increasing motivation to avoid AS and pursue healthy alternatives will reduce use. However, decisions about health and behaviour are not always rational and based upon a simple assessment of costs and benefits. To inform future interventions, research is required to increase understanding on which factors influence AS decision-making and increase risk amongst different populations. For example, although limited through its cross-sectional design, a community-based intervention included in this review sought to establish norms around AS use and appearance, and was associated with small reductions in AS use (Nilsson et al., 2004). If identified that social norms and peer expectations are significant factors influencing AS use then future interventions should test how to target these constructs.

Interventions may be informed by interventions targeting body image disturbance and eating disorders, which have frequently been based upon changing perceptions about media images, critiquing appearance ideals and increasing self-esteem (Alleva et al., 2015; Bailey et al., 2014). There is clear overlap with these concepts and strategies described within this review, and AS use is commonly discussed alongside body image and eating disorders (Rohman, 2009; Olivardia et al., 2004). With patterns of dependence amongst long-term AS users (Kanayama et al., 2009), and similarities between disorders such as muscle dysmorphia and behavioural addictions (Foster et al., 2015), approaches may also be informed by the evidence on preventing addictive behaviours. The transferability of messages from these fields is worthy of further exploration, and may be more appropriate to consider than evidence from attempts to reduce doping activities amongst athletes.

The lack of evidence about intervention impact upon AS use limits the findings of this review. This outcome was measured in five studies only, and intervention effects were small. Baseline levels of use were low, limiting the potential to demonstrate effectiveness with short-term follow-up measures. Additionally, while school years may be associated with onset of AS for a minority of users, initiation has more frequently been reported from 20-30 years of age (Pope et al., 2014a; Sagoe et al., 2014a), an age that interventions have very rarely targeted. As young people move from school into new environments, they are likely to be exposed to different opportunities, social expectations and pressures, which may affect motivation and factors that influence their decisions. It is feasible that interventions associated with effects on potential mediators may have positive impacts on future AS use, but further testing of key theoretical concepts in experimental situations is required.

The weakness of the evidence base is not just a reflection of the scarcity of evaluated interventions, but of their reporting. Since the publication of the earliest articles included within this review, a range of tools, guidance and checklists have been developed to support the development, delivery and reporting of interventions (Michie et al., 2013; Hoffmann et al., 2014; Des Jarlais et al., 2004). The development, delivery and evaluation of future interventions should be grounded in theory (Craig et al., 2008; Glanz and Bishop, 2010) and reporting should enable the reader to identify how and why the interventions were designed, and which mediating variables were targeted. Additionally, reporting of intervention fidelity, participant understanding of interventions and detail regarding comparison conditions was largely missing in the studies included in this review. Intervention fidelity can act as a moderating factor on why interventions are effective or ineffective and should be evaluated and reported (Bartholomew and Mullen, 2011; Gearing et al., 2011). It is recognised that authors are restricted in the amount of information they can provide in articles, but can make supporting information such as protocols and manuals freely accessible elsewhere (Abraham et al., 2014). This will increase transparency, understanding of what has been implemented and replicability. Only through the accumulation of replicable and well-reported interventions will a meaningful and rich evidence base emerge.

Conclusion

This review highlights that despite the increase in research around AS and other IPEDs over the past three decades, and substantial increase in use of these substances outside of professional sport, there is little evidence on how to reduce use. What evidence there is comes

predominantly from a set of stand-alone interventions delivered to school-based athletes that focus on a wide range of mediating factors, and there is a clear need to respond to the very different issues of the use of these drugs outside of sporting environments and in adult populations. Increasing understanding on factors that influence decision-making, and the transferability of evidence from other relevant fields, will inform strategies to tackle AS use. A more consistent and rigorous approach to the development and reporting of interventions, with reference to the tools and guidance developed over the past decade in the field of behaviour change science, is required to establish the evidence base in this area.

Conflict of interest statement

The Authors declare that there is no conflict of interest

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Figure 1: Flow of studies through the review

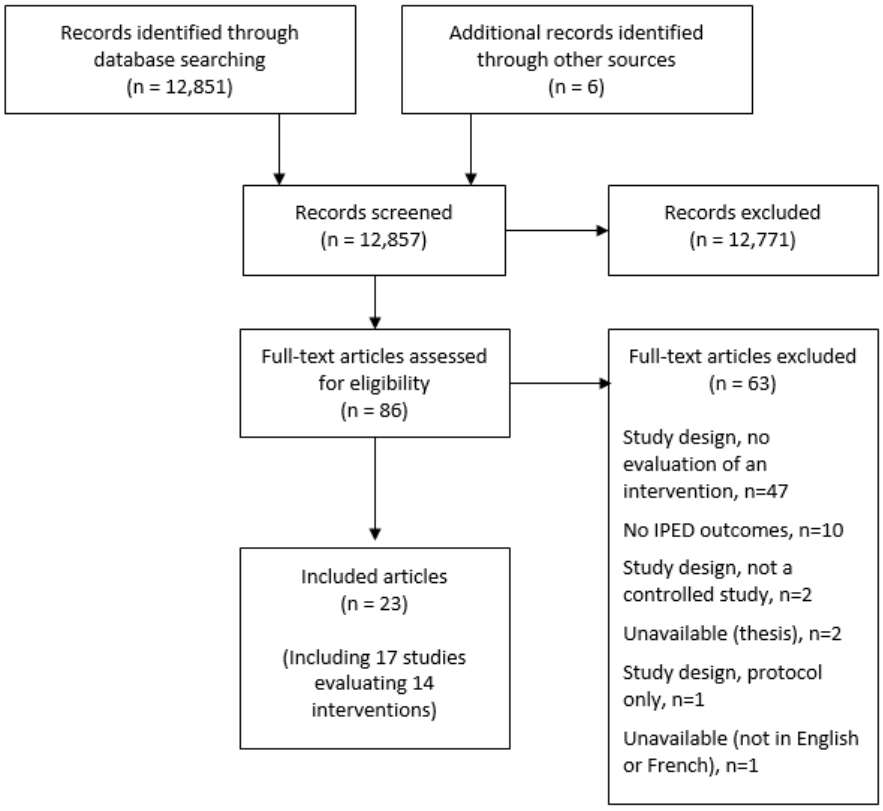


Table 1: Summary of included articles

Intervention description (Control group)	Citation(s) (Country)	Participants and setting	Design (sample size)	Quality rating	IPED Outcomes (follow up length)	Summary of results
Anti-doping culture promotion (General health education)	Barkoukis et al., 2016 (Greece)	Male and female adolescents at school	RCT (218)	Moderate	Doping attitudes; Perceived prevalence of doping in professional athletes (Post-intervention)	No intervention impact on doping attitudes, or perceived prevalence of doping amongst athletes in Greece.
Online doping ethical decision making training (Usual education; no intervention)	Elbe & Brandt, 2016 (Germany)	Male adolescent athletes at school	CBA (69)	Weak	Doping attitudes (Post-intervention)	Slight increase in undesirable attitudes towards doping following ethical training, although attitudes remained negative towards doping.
ATHENA: health promotion intervention (Information pamphlet)	Elliot et al., 2004, 2006, 2008; Ranby et al., 2009 (USA)	Female adolescent athletes at school	RCT (928)	Moderate	Use of body shaping substances; AS intentions, knowledge & norms; Body image (Post-intervention, 2 years)	At short-term evaluation ATHENA had a positive effect on initiation of body shaping substances, but there was no long-term effect. Intentions to use AS and creatine were reduced compared to the control group at long-term evaluation. Short-term knowledge of AS effects increased compared to controls, but perceptions of peers' use of IPEDs and coach and peer attitudes to body weight were mixed across 8

						measures. At long-term evaluation ATHENA participants favoured a heavier body shape compared to controls.
Brief educational intervention with handout (Handout only; no intervention)	Goldberg et al,, 1990 (USA)	Male adolescent athletes at school	RCT (190)	Weak	AS attitudes & knowledge (2 weeks)	Attitudes towards AS improved slightly in all groups. Knowledge of AS adverse effects increased compared to handout only controls on 3/13 measures and to no intervention controls on 6/13 measures.
Brief educational intervention with handout; Fear based education intervention with handout (No intervention)	Goldberg et al., 1991 (USA)	Male adolescent athletes at school	RCT (192)	Weak	AS attitudes, belief in negative consequences of AS use (2 weeks)	No impact of the balanced or fear based education on attitudes towards personal AS use across 7 measures. Greater belief in adverse effects for participants who received the balanced intervention compared to fear based education or control groups. No change in belief in adverse effects amongst the fear based education group.
ATLAS (Pilot): steroid education and nutrition and strength training (No intervention)	Goldberg et al., 1996a (USA)	Male adolescent athletes at school	CBA (120)	Weak	AS intentions & attitudes; Ability to resist AS offers (Post-intervention)	Compared to controls intention to use AS was reduced slightly on 2 measures. Impact on attitudes and beliefs about AS and AS norms were mixed across measures and ability to resist drugs did not change. Perception of body image and knowledge about AS effects and alternatives to AS use were improved compared to controls.
ATLAS: steroid education and nutrition and strength training	Goldberg et al., 1996b; 2000;	Male adolescent athletes at school	RCT (3,207)	Strong	Use of AS; AS attitudes, intentions, knowledge &	There were fewer new incidences of AS use and lower intentions to use amongst ATLAS participants compared to controls at end of season and 1 year follow up. Attitudes and

(Information pamphlet)	Mackinnon 2001 (USA)				norms; body image; ability to resist AS offers (Post-intervention, 1 year)	knowledge regarding AS favoured ATLAS participants at both times. Impacts on normative beliefs and perceptions about others' AS attitudes were mixed. Short-term benefits for drug resistance skills were not maintained at 1-year evaluation.
SATURN: random drug testing programme (No intervention)	Goldberg et al., 2003 (Pilot) (USA)	Male adolescent athletes at school	CBA (276)	Weak	Ergogenic drug use (including AS); drug attitudes & norms (Post-intervention)	There was no effect on initiation of ergogenic drugs but there was a small reduction in past month use in both groups. SATURN participants were more likely to have undesirable perceptions of others' drug use and attitudes, beliefs about drug consequences and drug testing and a greater desire to take risks.
	Goldberg et al., 2007 (Full study) (USA)	Male adolescent athletes at school	RCT (1,396)	Moderate	Drug use (including AS), drug attitudes & norms (Post-intervention)	There was no impact on past month drug use, but past year use was lower for SATURN participants on 2 of 4 time points. SATURN participants were more likely to have undesirable perceptions of others' attitudes to drug use and drug testing, and a greater desire to take risks than controls.
Anabolic steroid education (No intervention)	Jalilian et al., 2008 (Iran)	Male adolescent and adult community gym members	RCT (120)	Moderate	Use of AS; AS intentions, attitudes, norms & knowledge (Post-intervention)	AS use was reduced in both groups, but by a greater amount amongst the intervention group. Intentions to use AS were reduced in the intervention group only. Attitudes and knowledge about AS changed in a favourable direction in both groups, but changes were greater

						in the intervention group. There was no impact on subjective norms.
Health education intervention (No intervention)	Laure & Lecerf, 1999 (France)	Male and female adolescent athletes at school	CBA (287)	Weak	Attitudes & beliefs about doping (3 months)	Impacts were mixed with the intervention having a positive impact on some of the 35 measures amongst the intervention group and no impact on other measures.
Health education intervention (Information provision; no intervention)	Laure & Lecerf, 2002 (France)	Male and female adolescent athletes at school	CBA (379)	Moderate	Attitudes & beliefs about doping (3 months)	Across 35 measures education intervention participants had reduced risk factors and increased protective factors for doping compared to information only and no intervention controls. There was no impact of the information only intervention compared to controls.
Appearance and social norms focussed program (Not applicable)	Nilsson et al., 2001, 2004 (Sweden)	Male adolescents in the community	CCS (345)	Weak	Use of AS: tablets, injection (Post-intervention)	The proportions of participants using injectable and oral AS were reduced in the community following the intervention for injectable AS (1.9% reduction) and oral AS (1.3% reduction)
Hercules: anti-doping education alone or with strength training (No intervention)	Sagoe et al., 2016 (Norway)	Male and female adolescents at school	RCT (202)	Strong	AS intentions & knowledge; doping attitudes Satisfaction with appearance; ability to resist AS offers (Post-intervention)	Intentions to use AS increased slightly following the education & training intervention, but there were no significant differences compared to education alone or control groups. There was no intervention impact on attitudes towards doping, ability to reject AS offers or appearance satisfaction, but knowledge about AS and AS consequences increased following both education and training, and education alone, interventions.

Anabolic steroid education (Not reported)	Trenhaile et al., 1997 (USA)	Male pre-adolescent athletes at school	RCT (35)	Strong	AS attitudes & knowledge; self esteem; peer resistance (Post-intervention)	Attitudes and knowledge about AS were improved following the intervention and changed favourably compared with controls. No intervention impact reported on esteem or peer resistance.
Drug education (No intervention)	Tricker & Connolly 1996 (USA)	Male and female adolescent athletes at University	CBA (635)	Weak	AS intentions & attitudes; drug knowledge (Post-intervention)	Intervention participants had lower intentions to use AS on 1/3 measures and more desirable attitudes about AS on 2/2 measures than controls. No intervention impact on knowledge about performance enhancing drugs or other substances.
Anti-doping activities + curriculum (Curriculum only)	Wippert & Fleißer 2016 (Germany)	Male adolescent athletes at school	CS (213)	Weak	Doping knowledge (Up to 2 years)	Knowledge about doping was greater amongst those who received the anti-doping activities in addition to regular curriculum

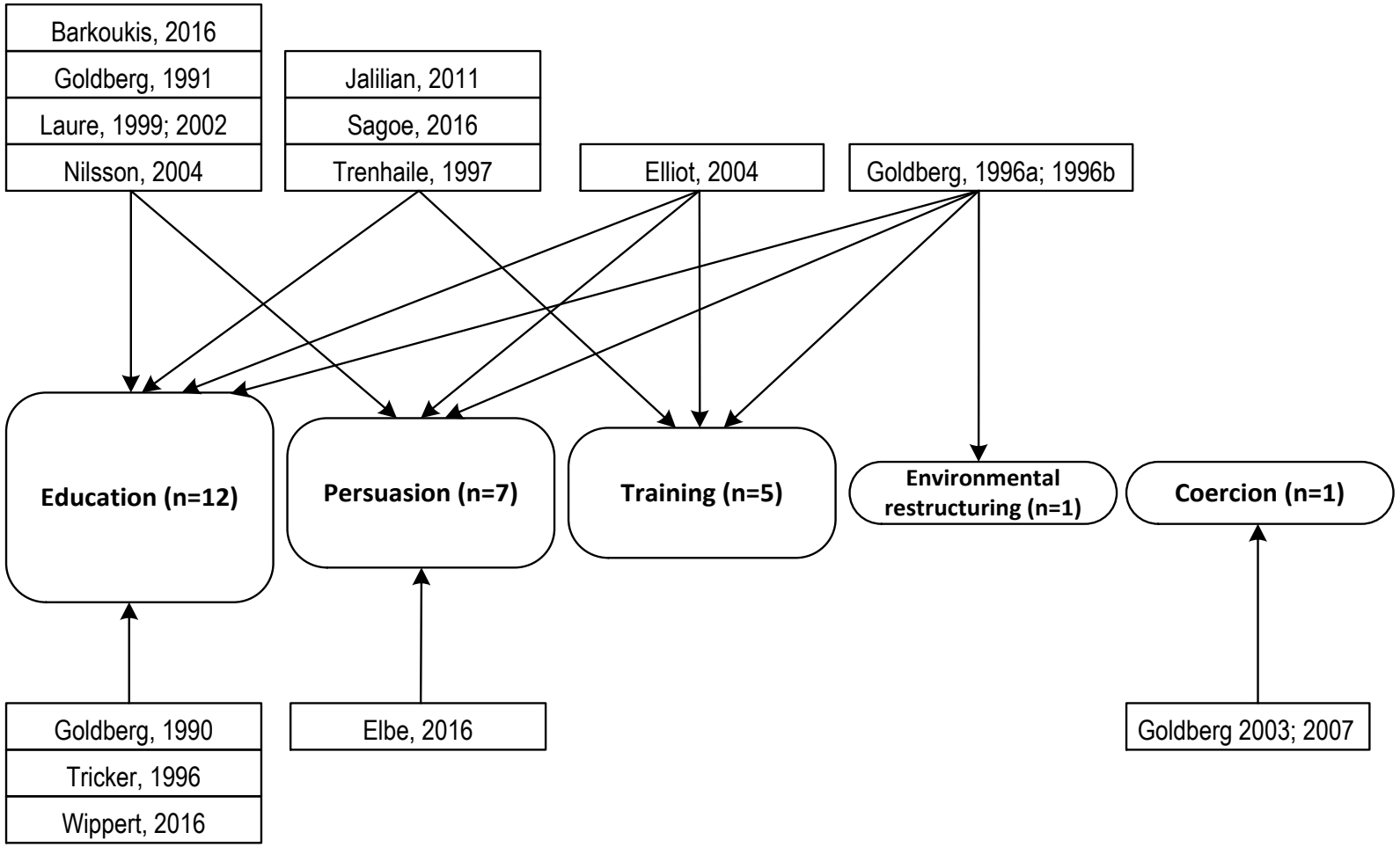
RCT=Randomised controlled trial. CCS = Cohort cross sectional study. CS=Cross sectional study. CBA=Controlled before and after study. AS=Anabolic steroids.

Table 2: Behaviour change techniques applied

Study	Goal setting (behaviour)	Self-monitoring	Instruction on how to perform the behaviour	Information about health consequences	Salience of consequences	Information about social & environmental consequences	Demonstration of behaviour	Information about others' approval	Behavioural practice/ rehearsal	Behaviour substitution	Credible source	Restructuring the physical environment	Framing/ reframing	Punishment
1				√		√				√				
2													√	
3	√	√	√			√		√	√				√	
4				√										
5				√	√	√								
6	√		√	√		√	√		√			√		
7														√
8			√	√						√	√			
9						√	√							
10				√	√	√		√						
11			√	√		√			√					
12	√		√	√										
13						√				√	√			
14						√					√			

1=Barkoukis et al. (2016). 2=Elbe & Brand (2016). 3=Elliot et al. (2004). 4=Goldberg et al. (1990). 5=Goldberg et al. (1991). 6=Goldberg et al. (1996a; 1996b). 7=Goldberg et al. (2003; 2007). 8=Jalilian et al. (2011). 9=Laure & Lecerf (1999; 2002). 10=Nilsson et al. (2001; 2004). 11=Sagoe et al. (2016). 12=Trenhaile et al. (1997). 13=Tricker & Connolly (1996). 14=Wippert & Fleißer (2016).

Appendix 1 The behaviour change function(s) of interventions



Appendix 2 Changes in IPED use

Citation(s) Study design	Outcome (follow up time)	Sample size		Measure	Pre-intervention		Post-intervention		Summary
		I	C		I	C	I	C	
Elliot et al., 2004; Ranby et al., 2009 (ATHENA) RCT	Initiation of body shaping drug use (post-season)	457	471		Not reported		Not reported		Lower initiation of body shaping substances, including AS, amongst ATHENA students, risk ratio =1.55 (1.03, 1.21)
	Steroid and creatine use (2 years)	406	411	Mean (SD)	Not reported	Not reported	0.02 (0.2)	0.02 (0.2)	No impact on steroid or creatine use compared to controls, beta coefficient =0.001.
Goldberg et al., 1996b; 2000 (ATLAS) RCT	Lifetime AS use (post-season)	1,145	1,317	%	1.0	1.5	1.5	2.5	Lifetime use of AS increased at a lower rate amongst ATLAS students following the intervention compared to control at both time points (Effect size not calculable).
	Lifetime AS use (post-season)	591	700	%	1.0	1.5	1.7	3.4	
Goldberg et al., 2003 (SATURN) CBA	New use ergogenic drugs (post-season)	62	95	Mean (SD)	0.00	0.00	0.11 (0.31)	0.10 (0.30)	The SATURN intervention had no effect on initiation of ergogenic drugs, Cohen's *d*= 0.03 (-0.28, 0.36).
	Past month use ergogenic drugs (post-season)			Mean (SD)	0.05 (0.22)	0.05 (0.22)	0.03 (0.18)	0.11 (0.32)	Reduction in past month use of ergogenic drugs amongst SATURN participants Cohen's *d*= -0.30 (-0.62, -0.02).
Jalilian et al., 2011 (AS education intervention) RCT	AS use (2 months)	60	60	%	18.3	21.7	10.0	18.3	Use of AS was reduced in both groups, but there was a greater increase amongst those who received the intervention, Cohen's *d*= -0.39; CI -0.98, 0.20.
Nilsson et al., 2001; 2004 (appearance norms-based intervention) CCS	Oral AS use (2 years)[1]	450	332	%	6.6		4.7		The proportions of participants using injectable and oral AS were reduced in the community following the intervention (Effect size not calculable).
	Injectable AS use (2 years)[1]	450	340	%	2.4		1.1		

RCT=randomised controlled trial. CBA=controlled before and after study. CCS=cross sectional cohort study. I=intervention group. C=control group. AS=anabolic steroids. RCT=randomised controlled trial. CCS=cohort cross sectional. CS=cross sectional. SD=standard deviation. NR=not reported in article. d=cohen's d. RR=risk ratio. [1]Data is reported separately for 16 and 17 year olds in the cited articles and combined here

ONLINE SUPPLEMENTARY MATERIALS

Search strategy for searching in Medline (Ebsco)

Search	Search Terms	# articles
S1	MM “Doping in sports” OR MM "Anabolic Agents"	6,889
S2	(TI (anabolic n4 steroid*) OR PED OR PEDs OR IPED* OR PIED* OR (performance N1 enhancing) OR (enhance performance) OR (performance N1 enhancement) OR (muscle enhancing) OR (muscle N1 enhancement) OR (enhance muscle*) OR (muscular N1 enhancement)) OR (AB (anabolic n4 steroid*) OR PED OR PEDs OR IPED* OR PIED* OR (performance N1 enhancing) OR (enhance performance) OR (performance N1 enhancement) OR (muscle enhancing) OR (muscle N1 enhancement) OR (enhance muscle*) OR (muscular N1 enhancement))	37,961
S3	S1 OR S2	41,747
S4	MH “Schools” OR MH "Sports+" OR MH "Youth Sports" OR MH "Athletes" OR MH "Prisons" OR MH "Weight Lifting" OR MH "Resistance Training"	187,335
S5	TI (school* OR gym* OR athlet* OR sport* OR fitness OR prison* OR offender* OR jail* OR (detention N1 (center OR centre)) OR (youth* n2 (club* OR centre* OR center* OR group*)) OR bodybuilder* OR (body N1 builder*) OR bodybuilding OR (body N1 building) OR weightlift* OR (weight* N2 train*) OR (strength* N2 train*) OR (resistance N2 train*) OR (power N2 lift*) OR gay OR homosexual OR LGBT)	158,107
S6	AB (school* OR gym* OR athlet* OR sport* OR fitness OR prison* OR offender* OR jail* OR (detention N1 (center OR centre)) OR (youth* n2 (club* OR centre* OR center* OR group*)) OR bodybuilder* OR (body N1 builder*) OR bodybuilding OR (body N1 building) OR weightlift* OR (weight* N2 train*) OR (strength* N2 train*) OR (resistance N2 train*) OR (power N2 lift*) OR gay OR homosexual OR LGBT)	314,122
S7	(TI (excess* OR addict* OR dependen*) N2 (exercise OR train* OR (physical N1 activity)) OR (musc* N1 dysmorph*)) OR (AB (excess* or addict* OR dependen*) N2 (exercise OR train* OR (physical N1 activity)))	3,217
S8	S4 OR S5 OR S6 OR S7	509,846
S9	S3 AND S8	6,465
S10	Limit: date of publication 1990-2016; Human	4,646

Results of study quality assessment

Quality assessment of all studies included in the review was undertaken using the Effective Public Health Practice Project quality assessment tool. Further information on the tool is available at: http://www.ephpp.ca/tools.html.

Citation	Selection bias	Study design	Confou-nders	Blinding	Data collection methods	Withdrawal & drop outs	Global Rating
Barkoukis et al, 2016	Moderate	Moderate	Weak	Moderate	Moderate	Strong	**Moderate**
Elbe & Brand, 2016	Weak	Moderate	Weak	Moderate	Strong	Strong	**Weak**
Elliot et al., 2004; 2006; 2008; Ranby et al., 2009	Moderate	Strong	Strong	Moderate	Strong	Weak	**Moderate**
Goldberg et al., 1990	Weak	Moderate	Weak	Moderate	Weak	Weak	**Weak**
Goldberg et al., 1991	Weak	Moderate	Weak	Moderate	Weak	Weak	**Weak**
Goldberg et al., 1996a	Weak	Weak	Strong	Moderate	Strong	Weak	**Weak**
Goldberg, 1996b; 2000; MacKinnon 2001	Moderate	Moderate	Strong	Moderate	Strong	Moderate	**Strong**
Goldberg et al., 2003	Weak	Weak	Strong	Moderate	Strong	Weak	**Weak**
Goldberg et al., 2007	Moderate	Moderate	Strong	Moderate	Strong	Weak	**Moderate**
Jalilian et al., 2008	Moderate	Moderate	Strong	Moderate	Strong	Strong	**Moderate**
Laure & Lecerf, 1999	Moderate	Weak	Weak	Moderate	Weak	Weak	**Weak**
Laure & Lecerf, 2002	Moderate	Moderate	Strong	Moderate	Strong	Weak	**Moderate**
Nilsson et al., 2001; 2004	Strong	Weak	Weak	Moderate	Strong	Moderate	**Weak**
Sagoe et al., 2016	Moderate	Moderate	Moderate	Moderate	Strong	Moderate	**Strong**
Trenhaile et al., 1997	Moderate	Moderate	Strong	Moderate	Strong	Strong	**Strong**
Tricker & Connolly, 1996	Weak	Weak	Strong	Moderate	Strong	Weak	**Weak**
Wippert & Fleißer, 2016	Weak	Weak	Weak	Moderate	Weak	Moderate	**Weak**

Summary of intervention delivery

Citation	Intervention	Provider	Mode of delivery	Duration	Intensity	Fidelity
Barkoukis et al., 2016	Anti-doping culture promotion	Physical education teachers	Group	Not reported	10 x 2 hour sessions	Not reported
Elbe & Brand, 2016	Ethical decision making training	Online	Individually accessed computer programme	3 weeks (average)	6 sessions	Not applicable
Elliot et al., 2004, 2006, 2008 Ranby et al., 2009	ATHENA	Coach & peers	Group	Not reported	8 x 45 minute sessions	High
Goldberg et al., 1990	Brief educational intervention	Not reported	Group	Single session	1x 20 minutes plus Q&A session & handout	Not reported
Goldberg et al., 1991	Brief educational intervention Brief fear-based intervention	Medical students	Group	Single session	1x 20 minutes plus Q&A session & handout	Not reported
Goldberg et al., 1996a; 1996b; 2000 MacKinnon et al., 2001	ATLAS	Coach, peers & research staff	Group	7 weeks	1x 50 minute classroom session & 1 weight room session per week	Not reported
Goldberg et al., 2003; 2007	SATURN	Not applicable	Not applicable	1 year	Not applicable	Not applicable
Jalilian et al., 2008	Anabolic steroid education	Peers	Group	Not reported	6 x 1 hour sessions; 1 x 3 hour workshop	Not reported
Laure & Lecerf, 1999	Health education based intervention	Research team (1999); Doctor & coach (2002)	Group	Single session	1 x 2 hour session	Not reported
Nilsson et al., 2001; 2004	Appearance and social norms focussed program	Health workers	Group; Media	2 years	Exposure to the intervention throughout duration	Not reported
Sagoe et al., 2016	Hercules	Anti-doping Norway	Group	12 weeks	4 x 90 minute education sessions; 12 x weight training sessions	Not reported
Trenhaile et al., 1997	Anabolic steroid education	Not reported	Group	2 weeks	6 x 30 minute sessions	Not reported

Tricker & Connolly, 1996	Drug education	Public Health official & coach	Group	10 weeks	Not reported	Not reported
Wippert & Fleißer, 2016	Anti-doping education	National Anti-doping Association	Group	2 x 1 day	1 day information tour presence in school; 1 day seminar	Not reported