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Experimental Manipulation of Affective Judgments about Physical Activity: A Systematic Review and Meta-Analysis of Adults

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Abstract

Affective judgments (AJ; i.e., thoughts about the overall pleasure/displeasure, enjoyment, and feeling states expected from enacting a behavior) have been linked reliably to physical activity (PA) in observational research and feature in various theoretical frameworks. The purpose of this meta-analysis was to examine the current effectiveness of interventions to change AJ and subsequent PA behavior and explore potential moderators. Eligible studies were published in a peer-reviewed journal in the English language, included an experimental design in the PA domain with a measure of AJ as the dependent variable, and were conducted with an adult (>17 yrs.) sample. Literature searches concluded in July 2017 using 11common data-bases, with additional hand searching conducted in February 2018. The search yielded 32 independent studies after screening for eligibility criteria. Results using random-effects meta-analysis showed positive changes in AJ favoring intervention over control groups $g = 0.43$ (95% CI = 0.26 – 0.60). These changes predicted ($\beta = 0.64$) positive changes in PA $g = 0.38$ (95% CI = 0.16 – 0.60) among a sub-sample ($k = 14$) of studies that also provided behavioral data. Moderator analyses showed the effects were inflated by potential publication bias, participant gender (females had higher AJ than mixed samples), baseline PA (larger effects for inactive samples) and focus of the intervention (larger effects when AJ was the primary focus), but specific behavior change techniques were inconclusive. AJ may show change from experimental intervention and meaningful links to behavior change but larger sample studies are required to obtain a more reliable effect size estimate. Further, few studies have employed behavior change techniques that would align with the theoretical reasons for changes in AJ so our evidence for practical intervention content is limited.

Key Words: Enjoyment, affective attitude, intrinsic motivation, exercise, interventions

The health benefits of regular physical activity (PA) participation support a reliable dose-response relationship with risk reduction of all-cause mortality, cardiovascular disease, stroke, hypertension, colon cancer and breast cancer in the 30%+ range (Hupin et al., 2015; Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010). Furthermore, regular PA has been linked to reduced mental health conditions such as depression and anxiety (Rebar et al., 2015). Current international PA guidelines of 150 minutes of moderate intensity or 75 minutes of vigorous intensity activity is sufficient to meet these health benefits (World Health Organization, 2012). Unfortunately, few adults meet these recommended guidelines, particularly in higher income countries (Hallal et al., 2012). For example, less than 20 percent of North Americans are physically active at recommended guidelines (Colley et al., 2011; Troiano et al., 2008). Thus, promotion of regular PA is paramount to public health and effective interventions are needed.

By far, the dominant theoretical approach employed to intervene on PA has been social cognitive in nature (Rhodes & Nasuti, 2011) and typically includes applications of social cognitive/self-efficacy theory (Bandura, 1977, 1998), theory of reasoned action/planned behavior (Ajzen, 1991; Ajzen & Fishbein, 1977), and the transtheoretical model of behavior change (Prochaska & Velicer, 1997). Commensurate with these theories, PA interventions have focused predominantly on techniques to educate about PA benefits, build perceived capability to perform PA, and self-regulate behavioral action (Chase, 2015; Conn, Hafdahl, & Mehr, 2011; Michie, Abraham, Whittington, McAteer, & Gupta, 2009; Rhodes, Bredin, Janssen, Warburton, & Bauman, 2017). Meta-analyses of PA interventions using these approaches tend to show behavior changes in the small but meaningful range, particularly those that emphasize self-regulation strategies such as self-monitoring, feedback, and planning

(d = .27; SD = .13 Rhodes et al., 2017). Thus, while intervention approaches from traditional social cognitive models do show some effectiveness in PA promotion, there is room to expand upon different targets to change behaviour.

One such area for a more refined analysis within social cognitive approaches is the separation between affective and instrumental reflections or expectations about PA. Traditionally, the theory of planned behaviour distinguishes between social (normative) and personal outcome (attitude) expectations (Ajzen, 1991), social cognitive theory distinguishes among social, physical, and self-evaluative outcome expectations (Bandura, 1998), while the transtheoretical model denotes specific constructs for positive and negative outcome expectations (Prochaska & DiClemente, 1982). However, a distinction between affective (pleasure, enjoyment) and instrumental (benefit, utility) outcome expectancy constructs has had convincing evidence in PA research (French et al., 2005; Kraft, Rise, & Sutton, 2005; Lawton, Conner, & McEachan, 2009; Lowe, Eves, & Carroll, 2002; Rhodes & Courneya, 2003). A meta-analysis and review (Rhodes, Fiala, & Conner, 2009) of the PA literature employing these constructs showed that affective expectancies were a significant predictor of behavior in 85% of the 34 samples (r = 0.43; 95% CI = 0.36 to 0.46) while only 35% supported a relationship with instrumental expectancies (r = 0.25; 95% CI = 0.21 to 0.29). A more recent meta-analysis of health behaviors (McEachan et al., 2016) found affective expectancies to be significantly more strongly related to behavior (affective attitude: r = 0.30, k = 47; instrumental attitude: r = 0.20, k = 47) than instrumental expectancies.

In parallel to these findings in the social cognitive tradition, the self-determination theory within the humanistic/organismic tradition (Deci & Ryan, 1985) has shown that intrinsic motivation (i.e., I do PA because it is enjoyable) is a better predictor of long term PA

than motivations that are regulated around more extrinsic means (e.g., I do PA for health) (Teixeira, Carraça, Markland, Silva, & Ryan, 2012). Taken together, Rhodes and colleagues (Nasuti & Rhodes, 2013; Rhodes et al., 2009) proposed an umbrella construct called affective judgment (AJ), defined as reflections or expectations about the overall pleasure/displeasure, enjoyment, and feeling states from enacting PA. AJ is meant to encompass constructs that feature thoughts about affect when performing a behavior, such as expected enjoyment (Kendzierski & DeCarlo, 1991), affective/experiential attitude (Ajzen & Fishbein, 2005; Fishbein & Ajzen, 2010) and intrinsic regulation (Deci & Ryan, 1985). While observational research has established AJ as a meaningful correlate of PA, there is now a need to identify whether this same effect size extends to experimental intervention and understand how to intervene upon the construct as a mediator of PA change. The Rhodes et al. (2009) review did provide a narrative overview of 20 intervention studies on AJ, but concluded mixed findings (8/20 studies had significant effects) and a large heterogeneity in the types of interventions and designs employed. There is a need to update this nearly decade old literature review with a quantitative synthesis of the findings. Furthermore, we are unaware of a study that has explored the potential behavior change techniques that may be most effective at engendering change in AJ and subsequent PA. Thus, the purpose of this meta-analysis was to examine the current effectiveness of interventions to change AJ about PA and subsequent behavior. The secondary purpose was to explore the moderators of intervention effectiveness, including demographic (e.g., age, sex) and methodological (e.g., measure employed, length of design) differences between studies as well as the content applied in the intervention.

Methods

Eligibility and Exclusion Criteria

This review followed PRISMA guidelines for meta-analyses (Moher, Liberati, Tetzlaff, & Altman, 2009). Five eligibility criteria were implemented for papers to be included: 1) published in an English, peer-reviewed journal, 2) experimental design (i.e., a comparison group and post assessment of AJ), 3) an investigation of PA with AJ as the dependent variable, 4) an explicit statement by the study authors that AJ was a target of the intervention, and 5) adult (aged 18+ years) study participants (clinical and non-clinical). AJ were defined as 'judgments about the overall pleasure/displeasure, enjoyment, and feeling states from enacting PA' (Rhodes, Fiala, & Conner, 2009, p. 181), and thus involve cognitive processing made in reflection or anticipation outside of the actual behavioral experience. This is not to be confused with affect (e.g., core affect, emotion, mood), which an evaluative neurobiological state (D. M. Williams, Rhodes, & Conner, 2018). PA was defined as any bodily movement that involved skeletal muscles to create energy expenditure (World Health Organization, 2011).

Studies were excluded from this meta-analysis if they included cross-sectional and qualitative designs or experimental designs without a comparison group. Studies were also excluded if they had clinical populations with specific rehabilitation protocols, such as upper extremity rehabilitation, as these contexts were considered too niched from general PA guidelines (World Health Organization, 2012). In addition, studies published in a language other than English were excluded.

Search Strategy

In July 2017, the second author searched 11 electronic databases to identify eligible articles: Academic Search Complete, CINAHL with Full-Text, ERIC, Health Source: Nursing/Academic Edition, MedLine with Full-Text, PsycARTICLES, PsycCRITIQUES,

PsycINFO, Social Sciences Abstracts, Social Sciences Full Text, and SPORTDiscus. Search terms were divided into three groups (i) design (e.g., *intervention* OR *trial* OR *experiment*), (ii) behavior (e.g., *physical activity* OR *exercise*), and (iii) affective judgment (e.g., *enjoyment* OR *affective attitude* OR *intrinsic motivation* OR *intrinsic regulation* OR *affective judgment*). Boolean searching was used to ensure all articles included at least one term from each of the three groups as follows: the phrase 'OR' was used within groups and 'AND' was used between groups. To streamline the search, the author applied two filters to the search strategy – peer-reviewed journals and English-language (see Appendix 6). Articles were screened for eligibility by title and abstract. Article exclusion at this level was primarily due to correlational designs, a lack of comparison groups, or articles including child and adolescent populations. Finally, we conducted manual cross-referencing to strengthen the search. See Figure 1 for a detailed depiction of the literature search screening process.

Data Extraction

Data were extracted for intervention, measurement, and participant characteristics, as well as effect sizes for AJ and PA behavior using two independent coders (first and third authors). Intervention characteristics included: use of theory, intervention duration and quality, behavior change techniques including total number used, presence of baseline data, type of comparison group used (no treatment control, usual care), and whether AJ was the primary intervention focus (primary intervention target vs. one of several targets in a multi-component intervention). Measurement characteristics included: PA and AJ measures. Participant characteristics included: sample size, mean age, gender, baseline activity status, and population type. Where effect size information was not included or could not be extracted from the available information, we contacted primary authors to collect the relevant data for

our analysis. If contact with the authors was unsuccessful or the effect size data was not available, we excluded the study.

Two coders (second and third authors) coded behavior change techniques according to Michie et al.'s (2013) 93-item taxonomy. Independently, the two coders completed a binary checklist (0 = no, 1 = yes) for each included study. Any discrepancies were resolved by discussion until 100% consensus was reached. A total number of behavior change techniques per study was also coded.

In addition, thematic coding was performed on the content of the interventions as it directly pertained to AJ for PA when it did not match the more generalized BCT taxonomy. The affective change technique (ACT) that emerged from the coding was "modify PA type". Further details, including definition and prevalence, can be found in Appendix 3.

Risk of Bias

We conducted a risk of bias assessment using a six-item criterion tool (von Elm et al., 2007). The instrument included questions in yes (1) or no (0) format (e.g., did the study report the sources and details of PA assessment; did the instruments have acceptable reliability for the specific age group?). Two independent coders assessed study quality and any disagreements were also resolved via discussion to reach a final decision. The studies were then classified into low (scoring 0-2), medium (scoring 3-4), and high (scoring 5-6) quality. A detailed quality assessment for each item by study is included in Appendix 2.

Data Analysis

To conduct the meta-analysis, the authors used the computer software Comprehensive Meta-Analysis V3 (Borenstein, Hedges, Higgins, & Rothstein, 2017) using a random effects

model. We used Hedge's g (Rosenthal & Rosnow, 1991) to calculate effect sizes for both AJ outcome data and PA outcome data based on pre and post-test means where possible, or post-test only means. When there was more than one time-point reported in the study, we used mean, standard deviation, and sample size data from the first and last time-points given, in order to capture the greatest potential change due to the intervention (S. Williams & French, 2011). When there were two or more experimental groups in the same study, we used the mean of the selected comparisons with a sample size correction in order to preserve the assumption of independence (Borenstein, 2015). However, when performing moderator analysis for change techniques (i.e. BCTs and ACTs), we used all comparisons with a sample size correction, assuming independence, due to the nature of the data to be analyzed (Peters & Mergersen, 2008; Romano & Kromrey, 2009). To examine whether experimental changes in AJ were related to changes in PA, we computed an ordinary least squares regression coefficient (AJ = predictor; PA = dependent variable), controlling for study sample size, similar to past approaches (Webb & Sheeran, 2006). We explored publication bias using Egger's Regression intercept, and small sample bias using the procedures outlined by Coyne et al. (2010).

Heterogeneity of the findings was examined using the Q-statistic and I-squared. The Q-statistic examines the null hypothesis that all studies are examining the same effect, and I-squared indicates the percentage of variation across studies due to heterogeneity and not chance (Higgins, Thompson, Deeks, & Altman, 2003). Moderator analysis was limited to categories with at least three studies. This is somewhat arbitrary but it allows for some triangulation of effect, so that a single study does not represent the estimate of a moderator (Rhodes, Kaushal, & Quinlan, 2016).

Results

The electronic database search yielded 2655 hits, which was reduced to 690 articles when peer-review and English-language filters were applied with duplicate removal. In screening at the title and abstract level, we excluded 616 articles that did not meet eligibility criteria (e.g., child/adolescent populations [n = 408]; cross-sectional studies [n = 51]; irrelevant topics [n = 51]; no control group [n = 37]; qualitative studies [n = 24]; not a PA study [n = 13]; feasibility study without comparison group [n = 12]; review papers [n = 9]; protocol papers [n = 6]; validation papers [n = 4]; abstract only [n = 1]). After initial exclusions based on title and abstract, there were 108 articles for full-text review, of which 32 were identified by cross-referencing. Seventy-five of the 108 articles were excluded due to missing/insufficient data, lack of clear control group, and various reasons (see Figure 1). The final article count for quantitative synthesis was 33, including 32 independent data sets (due to multiple articles written using the same data). Fourteen data sets also reported outcome data on PA behavior change.

General Study Characteristics

Table 1 provides study characteristics for the final 32 independent data sets and 4726 participants in the analysis (see also Appendix 1 for full extracted information or https://osf.io/t3sk5/?view_only=bfa8375c0893461d918ab4117d2df5e8 for all supplementary materials, raw data, and output screenshots). Sample sizes across data sets ranged from n = 20 to n = 1348. Participant samples across data sets also varied in age: the youngest mean age was 18 and the oldest was 67.7 years; 12 studies included young adults (mean age 18-35 years), seven data sets included adults aged 36-50, 10 data sets included adults aged 51-65, two data sets included older adult samples (mean age 65+ years), and one data set did not

specify the mean age of the sample. In terms of sex distribution: two data sets included only male participants, nine data sets included only female participants, and 21 data sets included both male and female participants. Finally, we note that the PA experience of participants varied across data sets of not meeting PA guidelines (n = 18 data sets), meeting PA guidelines (n = 1 data set), mixed activity levels (n = 5 data sets), and unreported levels (n = 8 data sets).

Our study quality assessment revealed that one data set was classified as low quality, 15 were classified as medium quality, and 16 were classified as high quality. Approximately half of all data sets included in this analysis were conducted in North America (n = 18); the rest were conducted in Europe (n = 11), Australia (n = 2), and Asia (n = 1). In terms of theory, six data sets did not explicitly mention a theoretical framework and 26 data sets employed either one or more theories, such as Self-Determination Theory (n = 9), Social Cognitive Theory (n = 2), or The Theory of Planned Behaviour (n = 7). Two studies were within-person repeated-measures designs, nine data sets reported data only at a follow-up time point (experimental post-test designs), while 21 experimental data sets reported on both baseline and follow-up data. Study duration was a minimum of one week and a maximum of 12 months in duration. A number of different tools were employed to measure AJ; for example: the PA Enjoyment Scale (n = 9), the enjoyment/interest subscale of the Intrinsic Motivation Inventory (n = 4), the intrinsic motivation subscale of the Behavioral Regulations in Exercise Questionnaire-2 (n = 4), semantic differential scales of affective attitude (n = 6), and study created (n = 5). Additionally, several different tools were used to assess PA, including pedometers, accelerometers, or attendance as objective measures in 7 data sets and validated self-report measures in 17 data sets including a combination of the following: 7-day PAR (n = 7), GLTEQ (n = 6), IPAQ (n = 1), PASE (n = 2), and other self-reported behavior tools (n =

1). In one data set, both objective (pedometer) and validated self-report (CHAMPS) measures were used to assess PA.

Experimental effects on Affective Judgments and Physical Activity

Meta-analysis results of the 32 studies (see Appendix 4 for reference list) can be found in Table 2 and Figure 2. Experimental manipulations of AJ had an effect size g = 0.43 (95% CI = 0.26 to 0.60). The examination of publication bias for the 32 studies, was significant (Egger's intercept t = 2.82 (30), $p < 0.01$), however, caution should be exercised with this estimate in cases such as this with small samples and large heterogeneity (Carter, Schonbrodt, Gervais, & Hilgard, 2017). Small sample bias was a significant moderator of the findings (Q = 10.89 (1); $p < 0.01$), using the n = 35 criterion suggested by Coyne et al. (2010). Studies with sample sizes less than 35 participants per condition (g = 0.80, 95% CI = 0.46 to 1.14) reported larger effect sizes than studies with greater than 35 participants per condition (g = 0.17, 95% CI = 0.00 to 0.33).

Meta-analysis results of the 14 studies (see Appendix 5 for reference list) that examined PA behavior change found a point estimate of g = 0.38 (95% CI = 0.16 to 0.60) in favor of the various interventions compared to their corresponding control conditions (see Appendix 7). Similar to the analyses of AJ, Egger's regression intercept was significant for PA data (t = 1.78 (12), p = 0.02). Again, caution should be exercised when interpreting this result, given the small samples in this analysis and considerable heterogeneity (Carter et al., 2017). Furthermore, unlike the AJ results, small sample bias was not a significant moderator (Q = 1.50 (1), p = 0.22).

Finally, the relationship between effect sizes for the magnitude of changes in AJ and the magnitude of changes in PA, weighted by sample size, was $\beta = 0.64$ among these 14

samples. We also tested this relationship by grouping the studies by those that changed AJ ($g > 0.19$) compared to those that did not change AJ ($g < 0.20$) and comparing the effect sizes of subsequent change in PA. This comparison was near significant ($Q = 3.30$ (1), $p = 0.07$) and showed that studies that changed AJ had a larger effect corresponding with changes in PA ($g = 0.63$, 95% CI = 0.23 to 1.04) than studies that did not change AJ ($g = 0.21$, 95% CI = -0.02 to 0.44).

Moderator Analyses of Affective Judgments

The test for heterogeneity among the 32 studies examining experimental effects on AJ yielded significant results [$Q = 175.84$ (31), $p < 0.01$; $I^2 = 82.37$]; therefore we further explored these data using moderator analysis. We tested 31 potential moderators, including 17 behavior change techniques (BCTs), one affective change technique themed from the studies (ACT), and thirteen key study characteristics (see Tables 2 & 3).

Study characteristics of the age of the sample, population (university, clinical, community), duration, quality assessment, theoretical framework, AJ instrument, number of BCTs used, presence of baseline data, and type of comparison group used (no treatment control group, usual care) were not significant moderators upon AJ ($p > 0.16$). By contrast gender of the sample ($Q = 7.71$ (1); $p = 0.01$), baseline PA levels ($Q = 19.60$ (2); $p < 0.01$), and AJ as the primary intervention focus ($Q = 4.94$ (1); $p = 0.03$) were moderators that explained heterogeneity among the study effect sizes. Specifically, studies that used a female sample ($g = 0.95$, 95% CI = 0.44 to 1.46) reported larger effect sizes than studies using a mixed sample ($g = 0.20$, 95% CI = 0.07 to 0.33), studies in which participants were not meeting PA guidelines at baseline ($g = 0.51$, 95% CI = 0.31 to 0.70) reported larger effect sizes than studies reporting mixed baseline PA ($g = 0.00$, 95% CI = -0.11 to 0.12), and studies

that did not specify (g = 0.23, 95% CI = -0.15 to 0.61). Studies that had a targeted AJ focus (g = 0.70, 95% CI = 0.36 to 1.05) reported larger effect sizes than studies that targeted AJ as part of a larger multi-component intervention (g = 0.26, 95% CI = 0.08 to 0.44).

Our analyses of intervention content found six of 17 possible BCTs as moderators of AJ. The presence of all six significant BCTs yielded decreased AJ outcomes compared to their absence ($p < .05$). The six BCTs were "problem solving" (present g = 0.23, 95% CI = 0.04 to 0.42, absent g = 0.55, 95% CI = 0.30 to 0.81), "action planning" (present g = 0.04, 95% CI = -0.05 to 0.13, absent g = 0.54, 95% CI = 0.32 to 0.76), "self-monitoring" (present g = 0.20, 95% CI = 0.01 to 0.39, absent g = 0.59, 95% CI = 0.33 to 0.84), "social comparison" (present g = 0.19, 95% CI = 0.01 to 0.36, absent g = 0.45, 95% CI = 0.28 to 0.62), "prompts/cues" (present g = -0.04, 95% CI = -0.30 to 0.23, absent g = 0.48, 95% CI = 0.31 to 0.65), and "pros and cons" (present g = 0.07, 95% CI = -0.07 to 0.20, absent g = 0.47, 95% CI = 0.28 to 0.67).

Moderator Analysis for Physical Activity

The test for heterogeneity among the 14 studies that included change in PA yielded significant results [Q = 48.35 (13), p < 0.01, I^2 = 73.11]; therefore we further explored these data using moderator analysis (see Tables 2 & 3). We tested 21 potential moderators, including 10 BCTs and eleven study characteristics. In terms of study characteristics, only age moderated the PA change results (Q = 8.05 (2); p = 0.02), with participants aged 36-50 yielding the largest effect sizes (g = 1.25, 95% CI = -0.51 to 3.01), 51-61 yielding the smallest effect sizes (g = 0.10, 95% CI = 0.09 to 0.30), and 18-35 yielding mid-range effect sizes (g = 0.47, 95% CI = 0.28 to 0.66).

Five BCTs moderated PA effect sizes ($p < .05$). The presence of "instructions on how to perform a behavior" (g = 0.51, 95% CI = 0.00 to 1.02) yielded increased PA behavior

change compared to its absence (g = 0.28, 95% CI = 0.09 to 0.47). The presence of the remaining four BCTs yielded decreased PA behavior change compared to their absence. They were: “problem solving” (present g = 0.14, 95% CI = -0.02 to 0.30, absent g = 0.55, 95% CI = 0.21 to 0.88), “action planning” (present g = 0.12, 95% CI = -0.04 to 0.29, absent g = 0.48, 95% CI = 0.19 to 0.78), “social support (unspecified)” (present g = 0.10, 95% CI = 0.00 to 0.21, absent g = 0.50, 95% CI = 0.18 to 0.83), and “pros and cons” (present g = 0.12, 95% CI = -0.02 to 0.26, absent g = 0.44, 95% CI = 0.16 to 0.73).

Discussion

The purpose of this meta-analysis was to examine the current effectiveness of interventions to change AJ about PA (i.e., thoughts about the overall pleasure/displeasure, enjoyment, and feeling states expected from enacting PA) and subsequent behavior. Our search of this literature retrieved 32 studies where experimental designs have been implemented to examine changes in AJ. Overall, these studies were of medium or low risk of bias and included a high proportion of community-based or clinical samples with mixed gender sampling and variability in ages across the young and middle-aged adult spectrum. Furthermore, the studies report on a wide array of our expected theoretical frameworks where an AJ construct is present including self-determination theory, extensions of theory of planned behavior and social cognitive theory, as well as several studies with no explicitly mentioned theory. Seventeen BCTs and one ACT specific to PA (i.e., comparison of different PA behaviors) from content analyses of the available studies were also present. Finally, 14 of these studies also included PA measures within their design so corresponding effects could be compared and the association between experimental effects on AJ their association with changes in behavior could be computed. Thus, the available sample of studies employing AJ

constructs in experimental designs represents a rich data-set for meta-analyses that advances the prior narrative review on this topic (Rhodes et al., 2009) with an additional 27 studies in which to draw conclusions.

Overall, our point-estimate for the effect of interventions compared to control conditions on AJ was g = 0.43 (95% CI = 0.26 to 0.60), while the corresponding effect on PA was g = 0.38 (95% CI = 0.16 to 0.60) suggesting a significant small-medium effect size (Cohen, 1992). Furthermore, the regression coefficient (β = 0.64) between the two effects indicates a large sized covariance between larger changes of AJ leading to larger changes in PA. However, the interpretation of these sizeable effects should be cautioned, because the heterogeneity of the studies was considerable and our analyses found potential publication bias (i.e., smaller sample studies had considerably larger effect sizes than larger sample studies). Studies with AJ as the primary focus of the experiment did show larger effects than studies where AJ was included as part of a broader multi-component intervention (e.g., targeting self-efficacy, self-regulation skills, etc.) and these studies were more likely to be the smaller sample studies (71% of the small sample studies treated AJ as the primary focus compared to 27% of the larger sample studies). Still, a cautious interpretation of the current findings seems prudent, similar to a prior meta-analysis of affective judgments in youth (Nasuti & Rhodes, 2013), other experimental analyses of social cognitive variables (Sheeran et al., 2016; van Erp, Verhagen, Grasman, & Wagenmakers, 2017), and prior meta-analyses of PA interventions (Rhodes et al., 2017). We conclude that interventions have often been successful at manipulating changes in AJ and subsequent PA behavior but the effectiveness is likely in the small range. We recommend that future studies focused on changing AJ power for this small

effect size to prevent the continuation of small sample bias and assist in obtaining a more reliable estimate of these effects.

The secondary purpose of our study was to explore the moderators of intervention effectiveness, including demographic (e.g., age, population, sex, PA level at baseline), methodological (e.g., study design, measure employed, theory employed) and the content applied in the intervention (e.g., behavior change techniques). The population type, whether undergraduate student, community or clinical population, and the age of the sample did not moderate the findings, suggesting that the effects are likely invariant to these sampling aspects. Our results also did not show significant variance across the experimental study design applied, the measures of AJ employed, or the theoretical frame employed. This corresponds with prior observational research on affective judgments (Rhodes et al., 2009) that found no significant variation on how the AJ was measured or conceptualized to its association with PA. The gender of the participants, however, did moderate the findings of AJ. Specifically, female samples ($g = 0.95$) reported larger changes in AJ than mixed samples ($g = 0.20$), although there were not enough study data to explore whether this relationship extended to PA change as well. The finding is difficult to interpret at this time, in part because there were not enough male-only samples to compare to female samples. While it is possible that individual differences in response to affective stimuli may have an underlying relationship with gender (Costa & McCrae, 1992), our findings in this meta-analysis may also be an artifact of the different study designs employed and the intervention content used across the samples. Future studies where participant gender is used as an ex post facto variable within the same design are therefore needed to shed light on this finding.

Baseline PA also moderated our findings, showing that participants who were not meeting PA public health guidelines reported larger changes in AJ (g = 0.51) compared to more active/nonspecified participants (g = 0.21 to 0.00). The finding is likely related to the law of initial values (Wilder, 1962), but it aligns well with the potential utility of changing AJ to improve PA among inactive populations who represent the group who could benefit the most in health outcomes (Warburton & Bredin, 2016).

The most interesting secondary research question, however, was whether the content of PA interventions could explain changes in AJ and behavior. Similar approaches have been very useful in discerning how to change self-efficacy (Ashford, Edmunds, & French, 2010; French, Olander, Chisholm, & Sharry, 2014; S. Williams & French, 2011). This evidence base could provide important practical information on how to change AJ, given their substantive relationship with PA (McEachan et al., 2016; Rhodes et al., 2009; Teixeira et al., 2012). While this analysis was exploratory, we speculated as to what may be the most important moderators of intervention effectiveness. Rhodes and colleagues (Rhodes et al., 2009; Rhodes & Kates, 2015) consider past affective experiences with PA as a key antecedent, which is commensurate with other similar viewpoints in social psychology (Baumeister, Vohs, DeWall, & Zhang, 2007). Thus, monitoring of and information about emotional consequences was expected to be a critical behavior change technique. Furthermore, self-determination theory clearly outlines that AJ in the form of intrinsic motivation is dependent upon specific needs, and thus techniques that are associated with relatedness (e.g., social support, social reward), autonomy (e.g., restructuring the social and physical environment), and competence (e.g., graded tasks, past success, verbal persuasion of capability) were expected as moderators. A prior thought listing procedure using theory of planned behavior belief-elicitation (Riecken,

Mark, & Rhodes, 2013) also showed that AJ were mainly linked to social involvement (social support, social reward), bodily states (monitoring of emotional consequences), and improved mental health expectations (information about emotional consequences), thus providing overlapping support for these theory-based BCTs.

Unfortunately, the most interesting finding from our analyses was that almost none of these BCTs were utilized in the interventions. Our coding showed an absence in the use of information about emotional consequences, monitoring of emotional consequences, body changes, social support (emotional), social reward, restructuring of the social and physical environment, or verbal persuasion of capability and past success. Only graded tasks techniques and general social support were applied to these studies, but these techniques did not discriminate changes in AJ. Furthermore, content coding of AJ change technique specific to PA showed a similar profile. Less than 10 studies applied these techniques and many were applied in less than five studies.

The likely reason for the paucity of techniques that relate to conceivable changes in AJ is the omnibus nature of many of the interventions included in the review and the variability in BCTs among the small number of studies that did include a more focused targeting of AJ. We identified a similar finding in a prior meta-analysis of affective judgment interventions among young people (Nasuti & Rhodes, 2013). Most of the BCTs employed in the interventions involved behavioral self-regulation strategies (e.g., setting goals, self-monitoring) and thus it is not surprising these were not related to changes in AJ. There were also some odd findings, such as the absence of BCTs (e.g., problem solving, action planning, self-monitoring), but not the presence of BCTs, that were linked to positive changes in AJ. These are not easily explained and may be due to unforeseen consequences of the selection process, as behavioral

strategies such as goal setting (McEwan et al., 2016) and self-monitoring (Michie et al., 2009) are powerful techniques for PA change when all interventions that use the techniques are included in the analyses. Overall, we believe the significant findings in these moderator analyses of change techniques are not easily explained, and thus do not provide a sound understanding for the key techniques to change AJ. The results clearly demonstrate a need for future research to target AJ techniques in order to examine their effectiveness. We believe this should be made a research priority in PA science as it would also help to reduce the current asymmetry in our understanding of the efficacy of strategies in the behavior change taxonomy (Michie et al., 2013). An exploration of strategies to change AJ compared to other types of constructs (e.g., self-efficacy) should also be an aim of future research. This will provide important information on whether the changes to AJ have utility over and above more standard/common self-regulatory behavior change strategies.

Despite the interesting findings and noteworthy limitations of current research that this review highlights, this literature review is limited by the search terms and search engines employed as well as studies in English. The limited data available also did not allow us to explore the impact of changing different types of AJs or the duration of potential effects. Furthermore, our reviewed literature is limited to published work which has strengths in the base level of quality that accompanies the peer review process and the reliability of search access on the topic, yet limits because of the potential positivity bias/aversion to null that results from the peer-review system (Ferguson & Heene, 2012).

In summary, AJ have been linked reliably to PA in observational research, and feature prominently in various forms across key theoretical frameworks such as self-determination theory, extended theory of planned behavior models, and social cognitive theory among

others. This meta-analysis of 32 studies was the first assessment of experimental manipulations of AJ and PA among adults. Our results showed that positive changes in AJ occur from intervention and these changes are associated with positive changes in PA with a large effect size among a sub-sample of studies that also provided PA data. Still, there was considerable heterogeneity in the findings and moderator analyses showed that these effects are potentially inflated by publication and small sample bias. Unfortunately, few of the studies employed behavior change techniques that would align with theoretical reasons for changes in AJ so our understanding of the practical intervention content is difficult to interpret at present. Thus, while AJ do show change from intervention and meaningful links to behavior change, future research designed to target theory-based mechanisms of change is needed to improve our understanding for promotion practice in PA.

Figure Caption Guide

Figure 1. PRISMA Flow Diagram Showing the Literature Search Screening Process

Figure 2. Affective Judgement Forrest Plot

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Table 1

Overall Study Characteristics

Characteristics	Sample: N=32 independent data sets, corresponding to N=33 articles	Percentages
Age		
18-35	12 (11 articles)	38%
36-50	7 (9 articles)	22%
51-65	10	31%
65+	2	6%
Not specified	1	3%
Gender		
Male	2	6%
Female	9 (10 articles)	28%
Mixed	21	66%
PA Levels at Baseline		

Meeting Guidelines	1	3%
Not Meeting Guidelines	18 (19 articles)	56%
Mixed	5	16%
Unreported	8	25%
Population		
Community	17 (18 articles)	53%
Clinical	10	31%
University students	5	16%
Geographical Location		
North America	18	56%
Europe	11 (12 articles)	34%
Australia	2	6%
Asia	1	3%
Study Design		
Pre-test post-test experimental	21 (22 articles)	66%

Within-person repeated measures	2	6%
Post-test experimental	9	28%
Quality Rating		
High	16 (17 articles)	50%
Moderate	15 (16 articles)	47%
Low	1	3%
Baseline Data		
Included	25 (26 articles)	78%
Not included	7	22%
Theory		
No framework explicitly mentioned	6	19%
Self-Determination Theory	9 (10 articles)	28%
Social Cognitive Theory	2	6%
Theory of Planned Behavior	7 (6 articles)	22%
Multiple	7 (8 articles)	22%

Other	1	3%
Affective Judgment Measurement		
Physical Activity Enjoyment Scale	9	28%
Intrinsic Motivation Inventory – enjoyment/interest Subscale	4	13%
Behavioral Regulations in Exercise Questionnaire-2 – intrinsic motivation subscale	4	13%
Semantic Differential	6	19%
Study Created	5	16%
Other	4 (5 articles)	13%
Physical Activity Measurement		
Objective	7	22%
Validated Self-Report	17	53%
Both	1	3%

Note. Not all studies included physical activity measurements. PA = physical activity. Guidelines refer to 150 min of vigorous or moderate intensity physical activity per week.

Table 2

Meta-Analysis of Experimental Effects on Affective Judgments and Physical Activity and Demographics/Study Characteristic Moderators Analysis

	Affective Judgment					Physical Activity				
	# studies	g (SE)	95% CI	Q-value	P-value	# studies	g (SE)	95% CI	Q-value	P-value
Point Estimate	32	0.43 (0.09)	0.26-0.60	175.84	<0.01	14	0.38 (0.11)	0.16-0.60	48.35	<0.01
Age				3.56	0.17				8.05	0.02
18-35	12	0.44 (0.15)	0.15-0.73			6	0.47 (0.10)	0.28-0.66		
36-50	7	0.74 (0.25)	0.24-1.24			2	1.25 (0.90)	-0.51-3.01		
51-65	10	0.24 (0.12)	-0.00-0.48			6	0.10 (0.10)	-0.09-0.30		
Gender				7.71	0.01				-	-
Female	9	0.95 (0.26)	0.44-1.46			-	-	-		
Mixed	21	0.20 (0.07)	0.07-0.33			-	-	-		
Population				1.20	0.55				0.47	0.79
Clinical	10	0.31 (0.13)	0.05-0.57			4	0.27 (0.22)	-0.15-0.70		

	Community	15	0.53 (0.14)	0.25-0.81			6	0.48 (0.21)	0.07-0.90)		
	University	7	0.42 (0.20)	0.04-0.81			4	0.39 (0.14)	0.12-0.66		
Baseline PA					19.60	<0.01				3.37	0.07
	Not meeting guidelines	20	0.51 (0.10)	0.31-0.70			7	0.42 (0.09)	0.24-0.60		
	Mixed	4	0.00 (0.06)	-0.11-0.12			-	-	-		
	Not specified	7	0.23 (0.19)	-0.15-0.61			4	0.10 (0.14)	-0.18-0.39		
Duration					3.20	0.20				0.81	0.37
	<2 months	11	0.77 (0.25)	0.28-1.25			7	0.55 (0.21)	0.14-0.96		
	2-6 months	10	0.30 (0.15)	0.01-0.58			5	0.30 (0.18)	-0.05-0.65		
	>6 months	9	0.30 (0.12)	0.06-0.53			-	-	-		
Quality Assessment					0.86	0.35				0.35	0.55
	Medium quality	15	0.51 (0.16)	0.20-0.82			7	0.46 (0.19)	0.09-0.83		
	High quality	16	0.34 (0.10)	0.14-0.54			7	0.46 (0.19)	0.09-0.83		
Theoretical Framework					5.18	0.16				4.13	0.25
	SDT	9	0.89 (0.31)	0.29-1.49			4	0.86 (0.35)	0.16-1.55		

	TPB	7	0.30 (0.15)	0.00-0.60			4	0.31 (0.18)	-0.05-0.67		
	Multiple	7	0.19 (0.08)	0.03-0.35			3	0.15 (0.09)	-0.03-0.33		
	No theory mentioned	6	0.31 (0.21)	-0.11-0.73			3	0.17 (0.28)	-0.38-0.72		
AJ Instrument					4.20	0.38				-	-
	BREQ-2 – intrinsic motivation subscale	4	1.46 (0.70)	0.08-2.84			-	-	-		
							-	-	-		
	IMI – interest/enjoyment subscale	4	0.40 (0.31)	-0.22-1.01							
	PACES	9	0.27 (0.11)	0.06-0.48			-	-	-		
	Semantic Differential	6	0.40 (0.16)	0.08-0.71			-	-	-		
	Study created	5	0.16 (0.14)	-0.11-0.44			-	-	-		
PA Instrument					-	-				0.15	0.69
	Objective	-	-	-			3	0.26 (0.38)	-0.47-1.00		
	Validated SR	-	-	-			11	0.42 (0.12)	0.18-0.66		
# of BCTs					4.73	0.19				0.39	0.82
	0 used	7	0.87 (0.25)	0.38-1.37			-	-	-		

1-3 used	6	0.24 (0.16)	-0.07-0.55			4	0.46 (0.10)	0.25-0.66		
4-6 used	10	0.33 (0.17)	-0.01-0.67			5	0.29 (0.26)	-0.22-0.80		
7+ used	9	0.39 (0.13)	0.13-0.65			4	0.39 (0.13)	0.13-0.66		
Baseline Data				1.29	0.26				-	-
Included	25	0.36 (0.09)	0.18-0.53			-	-	-		
						-	-	-		
Not included	7	0.65 (0.24)	0.17-1.13							
Small Sample Bias				10.89	0.00*				2.32	0.13
<35 participants per condition	17	0.80 (0.17)	0.46-1.14			8	0.58 (0.21)	0.16-1.00		
>35 participants per condition	15	0.17 (0.08)	0.00-0.33			6	0.22 (0.11)	0.01-0.43		
Type of Comparison Group				0.81	0.37				0.81	0.37
No treatment control	16	0.36 (0.12)	0.13-0.59			9	0.30 (0.09)	0.11-0.48		
Usual care	16	0.52 (0.14)	0.25-0.79			5	0.65 (0.38)	-0.10-1.40		
Primary intervention focus				4.94	0.03				1.35	0.24

Targeted AJ focus	16	0.70 (0.18)	0.36-1.05	7	0.54 (0.22)	0.11-0.97
AJ as secondary focus	16	0.26 (0.09)	0.08-0.44	7	0.25 (0.11)	0.04-0.47

Note: Calculated using all comparisons (Two arm, Control vs AB, Control vs ABC), assuming independence: Moderator analysis only done on moderators present in >3 studies; "-" denotes blank due to moderator present in <3 studies. ACT = Affective Change Technique; AJ = Affective Judgment; BCT = Behavior Change Technique; BREQ-2 = Behavioral Regulations in Exercise Questionnaire 2; IMI = Intrinsic Motivation Inventory; PACES = Physical Activity Enjoyment Scales; PA = Physical Activity; SDT = Self-Determination Theory; SR =Self-Report; TPB = Theory of Planned Behavior

Table 3

Moderator Analysis of Behavior Change Techniques

	Affective Judgment								Physical Activity							
Moderator	Absent			Present					Absent			Present				
	# studies	g (SE)	95% CI	# studies	g (SE)	95% CI	Q-value	P-value	# studies	g (SE)	95% CI	# studies	g (SE)	95% CI	Q-value	P-value
1.1 Goal Setting	33	0.48 (0.09)	0.30-0.67	9	0.23 (0.14)	-0.05-0.50	2.22	0.14	-	-	-	-	-	-	-	-
1.2 Problem Solving	29	0.56 (0.13)	0.30-0.81	13	0.23 (0.09)	0.05-0.41	4.28	0.04	10	0.55 (0.17)	0.21-0.88	7	0.14 (0.08)	-0.02-0.30)	4.54	0.03
1.3 Goal Setting (outcome)	37	0.44 (0.09)	0.27-0.61	5	0.20 (0.17)	-0.14-0.54	1.54	0.21	14	0.40 (0.11)	0.18-0.62	3	0.15 (0.21)	-0.27-0.57	1.07	0.30
1.4 Action Planning	34	0.54 (0.11)	0.32-0.76	8	0.05 (0.04)	-0.03-0.12	17.56	<0.01	12	0.48 (0.15)	0.19-0.78	5	0.1 2 (0.09)	-0.04-0.29	4.26	0.04
1.5 Review Behavioral Goals	39	0.42 (0.08)	0.26-0.59	3	0.23 (0.16)	-0.08-0.53	1.23	0.27	-	-	-	-	-	-	-	-
2.2 Feedback on Behavior	38	0.39 (0.08)	0.23-0.54	4	0.48 (0.25)	-0.00-0.96	0.12	0.73	-	-	-	-	-	-	-	-
2.3 Self-monitoring of Behavior	28	0.59 (0.13)	0.34-0.84	14	0.20 (0.09)	0.03-0.38	6.07	0.01	10	0.60 (0.15)	0.31-0.90	7	0.09 (0.08)	-0.06-0.25	8.99	<0.01

3.1 Social Support (unspecified)	28	0.49 (0.12)	0.26-0.72	14	0.31 (0.10)	0.11-0.51	1.39	0.24	10	0.50 (0.17)	0.18-0.83	7	0.10 (0.05)	0.00-0.21	5.21	0.02
4.1 Instructions on how to Perform a Behavior	25	0.37 (0.09)	0.20-0.55	17	0.50 (0.16)	0.17-0.82)	0.46	0.50	9	0.17 (0.09)	-0.01-0.36	8	0.61 (0.18)	0.25-0.96	4.57	0.03
5.1 Information about Health Consequences	31	0.38 (0.09)	0.21-0.55	11	0.49 (0.17)	0.16-0.81	0.35	0.55	12	0.28 (0.10)	0.09-0.47	5	0.51 (0.26)	0.00-1.02	0.70	0.40
6.1 Demonstration of the Behavior	29	0.34 (0.08)	0.19-0.49	13	0.66 (0.27)	0.14-1.19	1.33	0.25	10	0.21 (0.09)	0.02-0.39	7	0.62 (0.22)	0.20-1.04	3.07	0.08
6.2 Social Comparison	37	0.45 (0.09)	0.28-0.62	5	0.19 (0.09)	0.01-0.36	4.31	0.04	-	-	-	-	-	-	-	-
7.1 Prompts/cues	38	0.48 (0.09)	0.31-0.64	4	-0.04 (0.14)	-0.30-0.23	10.19	<0.01	-	-	-	-	-	-	-	-
8.1 Behavioral Practice/rehearsal	27	0.33 (0.08)	0.18-0.49	15	0.62 (0.24)	0.17-1.09	1.43	0.23	9	0.22 (0.10)	0.03-0.41	8	0.56 (0.21)	0.15-0.97	2.26	0.13
8.7 Graded Tasks	36	0.42 (0.09)	0.25-0.58	6	0.36 (0.22)	-0.06-0.78	0.06	0.80	-	-	-	-	-	-	-	-
9.2 Pros and Cons	37	0.47 (0.10)	0.28-0.67	5	0.07 (0.06)	-0.05-0.18	12.67	<0.01	13	0.44 (0.15)	0.16-0.73	4	0.12 (0.07)	-0.02-0.26	3.93	0.05
11.2 Reduce Negative Emotions	37	0.40 (0.09)	0.23-0.57	5	0.42 (0.13)	0.17-0.68	0.02	0.90	-	-	-	-	-	-	-	-
ACT - Modify physical activity type	34	0.42 (0.09)	0.26-0.59	8	0.33 (0.21)	-0.08-0.75	0.16	0.69	-	-	-	-	-	-	-	-

Note: Calculated using all comparisons (Control/2 vs A, Control/2 vs B, Control/3 vs A, Control/3 vs B, Control/3 vs C, Two arm), assuming independence. Moderator analysis only done on moderators present in >3 comparison; "-" denotes blank due to moderator present in <3 comparisons; ACT = Affective Change Technique from content analyses; BCT = Behavior Change Technique coded from Michie et al. (2013).

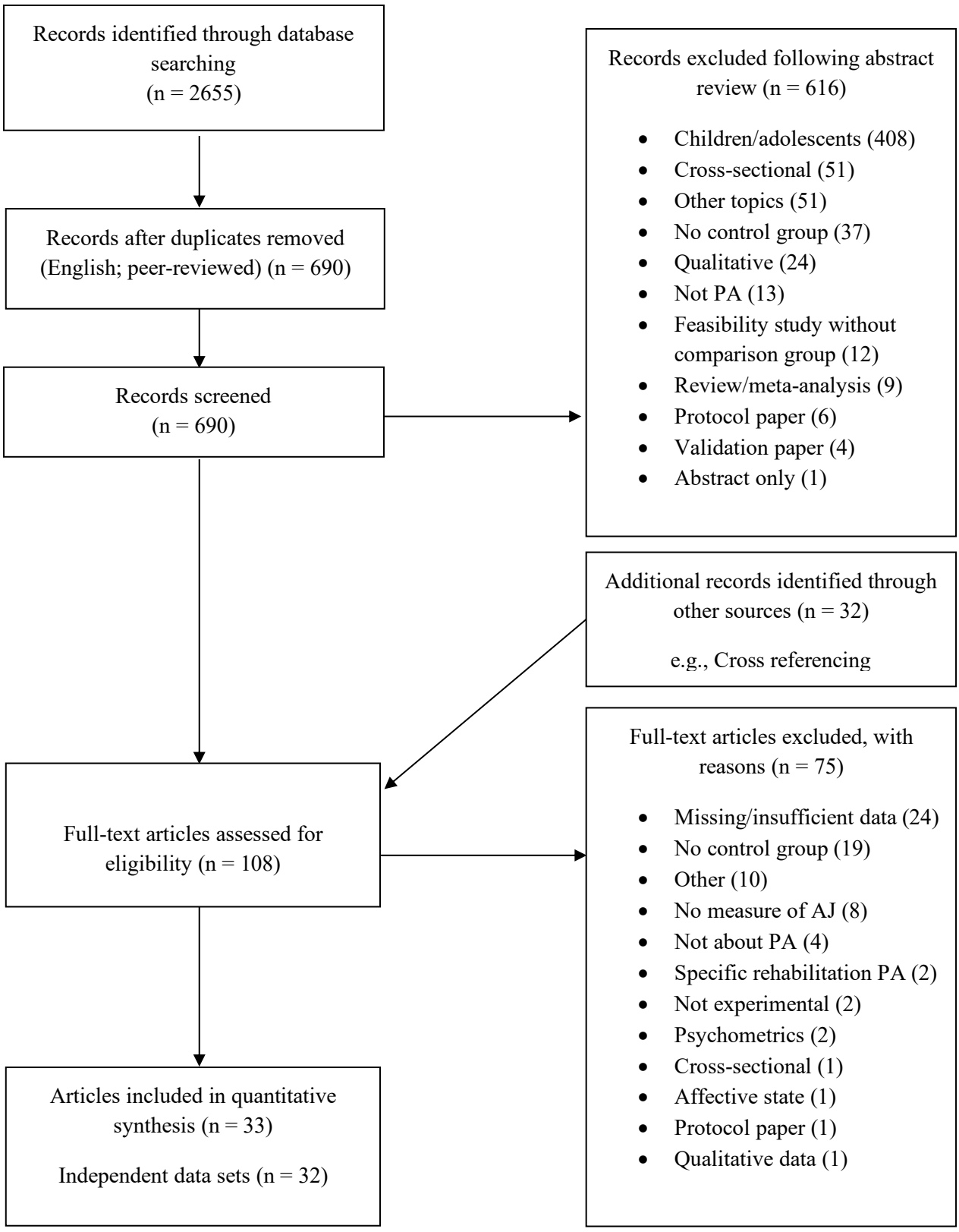

Figure 1. PRISMA Flow Diagram Showing the Literature Search Screening Process

Study name	Comparison	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Bopp et al., 2009	Two arm	0.31	0.23	0.05	-0.14	0.76	1.34	0.18
Conner et al., 2011 study 1	Two arm	-0.03	0.17	0.03	-0.37	0.30	-0.19	0.85
Conner et al., 2011 study 2	Two arm	0.74	0.24	0.06	0.27	1.21	3.06	0.00
Courneya et al., 2016	Two arm	0.00	0.14	0.02	-0.28	0.28	0.00	1.00
Fitzgerald et al., 2010	Two arm	1.47	0.47	0.22	0.56	2.39	3.16	0.00
Gill et al., 2016	Two arm	0.14	0.19	0.04	-0.23	0.51	0.76	0.45
Hardeman et al., 2009; 2011	Two arm	0.07	0.13	0.02	-0.20	0.33	0.50	0.62
Ivanova et al., 2014	Two arm	1.00	0.33	0.11	0.34	1.65	2.98	0.00
Kaltsatou et al., 2014	C vs AB	0.70	0.30	0.09	0.11	1.29	2.32	0.02
Kinnafick et al., 2016	Two arm	-0.14	0.25	0.06	-0.63	0.34	-0.59	0.56
Kliman & Rhodes 2008	Two arm	-0.18	0.17	0.03	-0.52	0.16	-1.03	0.30
Kraft et al., 2015	C vs AB	0.84	0.28	0.08	0.29	1.39	3.00	0.00
Lewis et al., 2016	Two arm	0.16	0.12	0.01	-0.07	0.39	1.39	0.17
Mark & Rhodes, 2013	Two arm	0.73	0.28	0.08	0.18	1.27	2.62	0.01
Milne et al., 2008	Two arm	1.48	0.29	0.09	0.91	2.05	5.05	0.00
Moustaka et al., 2012	Two arm	4.84	0.67	0.44	3.53	6.14	7.26	0.00
Nichols et al., 2000	Two arm	0.39	0.26	0.07	-0.12	0.90	1.49	0.14
Noradechanunt, 2017	C vs AB	0.71	0.39	0.15	-0.05	1.47	1.84	0.07
Patterson, 2017	C vs AB	0.38	0.40	0.16	-0.41	1.16	0.94	0.35
Pinto & Dunsiger, 2015	Two arm	0.22	0.17	0.03	-0.12	0.57	1.27	0.20
Pope et al., 2011	Two arm	-0.47	0.24	0.06	-0.94	-0.00	-1.97	0.05
Pope et al., 2015	C vs AB	-0.03	0.20	0.04	-0.42	0.36	-0.15	0.88
Rhodes et al., 2009	Two arm	1.43	0.41	0.17	0.63	2.24	3.51	0.00
Rogers et al., 2011	Two arm	0.66	0.31	0.10	0.04	1.27	2.09	0.04
Schneider et al., 2016	Two arm	0.50	0.37	0.13	-0.22	1.22	1.35	0.18
Shah et al., 2016	Two arm	0.23	0.26	0.07	-0.27	0.74	0.90	0.37
Silva et al., 2010a/b	Two arm	1.07	0.15	0.02	0.78	1.36	7.21	0.00
Stanley & Cumming, 2010	C vs ABC	0.56	0.26	0.07	0.05	1.08	2.15	0.03
Vallance et al., 2008	Two arm	0.17	0.13	0.02	-0.07	0.42	1.39	0.16
Van Stralen et al., 2011	C vs AB	0.01	0.07	0.01	-0.13	0.16	0.20	0.84
Wang et al., 2015	C vs ABC	-0.32	0.40	0.16	-1.10	0.46	-0.81	0.42
Williams et al., 2006	C vs AB	0.26	0.15	0.02	-0.04	0.55	1.72	0.09
		0.43	0.09	0.01	0.26	0.60	4.89	0.00