

This article has been accepted for publication in *British Journal of Sports Medicine* following peer review. The definitive copyedited, typeset version Sharp P, Spence JC, Böttorff JL, et al One small step for man, one giant leap for men's health: a meta-analysis of behaviour change interventions to increase men's physical activity, *British Journal of Sports Medicine* 2020;54:1208-1216 is available online at: <https://doi.org/10.1136/bjsports-2019-100912>
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One small step for man, one giant leap for men's health: A meta-analysis of behaviour change interventions to increase men's physical activity

Paul G. Sharp^{1*}, John C. Spence², Joan L. Böttorff^{3,4}, John L. Oliffe⁵, Kate Hunt⁶, Mathew Vis Dunbar⁷, Cristina M. Caperchione^{1,3}

¹Human Performance Research Centre, University of Technology Sydney, Sydney, NSW, Australia.

²Sedentary Living Lab, Faculty of Kinesiology, Sport, and Recreation, University of Alberta, Edmonton, AB, Canada.

³Institute for Healthy Living and Chronic Disease Prevention, University of British Columbia, Kelowna, BC, Canada

⁴School of Nursing, University of British Columbia, Kelowna, BC, Canada

⁵School of Nursing, University of British Columbia, Vancouver, BC, Canada

⁶Institute for Social Marketing, Faculty of Health Sciences and Sport, University of Stirling, Stirling, UK

⁷Library, University of British Columbia, Kelowna, BC, Canada

***Corresponding Author:**

Paul G. Sharp
Sport and Exercise Science
Human Performance Research Centre
Faculty of Health
University of Technology Sydney
UTS Sport and Exercise Science
Driver Avenue, Moore Park NSW 2021
PO Box 123, Broadway NSW 2007
email: paul.sharp@uts.edu.au
phone: +61 (02) 9514 5208

Word count (max. 4,500): **4,831**

Key Words: Physical activity, men's health, randomised controlled trial, intervention, meta-analysis

ABSTRACT

Objective: To determine the effects of behaviour change interventions on men's physical activity, long-term physical activity behaviour (≥ 12 months post-intervention), and to identify variations in outcomes due to potential moderating variables.

Design: Systematic review with meta-analysis. Pooled effect size (Cohen's d) was calculated assuming a random-effects model. Homogeneity and subsequent exploratory moderator analyses were assessed using Q , T^2 , and I^2 .

Data sources: Medline, EMBASE, CINAHL, SportDiscus, and Web of Science to April 2019.

Eligibility criteria for selected studies: Randomised control trials of behaviour change interventions in men (≥ 18 years) where physical activity was an outcome and data were from male-only studies or disaggregated by sex.

Results: Twenty-six articles describing 24 unique studies met the eligibility criteria. The overall mean intervention effect on men's physical activity was 0.35 (SE=0.050; 95% CI=0.26 to 0.45; $p<0.001$). Intervention moderators associated with greater increases in physical activity included: objective physical activity outcome measures, a gender-tailored design, use of a theoretical framework, shorter program intervention length (≤ 12 weeks), using four or more types of behaviour change techniques, and frequent contact with participants (≥ 1 contact per week). Twelve studies included additional follow-up assessments (≥ 12 months post-intervention) and demonstrated an overall mean effect of 0.32 (SE=0.09; 95% CI=0.15 to 0.48; $p<0.001$) for long-term physical activity change.

Summary: Behaviour change interventions targeting men's physical activity can be effective. Moderator analyses are preliminary and provide suggestive evidence for future longitudinal testing of physical activity interventions for men.

INTRODUCTION

Physical activity has an important role in disease prevention and illness management. Despite considerable research into effective physical activity interventions (1, 2) the influence of gender, as a social determinant of health, is poorly understood. Gender is an important socio-cultural factor influencing health and health-related behaviours.(3) For example, males worldwide live on average 5.8 years less than their female counterparts and have higher rates of all-cause mortality.(4) Factors associated with these life expectancy sex differences are men's alignments to health risking, masculine roles, identities and relations.(5) A complication is that these expressions of masculinities intersect with other social determinants of health (e.g., socio-economic status, race, culture) to marginalise some male sub-groups and impose significant health inequities. The net effects are that some men lack the knowledge and/or resources to promote their health and/or access professional health care services, and may be less willing to attend health education sessions compared to women.(6-9) The assumptions often made within this backdrop are that men cannot or will not access health promotion programs, and that programs designed for the general public will suffice for those men who are willing to attend.

Evaluations of health promotion programs often fall short in providing information about effective strategies to promote men's health and more positive health behaviours (e.g., increased physical activity) because of the under representation of men in these programs. For example, in a meta-analysis of the effects of adult physical activity interventions, researchers reported a small overall effect ($d=0.19$); however, 74% of participants within the included studies were women.(2) Underrepresentation of men in health promotion programs makes the generalisability of evidence-based strategies to this sub-population challenging. As such, there is a need to better understand how behaviour change interventions affect men's physical activity, particularly in the context of real-world or community-based settings, and to

investigate variables which may moderate intervention effectiveness. As approximately 31% of the population worldwide is insufficiently active,(10) and clinically relevant health benefits may be accrued through relatively small increases in physical activity,(11) millions of men stand to benefit from effective health promotion interventions.

It is important to recognise that in order to yield the full health benefits of being physically active, these behaviours must be sustained over time. While previous reviews of adult physical activity interventions have noted modest overall effects on physical activity immediately post-intervention, an important consideration is the extent to which these changes are sustained following intervention completion. It has been noted that a limited number of studies include additional follow-up measures post-intervention and the evidence for long term behaviour change is mixed.(12-14) A Cochrane review investigating the effectiveness of interventions for promoting self-reported physical activity found that intervention effects post-intervention ($d=0.28$) were not maintained in 6 of the 19 studies reporting outcomes after 6 months.(12) Two more recent reviews examining the effects of web-based and face-to-face interventions reported small effects at 12-months post-intervention ($d=0.20$, 0.19 , respectively), and either no or small effects at 24 months. However, most studies failed to measure the long-term (i.e., ≥ 12 months) effects on physical activity.(13, 14)

Developments in men's health promotion have resulted in an increased number of physical activity interventions targeted at engaging and retaining male participants.(15, 16) As a result, several strategies have been identified that show promise for improving male participation, retention, and overall success rates.(15, 16) A recent systematic review examined physical activity interventions for men in relation to the influence of masculinities.(15) Findings of this review indicated that interventions tailored specifically to the values, preferences, and interests of men (e.g., gender-tailored) may increase program effectiveness. This is further supported by research highlighting gender-tailored strategies and approaches

found to engage men in health behaviour change (e.g., male-only programs, ‘masculine’ setting, action-oriented content, etc.).(17-20) Despite the growing interest in men’s health promotion, the overall effectiveness of physical activity interventions for men remains unclear. The aim of this meta-analysis was to determine the effects of behaviour change interventions to increase men’s physical activity, long-term physical activity change (≥ 12 months post-intervention), and to identify variations in outcomes due to potential moderating variables.

METHODS

This review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) Statement (Table S1)(21) and was prospectively registered in the PROSPERO registry of systematic reviews (#CRD42018079448).

Inclusion criteria

Eligible studies for inclusion were randomised controlled trials (RCT) identified using the following framework.

1. *Population.* Studies included adult men age 18+ years. Mixed sex studies were included provided relevant data (see outcomes) for men were reported separately. Consistent with previous research,(15, 16) studies that exclusively included older adults (≥ 65 years) were excluded as they are likely to have different intervention requirements.
2. *Intervention.* Interventions with clear and deliberate intent to increase the physical activity levels of participants. Physical activity was defined as any bodily movement that increased energy expenditure beyond basal levels. Diverse physical activity behaviour change interventions were eligible (e.g., education sessions, supervised physical activity practice sessions). Articles that included both physical activity and other health behaviours (e.g., diet) were included, provided that physical activity change was an intended and explicitly reported outcome.

3. *Comparison.* Studies were randomised controlled trials.
4. *Outcomes.* An outcome measure of physical activity (e.g., steps per day, total activity minutes per week), disaggregated by sex (if applicable), available for both intervention and control groups, representing physical activity change from pre- to post- or multi-point test.

Search method

A comprehensive search strategy was undertaken to identify all possible studies for inclusion. The search was applied to MEDLINE and adapted for EMBASE, CINAHL, SportDiscus, and Web of Science. All searches were completed by a specialised research librarian (MVD) to April 2019. Search terms included MeSH and keywords relevant to the aims and in accordance with the eligibility criteria: (a) population (e.g., Male/ or (men or male?)); (b) intervention (e.g., Exercise/ or ("physical activit*" or exercis*)); and (d) outcomes (e.g., Fitness Trackers/ or Self Report/). Additional filters were used to limit results to RCTs (e.g., Randomized Controlled Trial/ or (randomi#ed or experimental) adj3 trial). Searches were limited to English language, original research, and academic journals. No editorials, reviews, commentaries, conference abstracts or other grey literature were included. The decision to not include grey literature was based on concerns relating to the absence of peer-review and the potential for identifying an unrepresentative sample of all unpublished studies. The reference lists of included articles were manually searched for potential studies not yet identified. See Table S2 for the complete search syntax. Prior to manuscript submission, identified articles were reviewed to ensure that no trial had been retracted between inclusion and publication.(22)

Screening of articles

All identified references were imported into EndNote X8 (Clarivate Analytics, Philadelphia, Pennsylvania, USA). Duplicates were automatically identified by matches in

authorship, year, and title, and manually reviewed prior to deletion. Overseen by the lead author (PGS), two trained research assistants performed a title and abstract review to screen remaining records for relevance. Full text articles were retrieved for all remaining records and further screened to identify the final set of articles for inclusion. Any uncertainty was discussed amongst the research team.

Data extraction, study quality, and quality of evidence

A coding framework was developed, pilot tested, and refined by two researchers (PGS and JCS). Study characteristics were coded by two reviewers (PGS and JCS) under four general categories relating to the study design (e.g., sample size, physical activity measurement), participants (e.g., mean age, health status), intervention (e.g., mode of delivery, behaviour change techniques [BCTs], theoretical underpinning) and results (e.g., mean change, standard deviation). Outcome data for use in the meta-analysis were recorded for baseline, immediately post-intervention, and 12-months or greater post-intervention. If more than one variable was available for physical activity, the variable that best reflected an overall measure of physical activity was selected (e.g., total MET-minutes, self-reported total physical activity). Interventions were coded using Michie and colleagues' (23) definitions for characterising behaviour change interventions including education, persuasion, incentivisation, coercion, training, restriction, environmental restructuring, modelling, and enablement. Relevant detail was sought from additional publications (e.g., protocol papers), when available. Interventions were deemed to be gender-tailored if there was evidence to suggest that they were designed specifically to the values, preferences, and interests of men. Intervention engagement was assessed as high (>80%), moderate (60-80%), or low (<60%) based on participants' average reported uptake of the intervention content (e.g., attendance, website visits) or the extent to which participants met reported engagement goals (e.g., % attending 10 of 12 sessions). The

coding framework is not exhaustive of all intervention aspects and only common comparable characteristics reported in sufficient detail across studies are subsequently reported on.

Study quality was independently assessed by two members of the research team (PGS and CMC) using The Effective Public Health Practice Project (EPHPP) tool.(24) This tool has been reported to have content and construct validity, excellent inter-rater reliability, and is recommended by the Cochrane Public Health Review Group for assessing the quality of public health and health promotion studies.(25-27) This six-domain (14 question) rating scale for interventions assesses selection bias, study design, assessment of confounders, data collection methods (reliability and validity) and reporting of blinding, withdrawals and dropouts. In accordance with the tool's guidelines, a score for each domain of weak (1 point), moderate (2 points) or strong (3 points) was awarded and averaged to provide a total score for each study. Based on their total score, studies are assigned a quality rating of weak (1.00–1.50), moderate (1.51–2.50) or strong (2.51–3.00). Where discrepancies existed between reviewers, deliberation occurred until consensus was reached.

Additionally, the overall quality of evidence was assessed by three members of the research team (PGS, CMC, and JLB) using GRADE.(28, 29) The quality of evidence was performed for each study outcome (i.e., physical activity change and long-term physical activity change) and reflects the extent to which we are confident that an estimate of the effect is correct. The quality of evidence can be assessed as high, moderate, low, or very low. As all studies were randomised trials, study quality is initially assumed to be high but can be rated down based on risk of bias, inconsistency of results, indirectness of evidence, imprecision, or publication bias.

Statistical methods

Standardised mean differences (i.e., effect size) with 95% confidence intervals were computed to represent the effect of the interventions on men's physical activity. A positive effect size indicates a more favourable change in physical activity for the intervention condition. Cohen's criteria were used for interpretation of effect sizes as small (<0.50), moderate ($0.50-0.79$), and large (>0.79).⁽³⁰⁾ Effect sizes were calculated using change from baseline scores, as this method removes a component of between-person variability from the analysis by controlling for pre-intervention differences.⁽³¹⁾ In some cases, the required statistics were not reported. If available, and if possible, change scores were calculated from pre-test and post-test means and standard deviations, means and standard errors, confidence interval, or other statistics (e.g., p-values), using conventional methods detailed by Borenstein, et al. (2011).⁽³²⁾ In studies that included multiple intervention groups, a pooled mean and standard deviation was calculated to create a single pair-wise comparison before entering the meta-analysis. Cluster-randomised trials were adjusted for using an estimation of the sample size.⁽³³⁾ In such instances, a design effect was calculated for each study using an intraclass correlation coefficient (ICC) of 0.05, which has been previously used in meta-analyses of physical activity trials.⁽³⁴⁻³⁷⁾

Comprehensive meta-analysis (CMA) version-3 software was used for all analyses. A random effects model with inverse variance weighting was applied to estimate the pooled effect for physical activity. Two overall effect size calculations were conducted to investigate the effect of interventions on men's physical activity (baseline to post-intervention) and long-term physical activity change (baseline to 12-month or greater post-intervention). Each study contributed one effect size calculation to the overall analysis and twelve studies reported an additional follow-up measure 12 months or greater post-intervention. Sensitivity analysis was conducted using the "one-study remove" procedure. Publication bias was analysed using Egger's regression test,⁽³⁸⁾ Duval and Tweedie's Trim and Fill Procedure,⁽³⁹⁾ and Rosenthal's

Fail-Safe N calculation.(40) Homogeneity of effects was assessed through the Q-statistic. A significant Q-within (Q_w) value indicates a heterogeneous distribution and suggests a need to conduct follow-up moderator analyses. To interpret heterogeneity, Tau-squared (T^2), an estimate of total variance between studies, and I-squared (I^2), a ratio of excess dispersion to total dispersion, were calculated. Larger T^2 values reflect the proportion of variance that can be attributed to real differences between studies. I^2 can be understood as the overlap of CIs explaining the total variance attributed to the covariates, interpreted as low (25%), moderate (50%), and high (75%) relative variance. Larger I^2 values require techniques (i.e., moderator analysis or meta-regression) to provide explanations.

Moderator analyses were conducted to explore potential variations in effectiveness due to differences in study, participant, or interventions characteristics, using mixed effects analysis. Subgroup analyses were used to explore heterogeneity and make comparisons between characteristics. Categories were determined based on previous literature as well as the cut points that may be relevant for future intervention design.(41) A common among-study variance was assumed across subgroups and a pooled within-group estimate of T^2 was used. In light of previous research exploring the effects of physical activity interventions,(42) as well as work done in the field of men's health,(15, 16, 19) it can be reasonably argued that more intensive interventions (e.g., greater contact frequency, utilising more types of BCTs) and interventions designed specifically for the target population (e.g., gender-tailored) will be more effective. However, because previous research has provided a limited foundation for confirmatory hypothesis testing, the moderator analyses were considered exploratory and intended to be hypothesis-generating. Moderator analyses were not conducted for long-term physical activity change as only 12 studies included an additional follow-up 12 months or greater post-intervention.

RESULTS

Description of included studies

The initial search strategy (excluding duplicates) identified 13,131 potentially relevant articles. Following title/abstract screening, 284 references remained from which an additional 258 articles were further removed following a full text review. Ultimately, 26 peer reviewed journal articles (Figure 1), representing 24 studies and independent samples,(43-68) were included in the review.

Tables 1 and 2 outline study design and intervention characteristics, respectively. Table S3 provides an overview of the included interventions and additional details about the included studies. Articles were published between 1997 and 2019 including a total sample size of 12,040 male participants. Ethnicity of participants were reported in only 7 studies, of which 5 were predominantly white (>70%). Interventions primarily targeted overweight individuals (number of effect sizes (k)=11) and lasted on average 20 weeks (range 4-52 weeks). Intervention design varied between studies and often included multiple components with the majority including an aspect of face-to-face contact (k =18), education (k =24; i.e., increasing knowledge or understanding), training (k =20; i.e., imparting skills), and enablement (k =20; i.e., increasing means/reducing barriers to increase capability or opportunity). Overall study attrition was 15% (range 5-30%).

Supplementary S4 displays the study quality assessment for all studies. Overall study quality was mostly moderate (k =20; 83%), primarily due to participant self-referral (selection bias) and an inability to blind participants due to the nature of behavioural interventions. Studies rated as strong (k =4; 17%) were able to account for these issues by recruiting participants through a comprehensive list of the population (e.g., clinical registry), which may not be feasible in community-based research, and making efforts to blind assessors to participants' group allocation. The overall quality of evidence, assessed using GRADE,(28,

29) was determined to be high for physical activity change and moderate for long-term physical activity change suggesting that we are very confident and moderately confident, respectively, that the true effect lies close to that of the estimate of the effect. Although there were concerns relating to self-referral and an inability to blind participants in some studies, we did not downgrade the quality because we deemed the overall risk of bias to be very low. Long-term physical activity change was downgraded by one level for inconsistency based on considerable heterogeneity ($I^2=80$) and relatively wide variance of point estimates across studies.

Table 1. Study design and participant characteristics

Primary source	Study		Participant				
	Location	Design	PA Measure	PA Outcome	N [†]	Mean Age [‡] (Yrs)	Health Status
Aguiar <i>et al</i> , 2016(43)	Australia	RCT	Obj	Secondary	101	52	Overweight
Andersen <i>et al</i> , 2012(44, 45)	Norway	RCT	Obj	Primary	150	37	Inactive
Ashton <i>et al</i> , 2017(46)	Australia	RCT	Obj	Primary	50	22	Inactive
Galvao <i>et al</i> , 2017(47)	Australia	RCT	Sub	Primary	463	64	Cancer
Gong <i>et al</i> , 2015(48)	China	Cluster	Sub	Secondary	450	64	Hypertension
Gray <i>et al</i> , 2013(49)	Scotland	RCT	Sub	Secondary	103	47	Overweight
Goroeneveld <i>et al</i> , 2011(50)	Netherlands	RCT	Sub	Not clear	816	47	General
Hunt <i>et al</i> , 2014(51)	Scotland	RCT	Sub	Secondary	747	47	Overweight
Livingston <i>et al</i> , 2015(52, 53)	Australia	Cluster	Sub	Primary	147	66	Cancer
Maruyama <i>et al</i> , 2010(54)	Japan	RCT	Obj	Primary	110	40	MetS
McGowan <i>et al</i> , 2013(55)	Canada	RCT	Sub	Primary	423	68	Cancer
Morgan <i>et al</i> , 2013(56)	Australia	RCT	Obj	Secondary	159	48	Overweight
Morgan <i>et al</i> , 2014(57)	Australia	RCT	Obj	Secondary	93	40	Overweight
Morgan <i>et al</i> , 2011a(58)	Australia	RCT	Obj	Secondary	53	41	Overweight
Morgan <i>et al</i> , 2011b(59)	Australia	RCT	Sub	Secondary	110	44	Overweight
Morgan <i>et al</i> , 2009(60)	Australia	RCT	Obj	Secondary	65	36	Overweight
Patrick <i>et al</i> , 2011(61)	USA	RCT	Sub	Secondary	441	44	Overweight
Petrella <i>et al</i> , 2017(62)	Canada	RCT	Obj	Secondary	80	49	Overweight
Pritchard <i>et al</i> , 1997(63)	Australia	RCT	Sub	Secondary	66	43	Overweight
Schröder <i>et al</i> , 2018(64)	Spain	RCT	Sub	Secondary	6059	65	Overweight + MetS
Shin <i>et al</i> , 2017(65)	Korea	RCT	Sub	Secondary	105	28	Overweight
Viestar <i>et al</i> , 2018(66)	Netherlands	RCT	Sub	Secondary	314	47	General
Werkman <i>et al</i> , 2010(67)	Netherlands	Cluster	Sub	Secondary	413	60	General
Wyke <i>et al</i> , 2019(68)	Europe [‡]	RCT	Obj	Primary	1113	46	Overweight

PA = physical activity; RCT = randomised controlled trial; Cluster = cluster randomised trial; Obj = objective; Sub = subjective; MetS = Metabolic Syndrome

[†]Value for total sample; includes women in mixed-sex studies (i.e., Gong *et al.*, 2015 [42% male], Werkman *et al.*, 2010 [85% male])

[‡]England, Norway, Netherlands, and Portugal

Table 2. Intervention characteristics

Primary source	Intervention					
	Delivery	Focus	Contact	Gender Tailored	Duration (weeks)	Types of BCTs (num; type)
Aguiar <i>et al</i> , 2016(43)	F2F, On	Com	Once	Yes	24	3 (Ed,T,En)
Andersen <i>et al</i> , 2012(44, 45)	F2F, Tel	PA	2-3/week	No	20	3 (Ed,T,En)
Ashton <i>et al</i> , 2017(46)	F2F, On	Com	Weekly	Yes	12	3 (Ed,T,En)
Galvao <i>et al</i> , 2017(47)	Tel	Com	Monthly	No	24	3 (Ed,Ev,En)
Gong <i>et al</i> , 2015(48)	F2F, Tel	PA	Weekly	No	6	3 (Ed,T,Ev)
Gray <i>et al</i> , 2013(49)	F2F	Com	Weekly	Yes	12	6 (Ed,I,T,Ev,M,En)
Goroeneveld <i>et al</i> , 2011(50)	F2F, Tel	Com	Monthly	No	24	3 (Ed,T, En)
Hunt <i>et al</i> , 2014(51)	F2F	Com	Weekly	Yes	12	6 (Ed,I,T,Ev,M,En)
Livingston <i>et al</i> , 2015(52, 53)	F2F	PA	Bi-weekly	No	12	2 (Ed,T)
Maruyama <i>et al</i> , 2010(54)	F2F, On, Tel	Com	Monthly	No	16	3 (Ed,T,En)
McGowan <i>et al</i> , 2013(55)	Tel, Mail	PA	Once	No	4	2 (Ed,T)
Morgan <i>et al</i> , 2013(56)	On, Mail	Com	Bi-weekly	Yes	12	3 (Ed,M,En)
Morgan <i>et al</i> , 2014(57)	F2F	Com	Bi-weekly	Yes	7	4 (Ed,T,Ev,En)
Morgan <i>et al</i> , 2011a(58)	F2F	Com	2-3/month	Yes	12	4 (Ed,T,Ev,En)
Morgan <i>et al</i> , 2011b(59)	F2F, On	Com	2-3/month	Yes	12	5 (Ed,I,T,Ev,En)
Morgan <i>et al</i> , 2009(60)	F2F, On	Com	2-3/month	Yes	12	3 (Ed,T,En)
Patrick <i>et al</i> , 2011(61)	On	Com	Other	Yes	48	4 (Ed,T,Ev,En)
Petrella <i>et al</i> , 2017(62)	F2F, On	Com	Weekly	Yes	12	5 (Ed,I,T,Ev,En)
Pritchard <i>et al</i> , 1997(63)	F2F	PA	Bi-monthly	No	48	2 (Ed,T)
Schröder <i>et al</i> , 2018(64)	F2F, Tel	Com	3/month	No	52	3 (Ed,T,En)
Shin <i>et al</i> , 2017(65)	F2F, On	Com	Monthly	No	12	3 (Ed,I,En)
Vieste <i>et al</i> , 2018(66)	F2F, Tel	Com	Bi/monthly	No	24	3 (Ed,T,En)
Werkman <i>et al</i> , 2010(67)	Mail, On	Com	Other	No	52	2 (Ed,En)
Wyke <i>et al</i> , 2019(68)	F2F	Com	Weekly	Yes	12	6 (Ed,I,T,Ev,M,En)

F2F = face-to-face; Tel = telephone; On = online; PA = physical activity; Com = combined (e.g., PA and diet); BCTs = behaviour change techniques; num = number; Ed = education; I = incentivisation; T = training; Ev = environmental; M = modelling; En = enablement.

Overall analysis

Intervention effects on physical activity are reported in Figure 2. The estimated overall mean effect of physical activity interventions in men was small but significant ($d=0.35$; $SE=0.05$; 95% $CI=0.26$ to 0.45 ; $p<0.001$). Review of the homogeneity statistic revealed a significant heterogeneous distribution ($Q_w=72.32$, $p<0.001$; $I^2=68.20$). The one study removed procedure indicated that no individual study had a substantial impact on the overall effect size. Egger's regression test revealed that publication bias may be present ($p<0.01$). No studies were added during the Trim and Fill procedure. Fail-safe N revealed that at least 876 unidentified studies with a mean effect of zero would be needed before the overall effect would no longer be statistically significant ($p>0.05$).

Twelve studies (45, 47, 48, 50, 51, 53, 56, 59, 60, 66-68) reported an additional follow-up measure at least 12 months post-intervention (Figure 3). The overall mean effect for long-term physical activity change was small but significant ($d=0.32$; $SE=0.09$; 95% $CI=0.15$ to 0.48 ; $p<0.001$) and had a significant heterogeneous distribution ($Q_w=55.81$, $p<0.001$; $I^2=80.29$). The one study removed procedure indicated that no individual study had a substantial impact on the overall effect size. Egger's regression test was non-significant ($p>0.05$). No studies were added during the Trim and Fill procedure and a Fail-safe N calculation indicated that 186 unidentified studies would be needed to nullify statistical significance ($p>0.05$).

Moderator analyses

Study characteristics

Mixed effects analysis produced significant between-moderator results for study characteristics on physical activity measurement, $Q_b(1) = 9.30$, $p \leq 0.01$. Studies that employed objective measures of physical activity were found to have a larger effect size ($d=0.51$; 95%

CI=0.37 to 0.65) than studies that used subjective measures of physical activity ($d=0.26$; 95% CI=0.17 to 0.35). Table 3 provides details of the analyses for study characteristics.

Intervention characteristics

Significant between-moderator results were present for contact frequency, $Q_b(2)=14.11$, $p\leq 0.001$, gender tailoring, $Q_b(1)=12.08$, $p\leq 0.001$, duration, $Q_b(1)=8.72$, $p\leq 0.01$, theory, $Q_b(1)=8.28$, $p\leq 0.01$, and number of types of BCTs, $Q_b(1)=10.62$, $p\leq 0.001$. Interventions that had between one or more weekly contacts produced a larger effect size ($d=0.50$; 95% CI = 0.39 to 0.62) than interventions that had less than one weekly contact ($d=0.22$; 95% CI=0.14 to 0.31). Interventions identified as gender-tailored had a larger effect size ($d=0.47$; 95% CI=0.36 to 0.58) than studies that were not gender-tailored ($d=0.22$; 95% CI=0.12 to 0.31). Those that were 12 weeks or less in duration produced a larger effect size ($d=0.46$; 95% CI=0.35 to 0.57) than interventions lasting 13 weeks or longer ($d=0.23$; 95% CI= 0.12 to 0.33). Interventions that identified one or more theory used the guide intervention design produced a larger effect size ($d=0.40$; 95% CI=0.31 to 0.49) than interventions that did not use theory ($d=0.15$; 95% CI=0.01 to 0.30). Interventions that utilised 4 or more types of BCTs had larger effect sizes ($d=0.51$; 95% CI=0.38 to 0.63) than those that used 3 or less types of BCTs ($d=0.24$, 95% CI=0.15 to 0.34). All moderators had low between-study variance (T^2) and explained moderate to large portions of subgroup variance (I^2). Table 3 provides details of the analyses for intervention characteristics.

Table 3. Physical activity interventions moderator analyses

	Effect size descriptive statistics					Null test	Heterogeneity statistics		
	k	D	SE	s ²	95% CI	Z	Q	T ²	I ²
Random effects model [†]	24	0.35	0.05	0.002	(0.26 to 0.45)	7.13***	72.32*	0.030	68.20
Study characteristics[‡]									
Study design							0.40		
RCT	21	0.37	0.05	0.003	(0.26 to 0.47)	6.80***		0.03	70.03
Cluster RCT	3	0.27	0.14	0.021	(-0.01 to 0.55)	1.87		0.05	62.55
Study quality							0.00		
Strong	4	0.36	0.13	0.002	(0.10 to 0.61)	2.75**		0.01	11.87
Moderate	20	0.354	0.05	0.003	(0.25 to 0.46)	6.51***		0.03	72.00
Measure							9.30**		
Subjective	14	0.26	0.05	0.002	(0.17 to 0.35)	5.66***		0.01	48.41
Objective	10	0.51	0.07	0.005	(0.37 to 0.65)	7.33***		0.01	29.81
PA outcome							0.33		
Primary	7	0.32	0.09	0.009	(0.14 to 0.50)	3.42***		0.03	63.97
Secondary	16	0.39	0.07	0.004	(0.26 to 0.51)	5.97***		0.04	68.91
Sample size							2.83		
N ≤150	13	0.46	0.08	0.006	(0.30 to 0.61)	5.76***		0.02	29.30
N ≥151	11	0.29	0.06	0.003	(0.18 to 0.41)	4.96***		0.03	77.89
Participant characteristics[‡]									
Mean age							0.20		
≤44 years	9	0.39	0.10	0.009	(0.20 to 0.58)	4.09***		0.00	0.00
≥45 years	15	0.34	0.06	0.003	(0.23 to 0.45)	5.88***		0.04	77.95
Population							0.78		
General	20	0.38	0.06	0.003	(0.27 to 0.49)	6.68***		0.04	71.28
Clinical	4	0.26	0.12	0.014	(0.03 to 0.49)	2.21*		0.02	47.50
Intervention characteristics[‡]									
Contact frequency							14.11***		
<1 weekly	14	0.22	0.05	0.002	(0.14 to 0.31)	4.98***		0.00	22.86
≥1 weekly	10	0.50	0.06	0.003	(0.39 to 0.62)	8.51***		0.02	47.60
Engagement							3.95		
High	3	0.68	0.17	0.028	(0.35 to 1.01)	4.04***		0.18	74.46
Moderate	10	0.34	0.07	0.010	(0.20 to 0.48)	4.79***		0.03	63.95
Low	6	0.31	0.10	0.005	(0.11 to 0.51)	3.04**		0.00	0.00
Gender-tailored							12.08***		
No	12	0.22	0.05	0.002	(0.12 to 0.31)	4.53***		0.00	21.27
Yes	12	0.47	0.06	0.003	(0.36 to 0.58)	8.55***		0.02	46.82
Duration							8.72**		
≤12 weeks	13	0.46	0.06	0.003	(0.35 to 0.57)	8.03***		0.03	53.08
≥13 weeks	11	0.23	0.05	0.003	(0.12 to 0.33)	4.26***		0.00	25.01
Theory							8.28**		
No	5	0.15	0.07	0.005	(0.01 to 0.30)	2.07*		0.00	0.01
Yes	19	0.40	0.05	0.002	(0.31 to 0.49)	8.84***		0.02	49.62
BCTs							10.62***		
≤3 techniques	16	0.24	0.05	0.002	(0.15 to 0.34)	5.32***		0.01	26.98
≥4 techniques	8	0.51	0.07	0.004	(0.38 to 0.63)	7.72***		0.03	59.22

[†]Q_w-value used to determine heterogeneity

[‡]Q_b-value used to determine significant differences between moderators

*p≤.05, **p≤.01, ***p≤.001

k = number of effect sizes; d = effect size (Cohen's d); SE = standard error; s² = variance; Z = test of the null hypothesis; T² = between study variance in random effects model; I² = total variance explained by moderator(s).

DISCUSSION

This paper reports on the first meta-analysis of RCTs to synthesise the effects of behaviour change interventions to increase men's physical activity, long-term physical activity change, and to identify variations in outcomes due to potential moderating variables. Overall, interventions had a small but significant effect on increasing physical activity levels ($d=0.35$) as well as post-intervention sustainability of changes in physical activity ($d=0.32$). These effect sizes are larger than a meta-analysis investigating the effect of physical activity interventions for healthy adults ($d=0.19$; 358 studies, 99,011 participants); however, the sample in that review was predominantly (74%) female.(2) Similar meta-analyses of interventions to promote physical activity among sedentary adults ($d=0.31$; 11 studies; 3940 participants; 44% male)(12) and chronically ill (e.g., hypertension, cancer, diabetes) adults ($d=0.45$; 163 studies, 22,527 participants, 50% male),(1) are more in line with the present findings.

The significant positive effect found in the present analysis supports claims that physical activity is an acceptable intervention strategy for men and suggests that physical activity may be an important point-of-entry to encourage male participation in behaviour change. As Connell(69) suggested, 'masculinity' is associated with action and doing, and in this regard physical activity clearly qualifies as an acceptable outlet and performance opportunity for many men. This supports the notion that men are motivated to engage in activities which are perceived to be more 'masculine', such as sport and physical activity, as they may be associated with strength, friendly competition, and mastery.(70) Particularly when the aim is to improve health (e.g., weight loss), including a focus on physical activity may be more appealing and acceptable to men than simply providing support for 'dieting' or dietary modifications alone.(70, 71) Notably, a majority of the identified interventions in the present analysis had a primary focus on other health behaviours (e.g., weight loss) but used physical activity as an adjunct intervention strategy. Further, many of the studies ($k=15$; 75%) combined

physical activity and other health behaviours (e.g., diet), revealing opportunities for layering behaviour changes, in relative and relational ways that may engage and sustain men's participation. In this regard, physical activity may be viewed as a gateway that garners masculine capital, through which men may become more willing to address other health behaviours.(20, 72)

Participant characteristics within the included studies highlight some important trends and areas for future research. While the target audience for many of the interventions reviewed here were overweight men, there are also likely to be gains in tailoring physical activity programs for other sub-groups of men including those experiencing chronic illness. For example, prescription physical activity(73) and recreational football(74) have proven to be strong draws for men living with prostate cancer, as they have for weight loss(51) and physical activity interventions.(68) Resistance training has also been noted as a preferred modality of physical activity among men due to its perceived 'masculine' nature associated with strength but most importantly because it targets disease-related risk factors for men (i.e., bone loss for men on androgen deprivation therapy).(75) Further, few studies provided sufficient detail of participants' socio-cultural background, illuminating the need to formally evaluate the fit of men's physical activity health promotion programs for marginalised sub-groups. Men's health inequities, for example, may limit the access and involvement of sub-groups including Indigenous men, those from culturally and linguistically diverse communities, and men with low socio-economic status. These sub-populations may benefit from culturally sensitive approaches to physical activity, with programs designed to reduce structural barriers and address the resource poor realities of these under-served end-users. It is especially poignant within these contexts that sustained programing, inclusive of longitudinal evaluations, are completed to ensure sustainability of the changes that are often initially garnered and gained immediately post-intervention.

The findings indicate that a variety of program designs and approaches hold potential for positively influencing men's physical activity. For instance, using multiple appropriate BCTs and increased contact with participants (i.e., at least weekly throughout the program) were associated with significantly larger physical activity effects, suggesting that intensive interventions (i.e., greater intervention dose and frequency) may be more effective. While brief or limited contact interventions may be appealing as a cost-effective option, they limit opportunities for men to interact and connect with similar others. There is evidence to suggest that men are drawn to programs where they can connect with men similar to themselves, in a 'male-friendly' environment, and engage in friendly banter and competition.(20, 76) That shorter duration interventions (12 weeks or less) were found to be more effective than longer duration interventions, may reflect the majority of reviewed studies (k=11) were 12 weeks in duration. Although very brief interventions can produce acute changes in physical activity,(77, 78) sustainable behaviour change likely requires some threshold of intervention intensity. Similarly, if the relative intervention intensity of longer duration interventions is too low, it may not be sufficient to elicit behaviour change. That most of these interventions ran for 12 weeks, may bias or affirm that the optimal intervention duration for men lies somewhere in this range.

Although the majority of interventions in the included studies involved some type of face-to-face contact and multiple BCTs, it is noteworthy that interventions identified as gender-tailored were significantly more effective than those that were not ($d=0.47$ vs. 0.22). This encouraging evidence adds to a small but growing body of research that indicates that the mode of program delivery, as well as the content, is an integral factor in successful programs aimed at increasing men's physical activity.(15, 16) While offering male only interventions is a gender-tailored intervention in itself, the novel and diverse modes of program delivery represented in these interventions point to the need to be responsive to the needs and

preferences of diverse groups of men to optimise intervention engagement and program outcomes. Nevertheless, strategies used in the gender-tailored interventions reflect themes identified in successful efforts to promote men's health described by others and provide a useful direction for continuing efforts to promote men's health.(18, 19, 79) For example, gender-related strategies found to engage and retain men include the use of male-oriented language (e.g., simple, straightforward messages/communications), images, humour and positive 'banter'; action oriented, strength-based approaches including realistic and manageable recommendations; and providing men with flexible options that promote autonomy, self-reliance, and mastery.

While additional research is needed regarding long-term physical activity change, it is promising that the 12 of 24 studies that included a long-term (i.e., ≥ 12 months) follow-up measure had a small intervention effect ($d = 0.32$). One study included in the present analysis targeting overweight inactive male football fans, reported evidence of long-term behaviour maintenance of participants at 3.5 year follow-up.(80) These longitudinal findings of 213 men suggested that physical activity was significantly higher at 3.5 years than at baseline. This large-scale trial has informed the development of several subsequent gender-tailored interventions which also now include long-term follow-up in order to assess sustainability of physical activity change. For example, EuroFit,(68) which was delivered in 4 European countries, engaging 1,113 men, includes a long term follow-up of 12-months.

It is interesting to note that interventions that were assessed using objective measures of physical activity were significantly more effective than interventions using subjective (self-report) measures. Self-reported measures have been observed to be both higher and lower than objective measures of physical activity(81). Factors shown to predict discordances between measures include demographic characteristics such as education status(82) as well as differences in perceptions of what constitutes moderate or vigorous activity across

demographic sub-groups.(83) Interpreting subjective measures can be challenging.(84, 85) For example, an intervention may affect how accurately an individual perceives and reports their physical activity and sedentary behaviours.(84)

There are a number of strengths and limitations to this review, and to the underlying included studies, that should be acknowledged. This meta-analysis is the first to examine the effects of behaviour change interventions in men and builds on previous research identifying effective intervention strategies for engaging and retaining male participants. All 24 included studies had a randomised design, thus minimising bias. However, considerable heterogeneity existed across the studies, including the ways in which studies targeted men as participants, as well as the various modes of intervention delivery. With regards to the assessment of study quality, we acknowledge that there is often poor agreement between tools and that tools may measure different constructs of study quality.(25) The EPHPP was chosen as a recommended tool for assessing the quality of public health and health promotion studies. Despite this, challenges with assessing community-based trials remain as the majority of studies were rated down for participant self-referral and a lack of participant blinding. For almost any real-world behavioural intervention, a degree of volition and motivation to attend is required, both overall and session-by-session. Further, usually it is not possible to blind participants, or those delivering or assessing the intervention to group allocation, in these type of interventions (i.e., participants know they are exercising). Considered collectively, these assessment tools include assumptions which favour a biomedical approach in which internal validity, as an outcome of tightly controlled trials, is prioritised over external validity and thus raises challenges for real-world implementation.(86) What is not reflected within such assessment is the value of pragmatic trials in implementing behaviour change within the environments in which they will be used.(86, 87) Another limitation is that potentially relevant studies conducted on mixed-sex samples were not included because they failed to systematically report their findings

disaggregated by sex, despite calls for the need to do so.(9) Thus, the majority of studies included were male only.

In conclusion, this meta-analysis suggests that there is potential for supporting men to make small, but potentially important, changes in their physical activity. Specifically, gender-tailored interventions, which include a core focus on physical activity, may help in attracting, engaging and retaining men to health behaviour interventions. This includes those with a primary focus on other behaviours, which is important for the improvement of individual and public health (e.g. weight loss), in addition to physical activity. There is clearly scope to improve our understanding of what types of men different intervention approaches engage and work with, and why, and for more research on the long-term maintenance of physical activity changes.

KEY POINTS

What is already known?

- 1) Men are underrepresented in health promotion programs
- 2) Physical activity has been identified as a draw facilitating men's engagement with health promotion initiatives and programs and/or injury and illness management
- 3) Growing interest in men's health promotion has led to the development of interventions which include a focus on physical activity
- 4) Two systematic reviews have been conducted on physical activity interventions in men; yet the effects of RCT physical activity interventions are poorly understood

What are the new findings?

- 1) Behaviour change interventions have a small but significant positive effect on men's physical activity

- 2) Interventions tailored to men's values and interests and inclusive of regular group contact that utilise multiple behaviour change strategies appear most effective
- 3) There is some evidence that physical activity is maintained at long-term follow-up; however, more longitudinal research is needed

ACKNOWLEDGEMENTS

Paul Sharp is supported by an Australian Government Research Training Program Scholarship. The other authors report no financial disclosure. No funding was received for this study.

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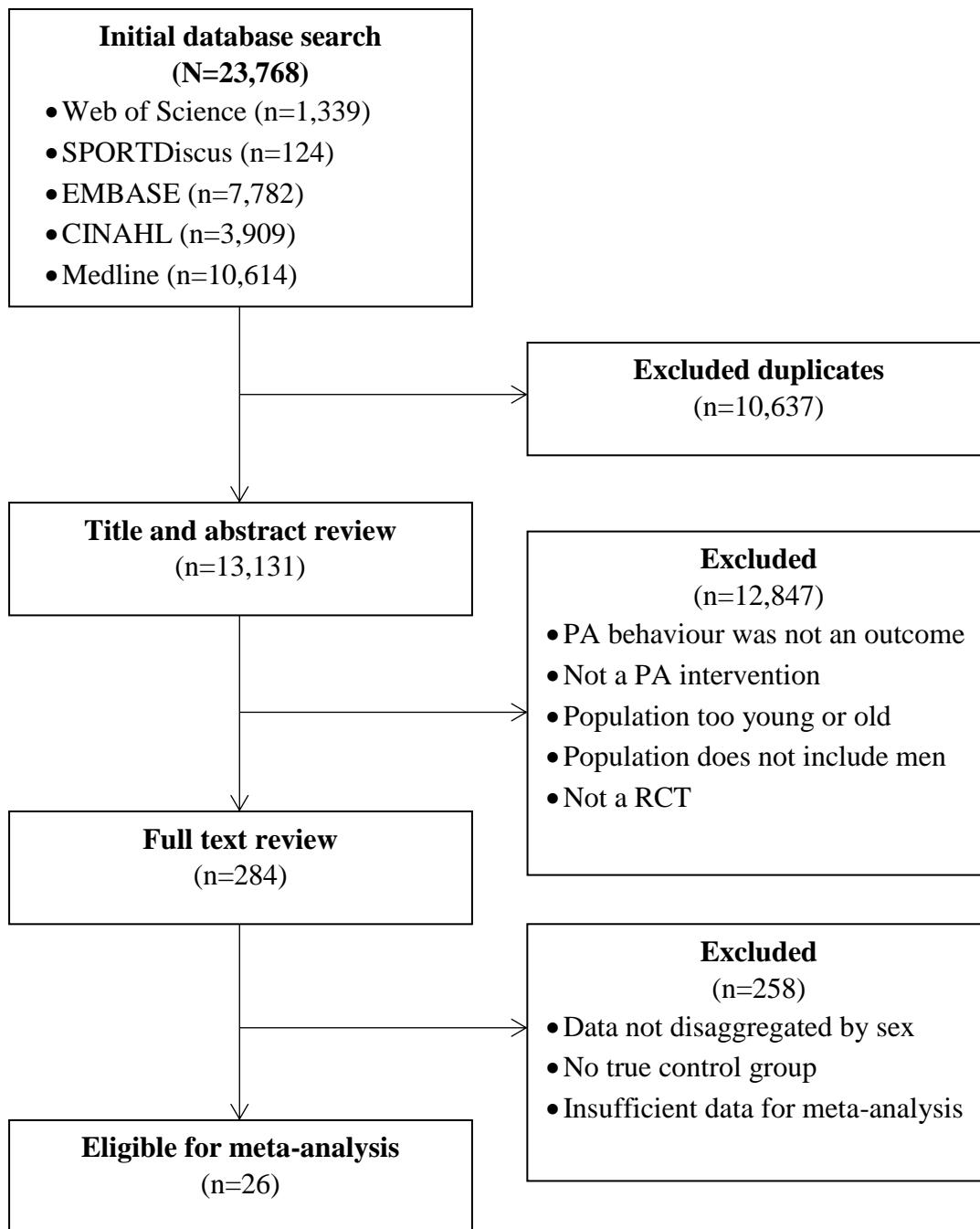


Figure 1. Pathway of articles identified and excluded.

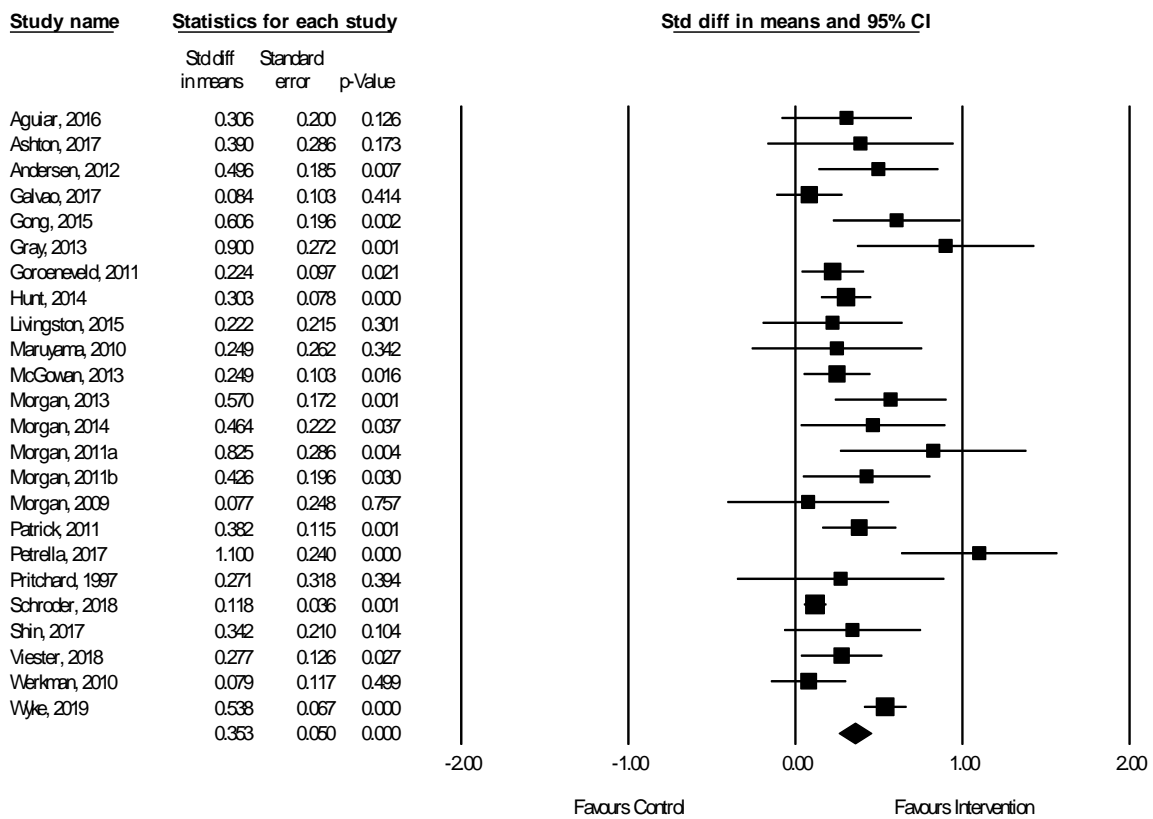


Figure 2. Forest plot of effect sizes representing effect on physical activity (baseline to post-intervention)

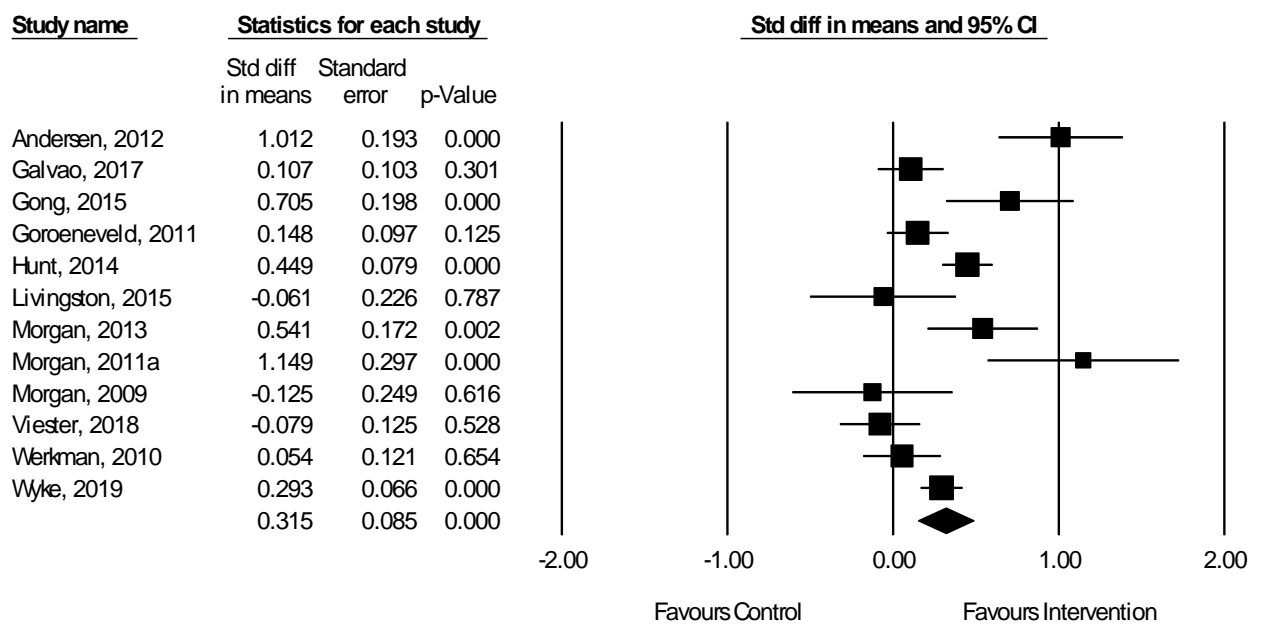


Figure 3. Forest plot of effect sizes representing effect on long term (i.e., >12 month) physical activity change