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The effects of physical activity interventions on psychosocial outcomes in adolescents: A meta-analytic review

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HIGHLIGHTS

- Four meta-analyses on the effects of physical activity interventions were conducted.
- Significant effects of physical activity were found on all psychosocial outcomes.
- Physical activity interventions can be effective in reducing psychosocial problems.
- Effects depend on several outcome, study, sample and intervention characteristics.

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ABSTRACT

Physical activity interventions are often implemented in the adolescent mental health care practice to prevent or treat psychosocial problems. To date, no systematic review of the effect of these physical activity interventions in adolescents has been conducted. In the current study, four multilevel meta-analyses were performed to assess the overall effect of physical activity interventions on externalizing problems, internalizing problems, self-concept, and academic achievement in adolescents. In addition, possible moderating factors were examined. In total, 57 studies reporting on 216 effect sizes were included, and the results showed significant small-to-moderate effects of physical activity interventions on externalizing problems ($d = 0.320$), internalizing problems ($d = 0.316$), self-concept ($d = 0.297$), and academic achievement ($d = 0.367$). Further, moderator analyses showed that outcome, study, sample, and intervention characteristics influenced the effects of physical activity interventions on psychosocial outcomes. Implications for theory and practice concerning the use of physical activity interventions in adolescent mental health care practice are discussed.

Contents

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1. Introduction

For decades, physical activity has been associated with a broad range of positive outcomes in youth. Historically, empirical research focused on identifying associations between physical activity and general health benefits, such as lower risks of chronic diseases and adiposity (Andersen et al., 2006; Haynos & O'Donohue, 2012; Janssen & LeBlanc, 2010). This type of research was later extended to psychosocial outcomes (Biddle & Asare, 2011; Strong et al., 2005). Nowadays, a large body of empirical evidence describing the relation between physical activity and psychosocial outcomes is available. Physical activity is associated with better academic performance, higher self-esteem, and less anxiety, depression, and behavioral problems (Bailey, 2006; Biddle & Asare, 2011; Daniels & Leaper, 2006; Rasberry et al., 2011; Rasmussen & Laumann, 2013; Samek, Elkins, Keyes, Iacono, & McGue, 2015; Singh, Uijtdewilligen, Twisk, Van Mechelen, & Chinapaw, 2012; Strauss, Rodzilsky, Burack, & Colin, 2001). Hence, physical activity interventions are widely used to treat or prevent all kinds of psychosocial problems in youth. The present meta-analytic study provides a systematic review of the literature on the effects of physical activity interventions on four psychosocial outcomes in adolescents: externalizing problems, internalizing problems, self-concept, and academic achievement.

1.1. Theoretical framework

Physical activity interventions contain elements of sports or (aerobic) exercise, and are implemented in many different settings. There are several theories on how physical activity interventions may lead to improved psychosocial outcomes. First, some researchers have argued that the physiological effects of physical activity positively influence psychological and cognitive aspects (Matta Mello Portugal et al., 2013; Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991; Singh et al., 2012). For example, physical activity leads to increased body temperature, higher norepinephrine and endorphins releases, elevated blood and oxygen flow to the brain, heightened nerve cell growth and brain plasticity, and decreased blood pressure and resting heart rate (Cotman & Berchtold, 2002; Kenney, Wilmore, & Costill, 2015; Ide & Secher, 2000). These physiological effects have often been related to reduced stress, anxiety and depression levels, and better cognitive functions, such as more concentration and an improved learning ability (Chang, Labban, Gapin, & Etnier, 2012; Knöchel et al., 2012; Petruzzello et al., 1991; Singh et al., 2012; Smith, Potter, McLaren, & Blumenthal, 2013; Trudeau & Shephard, 2010).

Second, scholars have hypothesized that the context in which the physical activity is offered, provides a wide range of learning opportunities for social skills and moral virtues that are thought to protect against psychosocial problems (Holt & Neely, 2011). By participating in physical activities, such as sports, youth are expected to develop honesty, sportsmanship, fairness, and moral judgment, and to learn obeying rules and authority, self-control, conflict-resolution, skills to cope with disappointments, and to cooperate with others (Arnold, 1994; Kreager, 2007; Shields & Bredemeier, 1995). Additionally, it was shown that young athletes had higher levels of emotion regulation and initiative taking compared to non-athletes (Larson, Hansen, & Moneta, 2006). As a result of these (alleged) contribution of sports to the moral and socio-emotional development of youth, it is often stated that physical activity interventions comprising sports elements may help in preventing or treating internalizing and externalizing problems (Boone & Leadbeater, 2006; Rutten et al., 2007; Shields & Bredemeier, 1995).

Third, a common underlying rationale for physical activity interventions is that participation in physical activities, such as sports, may have a positive effect on social inclusion, sense of identity, community participation, and bonding with society (Agnew & Petersen, 1989; Bailey, 2005; Haudenhuyse, Theeboom, & Skille, 2014; Perks, 2007). According to this sociological approach, young athletes can derive their identity from the sports team they belong to or the group of athletes practicing the same sport, which could influence the youth's self-concept positively (Armour & Duncombe, 2012; Boone & Leadbeater, 2006). Further, professional players and coaches may become important role models for young athletes, who can reinforce prosocial behaviors and prevent antisocial behaviors (Rutten et al., 2007). Also, the sports field may be seen as a context in which people from different backgrounds can interact with each other, leading to the social inclusion of vulnerable youth and stronger bonds with society (Perks, 2007). Consequently, it is argued that sports participation may prevent externalizing behaviors, and increase school involvement (Agnew & Petersen, 1989; Bailey, 2005; Fredricks & Eccles, 2006; Nichols, 2010; Eccles, Barber, Stone, & Hunt, 2003). On the other hand, there are also scholars who have pointed to the negative effects of physical activity interventions on social inclusion. For instance, social inequalities between players can actually be emphasized through the competitive component of sports resulting in stronger "us" and "them" feelings (Haudenhuyse et al., 2014; Hutchins, 2007; Spaaij, Farquharson, & Marjoribanks, 2015). However, to date there is little empirical evidence to support either assumption of the effects of physical activity interventions on social inclusion (Bailey, 2005; Haudenhuyse et al., 2014; Henley, Schweizer, de Gara, & Vetter, 2007).

Finally, it has been argued that by learning athletic skills, achieving goals, and experiencing success by winning games, physical activity interventions can positively influence self-concept (Bowker, 2006; Petruzzello et al., 1991). Physical activity may increase specific domains of self-concept (i.e., physical competence and satisfaction with physical appearance), which in turn positively influences global self-concept

(Lubans, Plotnikoff & Lubans, 2012). On the contrary, Richman and Shaffer (2000) showed that when young athletes do not experience increased physical competence or improved body image (for example, by not gaining strength, not experiencing weight loss, or losing games all the time), physical activity may actually have a negative influence on global self-concept.

1.2. Previous reviews and gaps in the literature

An extensive amount of systematic reviews on the effects of physical activity interventions on psychosocial outcomes are available, but these mainly focus on internalizing problems or cognition in adult populations (see for example, Daley, 2008; Herring, O'Connor, & Dishman, 2010; Penedo & Dahn, 2005; Petruzzello et al., 1991; Phillips, Kiernan, & King, 2003; Tomporowski & Ellis, 1986). The effects of physical activity on psychosocial outcomes in juvenile populations have received much less attention in the literature (Ahn & Fedewa, 2011; Biddle & Asare, 2011). We chose to examine the effect of physical activity interventions in adolescence, because of the importance of this developmental stage for the onset of psychosocial problems (Strong et al., 2005). As for psychosocial outcomes, we chose the psychosocial outcomes that are most studied and most targeted by physical activity interventions, among which are externalizing problems, internalizing problems, self-concept, and academic performance (Biddle & Asare, 2011; Chamberlain, 2013).

To date, no systematic review of the effect of physical activity on externalizing problems has been conducted. Local governments and institutions all over the world have implemented physical activity interventions to prevent externalizing problems of juveniles (Coakley, 2002; Kelly, 2013; Nichols, 2010; Chamberlain, 2013). However, the available narrative (selective) reviews show that empirical evidence of the effect of physical activity interventions on externalizing problems is mostly anecdotal, and has serious methodological problems (Coakley, 2002; Chamberlain, 2013; Kelly, 2013; Sandford, Duncombe, & Armour, 2008). Although most researchers see a role for physical activity interventions targeting externalizing problems, critical notes have been made (Coakley, 2002; Chamberlain, 2013; Spruit, Van Vugt, Van der Put, Van der Stouwe & Stams, 2015). For example, Spruit et al. (2015) recently found in their meta-analysis of 52 studies, including 431 effect sizes, that there was no overall relation between sports participation and juvenile delinquency, and that sports participation was in some cases even related to more juvenile delinquency. It has been argued by these and other scholars that more understanding of the effect of physical activity interventions on externalizing problems is necessary in order to validate the widespread use of physical activity interventions in preventing externalizing problems (Chamberlain, 2013; Kelly, 2013; Nichols, 2010; Spruit, et al., 2015).

Small-to-moderate effect sizes have been found in a "review of reviews" for the effect of physical activity interventions on internalizing problems, such as depression and anxiety in children and adolescents (Biddle & Asare, 2011). However, the authors mentioned that the studies included in the reviews generally have questionable designs, and that several reviews included cross-sectional studies, which made statements about causality problematic (Biddle & Asare, 2011). The Cochrane review of Larunet al. (2006) has been discussed in Biddle and Asare (2011), but deserves some special attention here as well. Larun et al. (2006) conducted eight meta-analytic comparisons of RCT's on the effects of exercise on anxiety and depression in different samples, and with different types of control groups. Overall, the authors concluded that a small effect of exercise on anxiety and depression appeared, but generalization of these results was difficult due to the limited number of studies included (i.e., two to six studies per comparison), and the diversity of the sample and study characteristics (Dunn & Weintraub, 2008; Larun et al., 2006). In sum, the available evidence indicates positive effects of physical activity interventions on internalizing problems, but this evidence has considerable flaws (Biddle & Asare, 2011; Dunn & Weintraub, 2008).

Self-concept in youth has also been a highly studied topic in physical activity intervention research. Biddle and Asare (2011) summarized the results of three systematic reviews. The reviews discussed in Biddle and Asare (2011) reported a small-to-moderate effect of physical activity interventions on self-esteem in youth. The recent meta-analysis of Liuet al. (2015) of 38 studies found small-to-moderate effect sizes of physical activity interventions in participants aged 4 to 20 on general self-outcomes, self-concept and self-worth. To date, no recent meta-analysis exists focusing on the effect of physical activity interventions on self-concept in adolescents specifically. The reviews of Ekeland et al. (2004; described in Biddle and Assare, 2011) and Liu et al. (2015) included samples ranging from preschoolers to college students. It is possible that this broad spectrum may lead to a disfigured image of the effect of physical activity interventions on self-concept, since specifically adolescence is characterized as an important phase for the development of self-concept (Strong et al., 2005). Therefore, a systematic review examining the effect of physical activity interventions on self-concept in adolescents is necessary.

Most previously conducted reviews on the effect of physical activity interventions on academic achievement focused on the broad domain of cognition and academic performance, such as attention, concentration, intelligence, dropout rates, motivation, and classroom behavior (Fedewa & Ahn, 2011; Howie & Pate, 2012; Rasberry et al., 2011; Singh et al., 2012; Trudeau & Shephard, 2008; Tomporowski, Davis, Miller, & Naglieri, 2008). The available evidence supporting the effect of physical activity on specifically academic achievement is mostly correlational (Trudeau & Shephard, 2008; Tomporowski et al., 2008; Singh et al., 2012). The meta-analysis of Fedewa and Ahn (2011) combined experimental studies and correlational studies to assess the effect of physical activity interventions on academic achievement in children ($d = .24$ on grade point average), which limits the possibility of statements about causality. The systematic review of Rasberry et al. (2011) provided a detailed overview of the effect of physical activity on academic achievement in intervention studies. They showed that almost half of the outcomes of physical activity on children's academic achievement in intervention studies were positive (48%), the other half neutral (49%), and only one outcome (3%) was negative, implicating that physical activity can improve academic achievement (Rasberry et al., 2011). However, the authors did not report about the strength of the effect of physical activity interventions on academic achievement, and the generalization of conclusions was difficult due to methodological weaknesses of included studies, the diversity of the samples, and the limited number of studies included (Rasberry et al., 2011). All in all, there are indications of a positive effect of physical activity interventions on academic achievement, although insight into the strength of the effect and possible moderating factors is lacking (Rasberry et al., 2011; Howie & Pate, 2012; Fedewa & Ahn, 2011).

1.3. The current meta-analysis

The present study aims to fill in the gaps in existing literature by conducting four multilevel meta-analyses on the effect of physical activity interventions on externalizing problems, internalizing problems, self-concept, and academic achievement in adolescents. It is necessary to focus on adolescence exclusively because of the importance of this developmental stage for the onset of psychosocial problems (Strong et al., 2005). The physical, neurological, and socio-emotional transitions that occur during adolescence make adolescents vulnerable for psychosocial problems (Dahl, 2004; Smetana, Campione-Barr, & Metzger, 2006). In the USA, 20–25% of the adolescents experience emotional distress, and approximately 10% of the adolescents have severe mental problems (Knopf, Park, & Paul Mulye, 2008).

Externalizing problems, internalizing problems, self-concept, and academic achievement were considered the most relevant outcomes to examine in a series of comprehensive meta-analyses, because they are the best theoretically supported and most empirically evaluated outcomes, which are most frequently targeted by physical activity interventions in youth care practice (Biddle & Asare, 2011; Chamberlain, 2013). By focusing on a narrow age range, and including only (quasi-)experimental studies, the current study takes into account the shortcomings of previous systematic reviews. Further, the multilevel approach allows comprehensive moderator analyses to assess the influence of study, sample and intervention characteristics on the effect of physical activity interventions on psychosocial outcomes (Van den Noortgate, López-López, Marín-Martínez, & Sánchez-Meca, 2013; Van den Noortgate & Onghena, 2003), gaining more insight into when, how and who could benefit most from physical activity interventions. The multilevel meta-analytic techniques enable the use of all available effect sizes in the analyses, so all information can be preserved and maximum statistical power is generated (Assink et al., 2015).

The first research question addresses the strength of the effect of physical activity interventions on externalizing and internalizing problems, self-concept and academic achievement. The second research question addresses possible moderating effects of outcome, study, sample and interventions characteristics that may influence the strength of the effects of physical activity interventions on psychosocial outcomes.

2. Methods

2.1. Inclusion criteria

All studies examining the effect of physical activity interventions on externalizing and internalizing problems, self-concept, and academic achievement published before August 2015 were included in the current four meta-analyses. Multiple inclusion criteria were formulated to select the studies for the present review. First, the physical activity intervention had to have a sports or (aerobic) exercise component, which had to be a considerable part of the intervention. Wilderness or adventure programs comprise outdoor recreational activities (often with physically challenging elements), such as rock climbing, camping, backpacking, and hiking as a form of group therapy (Jones, Lowe, & Risler, 2004; Wilson & Lipsey, 2000). We consider these programs to be considerably different from sports and exercise interventions studied in previous reviews (e.g. Biddle & Asare, 2011; Chamberlain, 2013; Fedewa & Ahn, 2011; Liu et al., 2015; Rasberry et al., 2011). In order to increase the comparability between the studies included in the meta-analyses, and to make meaningful comparisons with other review studies on the effects of physical activity interventions, we chose not to include wilderness programs in the current study. Second, the mean age of the participants in the sample had to be between 11 and 18, and the age range of the sample had to be between 10 and 21 years old. Third, the study had to be experimental (i.e., a treatment group was compared to a comparison group of juveniles who did not participate in a physical activity intervention). Fourth, the study had to provide sufficient statistical information to calculate an effect size. Fifth, the study had to report on psychosocial outcomes that were of interest in the present review. Externalizing problems were operationalized as any type of aggressive or delinquent behavior, or conduct problem. Internalizing problems were operationalized as anxiety, depression, and/or emotional problems. Self-concept included global measures of self-concept, self-esteem, or self-worth. Academic achievement consisted of measures of actual grades or standardized achievement tests. Finally, populations with physical health issues (except for obesity) were excluded.

2.2. Selection of studies

The following search strategy was conducted to find qualified studies. First, nine electronic databases were searched: Ovid, Google Scholar, EBSCOhost (including SPORTdiscus), Proquest, Web of Science, Picarta, Wiley Online Library, Wiley Cochrane Library, and ScienceDirect. The search string comprised three elements: a physical activity intervention element, an age element, and a psychosocial outcome element. For the physical activity intervention element, the following keywords were used: "physical activity intervention", "sport* intervention", or "exercise intervention". For the age element, the following keywords were used: "youth", "adolescen*", or "child". For the psychosocial outcome element, the keywords "behavior*", "internali*", "anxiety", "depression", "externali*", "delinquency", "conduct", "ODD", "aggression", "behavio* problem", "antisocial", "psychosocial", "emotion*", "mental", "psychiat*", "academic", "grades", "GPA", "self-concept", or "self-esteem" were used. The keywords were only entered in specific text fields of the databases (i.e., the title, abstract and/or keywords) to reduce the number of unqualified hits. In total, 3169 titles were screened in the electronic databases. Further, the reference lists of 32 review articles on physical activity interventions were searched to find qualified studies.

In total, the initial search strategy yielded 546 studies (including reviews) of which the abstracts (and methods section) were read, and excluded in case the study did not fit one of the inclusion criteria. This resulted in 110 studies. Further examination of the full texts of the 110 studies led to the inclusion of 57 studies, with 57 independent samples (s), and 216 effect sizes (k) in the current review. For a flow chart of the search procedure, see Appendix A. Appendix B presents the characteristics of the included studies.

2.3. Coding the studies

The included studies were coded by the first author using a coding sheet according to the guidelines of Lipsey and Wilson (2001). The outcome variable was coded as externalizing problems, internalizing problems, self-concept, or academic achievement. For externalizing problems, it was coded whether the outcome measure was aggression, delinquency, or another type of externalizing behavior. For the studies on internalizing problems, it was coded whether the study measured anxiety, depression, or other internalizing problems. For self-concept, no further distinction was made. For academic achievement, a distinction between types of academic achievement (language achievement, science achievement, or overall achievement/other grades) was made. Additionally, it was coded whether the outcome measure for academic achievement was a standardized achievement test or actual grades. Further, several study, sample, and physical activity intervention characteristics that may moderate the effect of physical activity interventions were coded. In order to reduce the problem of multiple testing (Tabachnik & Fidell, 2013), only possible moderators of theoretical importance were coded.

As for study characteristics, we coded whether the authors were independent researchers, or whether they were involved in the development or implementation of the intervention. Littell (2005) mentioned that dependent researchers may be less critical of their own intervention than independent authors, which may cause some biased results. In case the authors of the studies did not report anything about their own involvement, the study was coded as independent. Further, the design of the study (RCT or quasi-experimental) was coded, since it has been argued that quasi-experimental studies are more susceptible to bias, and may show larger effects than RCT-studies (MacLehose et al., 2000). Also, we coded whether or not the comparison group received any form of treatment or activity that the physical intervention group did not receive, as it is expected that this may influence the strength of the effect of physical activity interventions (Larun et al., 2006). In addition,

it was coded whether the outcome variable was measured by self-report or by other informants, since there are often discrepancies between informants when assessing psychosocial problems, with the largest discrepancies between self-report and other informants' report (Achenbach, McConaughy, & Howell, 1987). Finally, in case there was a follow-up test after post-test, the duration of the follow-up was coded in weeks, since the length of follow-up time may influence the strength of the effect of interventions (Lundahl, Risser, & Lovejoy, 2006; Van der Stouwe, Asscher, Stams, Deković, & van der Laan, 2014).

Several sample characteristics were also coded. First, the sample type was coded (community, clinical, or obese sample, or a sample of juveniles with a mental disability). We coded a sample as clinical in case the sample received any type of care due to psychological or mental health problems, including juvenile delinquents. Second, we coded whether the sample had a clinical diagnosis (DSM axis I-diagnosis), as it may be expected that physical activity interventions may have larger treatment effects in adolescents with a clinical diagnosis than in healthy adolescents due to a ceiling effect (Boyd & Hrycaiko, 1997). Third, the proportion of males in the sample was coded, since there are some indications of gender differences in the effects of physical activity on psychological outcome measures (Hassmen, Koivula, & Uutela, 2000). The last coded sample characteristic was the proportion of youth with a minority background (non-Caucasian) in the sample, since it is unknown how well the findings of previous research generalizes across ethnic groups (Calfas & Taylor, 1994; Strong et al., 2005).

Lastly, we coded six physical activity intervention characteristics. According to Ekeland et al. (2004), we coded whether the intervention consisted of physical activity only, or that the physical activity was part of a comprehensive intervention (i.e., where physical activity was combined with psychological intervention components, leisure activities, or health education). Further, the dose of physical activity may be relevant in determining the effects of physical activity interventions (Dunn & Weintraub, 2008), so the duration of the intervention (in weeks) and the frequency of the intervention (in hours per week) were coded. Also, we coded whether the physical activity intervention consisted of sports or (aerobic) exercise activities. Sports-based interventions often focus on learning skills and virtues, and improve social relations and interactions, while (aerobic) exercise interventions often concentrate on the physiological effects of physical activity and body alterations (Lubans, Plotnikoff & Lubans, 2012). Additionally, it was coded whether the physical activity intervention consisted of team sports activities or individual physical activities. Finally, it was coded whether the therapist/instructor had a psychological or pedagogical background, as it is expected that an instructor's knowledge of pedagogy and understanding of the developmental needs of individual participants, positively influence the effect of physical activity interventions on psychosocial outcomes (Côté & Gilbert, 2009).

To assess interrater agreement, 14 studies ($k = 74$) were randomly selected, and double coded by a research assistant. The percentages of agreement for the moderator variables ranged from sufficient (79%) for the variable frequency of intervention, to perfect (100%) for the variables dependence of authors, duration of treatment, follow-up period, proportion of males, proportion of minority groups, type of internalizing problem, type of externalizing problem, type of academic achievement, and type of informant. For the calculated effect size and the sample sizes the percentages of agreement were 95% and 100%, respectively.

2.4. Calculations and analyses

Effect sizes were transformed into Cohen's *d* by using the calculator of Wilson (2013) and formulas of Lipsey and Wilson (2001). Most *d*-values were calculated based on reported means and standard deviations. Effect sizes were calculated in the majority (82%) of the studies for both pre- and post-test. In those cases, pre-test effects were then subtracted from post-test effects to correct for pretreatment differences. A positive effect size indicated that the physical activity intervention group benefited more than the control group, whereas a negative effect size indicated that the control group benefitted more than the physical activity intervention group. If a study only mentioned that an effect was not significant, the effect size was coded as zero (Lipsey & Wilson, 2001). For each meta-analysis, the continuous variables (duration and frequency of intervention, proportion males, and proportion youth of non-Caucasian ethnicity) were centered around their mean, and categorical variables were recoded into dummy variables. Extreme outliers in effect sizes were identified using box plots (Tabachnik & Fidell, 2013), and were winsorized (i.e., replaced by the highest or lowest acceptable score falling within the normal range) for all meta-analyses (Lipsey & Wilson, 2001). Standard errors were estimated using formulas of Lipsey and Wilson (2001).

In the majority of the studies, it was possible to calculate more than one effect size. Most studies reported on multiple outcome variables, multiple scales to assess the variable of interest, multiple informants that reported about the outcome variable, or reported the effects of physical activity interventions in subsamples separately. It is possible that effect sizes from the same study are more alike than effect sizes from different studies. Therefore, the assumption of independent effect sizes that underlie classical meta-analytic strategies was violated (Hox, 2002; Lipsey & Wilson, 2001). In line with recently conducted meta-analyses, we applied a multilevel approach to the series of current meta-analyses in order to deal with the interdependency of effect sizes (Assink et al., 2015; Houben, Van den Noortgate, & Kuppens, 2015; Van den Bussche, Van den Noortgate, & Reynvoet, 2009; Van den Noortgate et al., 2013; Weisz et al., 2013). The multilevel approach accounts for the hierarchical structure of the data, in which effect sizes are nested within the studies (Van Den Noortgate & Onghena, 2003). Further, a multilevel meta-analysis enables using all effect sizes reported in the primary studies, so that all information is preserved and maximum statistical power is achieved (Assink et al., 2015).

We used a three-level meta-analytic model to calculate the combined effect sizes and to perform the moderator analyses. Three sources of variance were modeled, including the sampling variance for the observed effect sizes (level 1), the variance between effect sizes from the same study (level 2), and the variance between the studies (level 3) (Cheung, 2014; Van den Bussche et al., 2009; Van den Noortgate et al., 2013; Wibbelink & Assink, 2015). The sampling variance of observed effect sizes (level 1) was estimated by using the formula of Cheung (2014). Log-likelihood-ratio-tests were performed to compare the deviance of the full model to the deviance of the models excluding one of the variance parameters, making it possible to determine whether significant variance is present at the second and third levels (Wibbelink & Assink, 2015). Significant variance on level 2 or 3 indicates a heterogeneous effect size distribution, meaning that the effect sizes cannot be treated as estimates of a common effect size. In that case, we proceeded to moderator analyses, because the differences between the effect sizes may be explained by outcome, study, sample, and/or intervention characteristics. For each of the four meta-analyses, moderator analyses were only performed in case each category of the potential moderator was filled with at least three studies.

The four multi-level meta-analyses were conducted in R (version 3.2.0) with the metafor-package, using a multilevel random effects model (Assink et al., 2015; Viechtbauer, 2010; Wibbelink & Assink, 2015). The restricted maximum likelihood estimate was used to estimate all model parameters, and the Knapp and Hartung (2003) was used for testing individual regression coefficients of the meta-

analytic models and for calculating the corresponding confidence intervals (see also Assink et al., 2015; Houben et al., 2015; Wibbelink & Assink, 2015).

2.5. Publication bias

In systematic reviews, the aim is to include all studies previously conducted that meet the inclusion criteria (Lipsey & Wilson, 2001). However, a common problem is that studies may not have been published because of non-significant or unfavorable findings, and therefore are difficult to locate. Not including these studies may lead to an overestimation of the true effect size, the so called "publication bias" (Rosenthal, 1979). In order to check the presence of publication bias in our meta-analyses, we performed a trim and fill procedure (Duval & Tweedie, 2000) by drawing a trim-and-fill plot in R (Version 3.2.0) using the function "trimfill" of the metafor package (Viechtbauer, 2010). We tested if effect sizes were missing on the left side of the distribution, since publication bias would only be likely to occur in case of non-significant or unfavorable (i.e., negative) results. In case the trim-and-fill plot imputed estimations of effect sizes of missing studies, we included these estimations and performed the meta-analysis again to compute an overall effect size that would take the influence of publication bias into account (Duval & Tweedie, 2000).

3. Results

To assess the effect of physical activity interventions on the four psychosocial outcomes, four separate meta-analyses were conducted. The results of each meta-analysis are described below. Table 1 shows the overall effect of physical activity interventions on externalizing problems, internalizing problems, self-concept, and academic achievement.

3.1. Effect of physical activity interventions on externalizing problems

The meta-analysis on the effect of physical activity interventions on externalizing problems contained 14 independent studies (s), reporting on 35 effect sizes (k), and a total sample of $N = 1169$ subjects. The total sample consisted of $n = 534$ subjects in the intervention groups, and $n = 635$ subjects in the comparison groups.

3.1.1. Overall effect on externalizing problems

A significant small-to-medium effect ($d = 0.320$) of physical activity interventions on externalizing problems was found, indicating that physical activity interventions reduced externalizing problems in adolescents. The presence of publication bias is unlikely, as the trim-and-fill plot did not show any imputed effect sizes on the left side of the funnel (see Fig. 1 in Appendix C). Since the variance was significant on the third level, we proceeded to conduct moderator analyses of outcome, study, sample, and intervention characteristics to examine which factors moderate the effect of physical activity interventions on externalizing problems. Table 2 shows the results of these moderator analyses.

3.1.2. Results of moderator analyses on externalizing problems

3.1.2.1. Outcome characteristic. The type of externalizing problems (aggression, delinquency, or other conduct problems) did not moderate the effect of physical activity interventions on externalizing problems.

3.1.2.2. Study characteristics. Whether or not the comparison group received any form of treatment had a moderating effect. Larger effects of physical activity interventions were found when intervention groups were compared to control groups that received any other type of intervention (i.e., psychosocial interventions, other leisure activities). No effect of physical activity interventions was found in case the intervention group was compared to a comparison group which did not receive any treatment. The dependence of the authors, the design of the study, and the type of informant did not moderate the effect of physical activity interventions.

3.1.2.3. Sample characteristics. Sample type, whether or not the sample had a clinical diagnosis, the proportion of males, and the proportion of minority groups in the sample did not moderate the effect of physical activity interventions on externalizing problems.

3.1.2.4. Intervention characteristics. No moderating effects were found for intervention characteristics. More precisely, the type of intervention (physical activity only vs. comprehensive intervention), the duration and frequency of the intervention, the type of physical activity (sports or exercise), whether the intervention consisted of team or individual physical activities, and whether or not the instructor/therapist had any pedagogical background did not influence the strength of the effect of physical activity interventions on externalizing problems.

3.2. Effect of physical activity interventions on internalizing problems

The meta-analysis on the effect of physical activity interventions on internalizing problems contained 24 independent studies (s), with 79 effect sizes (k), and a total sample of $N = 2974$. The total sample contained $n = 1332$ in the intervention groups, and $n = 1642$ in the comparison groups.

3.2.1. Overall effect on internalizing problems

A significant small-to-medium effect ($d = 0.316$) was found for physical activity interventions on internalizing problems, indicating that physical activity interventions significantly reduced internalizing problems in adolescents. As for publication bias, the trim-and-fill plot did not show any imputed effect sizes on the left side (see Fig. 2 in Appendix C), indicating no publication bias. Since the variance was significant on both levels, we conducted moderator analyses in order to

Table 1
Overall effects of physical activity interventions on psychosocial outcomes.

Outcome	s	k	Mean d	95% CI	p	σ^2_{level2}	σ^2_{level3}	% Var. level 1	% Var. level 2	% Var. level 3
Externalizing problems	14	35	0.320	0.023;0.616	.036*	0.002	0.234***	19.3	0.8	79.9
Internalizing problems	24	79	0.316	0.073;0.558	.011*	0.023*	0.298***	12.3	6.3	81.4
Self-concept	33	68	0.297	0.127;0.468	.001***	0.010	0.174***	28.7	3.9	67.4
Academic achievement	10	34	0.367	0.038;0.697	.030*	0.003	0.229***	18.4	0.9	80.7

Note. s = number of studies; k = number of effect sizes; CI = confidence interval; Mean d = mean effect size (d); CI = confidence interval; % Var = percentage of variance explained; σ^2_{level2} = variance between effect sizes within the same study; σ^2_{level3} = variance between studies.

Table 2
Moderator effect of physical activity interventions on externalizing problems.

Moderator variables	*s*	*k*	β_0 (mean *d*)	t_0	β_1	t_1	$F(df_1, df_2)$
Outcome characteristics							
Type of externalizing problem	14	35					$F(2,32) = 2.416$
Other conduct problem (RC)	10	19	0.391	2.803**			
Aggression	3	8	0.160	0.983	−0.231	−1.904+	
Delinquency	3	6	0.168	1.045	−0.223	−1.939+	
Study characteristics							
Authors	14	35					$F(1,33) = 2.362$
Independent (RC)	10	29	0.184	1.116			
Dependent	4	6	0.671	2.485*	0.487	1.537	
Design	14	35					$F(1,33) = 0.101$
RCT (RC)	11	26	0.296	1.698			
Quasi-experimental	3	9	0.412	1.289	0.116	0.318	
Type comparison group	14	35					$F(1,33) = 12.428$**
No intervention/activity (RC)	9	22	−0.013	−0.083			
Some intervention or activity	6	13	0.804	4.214***	0.818	3.525**	
Informant	14	35					$F(1,33) = 2.521$
Self-report (RC)	7	12	0.231	1.494			
Other informant	8	23	0.386	2.569*	0.155	1.588	
Sample characteristics							
Sample type	14	35					$F(2,32) = 0.301$
Community (RC)	6	15	0.265	1.217			
Clinical	6	13	0.453	1.855+	−0.100	−0.362	
Mental disability	3	7	0.164	0.584	0.265	1.217	
Clinical diagnose	14	35					$F(1,33) = 0.119$
No (RC)	11	28	0.296	1.758+			
Yes	3	7	0.429	1.246	0.132	0.345	
Proportion males (continuous)	12	27	0.255	1.825+	−0.612	−1.431	$F(1,25) = 2.047$
Proportion minority (continuous)	7	16	0.443	1.763	0.763	1.125	$F(1,14) = 1.266$
Intervention characteristics							
Type of intervention	14	35					$F(1,33) = 0.002$
Physical activity only (RC)	11	23	0.319	1.831			
Comprehensive intervention	3	12	0.337	1.041	0.018	0.049	
Duration (continuous)	13	33	0.360	2.290*	0.006	1.672	$F(1,32) = 2.895$
Frequency (continuous)	11	25	0.416	2.228*	−0.115	−0.691	$F(1,23) = 0.447$
Type of physical activity	14	35					$F(1,33) = 0.536$
Sports (RC)	10	26	0.386	2.220*			
Exercise	4	9	0.136	0.463	−0.250	−0.732	
Team vs. individual	13	34					$F(1,32) = 1.775$
Team physical activity (RC)	7	19	0.534	2.575*			
Individual physical activities	6	15	0.121	0.527	−0.413	−1.332	
Instructor/therapist	10	26					$F(1,24) = 0.011$
Pedagogical background(RC)	3	7	0.445	1.208			
Non-pedagogical background	7	19	0.491	2.025	0.046	0.105	

Note. s = number of independent studies; k = number of effect sizes; β_0 = intercept/mean effect size (d); t_0 = difference in mean d with zero; β_1 = estimated regression coefficient; t_1 = difference in mean d with reference category; $F(df_1, df_2)$ = omnibus test; (RC) = reference category.
$^{+}$ $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

examine which factors moderated the effect of physical activity interventions on internalizing problems. Table 3 presents the results of these moderator analyses.

3.3. Results of moderator analyses on internalizing problems

3.3.1. Outcome characteristic

The type of internalizing problems (anxiety, depression, or other internalizing problems) did not moderate the effect of physical activity interventions on internalizing problems.

3.3.2. Study characteristics

The study design moderated the strength of the effect of physical activity interventions on internalizing problems. Studies using an RCT design showed weaker effects than studies using a quasi-experimental design. Whether or not the authors were dependent, the type of comparison group, the type of informant, and the follow-up time did not moderate the effect of physical activity interventions on internalizing problems.

3.3.3. Sample characteristics

Moderating effects were found for the proportion of males in the sample and whether or not the sample had a clinical diagnosis. Larger effects were observed in samples with fewer males, and in samples with a clinical diagnosis. The sample type and the proportion of minority groups in the sample did not moderate the effect of physical activity interventions on internalizing problems.

3.3.4. Intervention characteristics

We found no moderating effects of intervention characteristics. The type of intervention, the duration and frequency of the intervention, the type of physical activity, whether the intervention consisted of team or individual physical activities, and whether or not the instructor/therapist had any pedagogical background did not moderate the effect of physical activity interventions on internalizing problems.

Table 3
Moderator effect of physical activity interventions on internalizing problems.

Moderator variables	*s*	*k*	β_0 (mean *d*)	t_0	β_1	t_1	$F(df_1, df_2)$
Outcome characteristic							
Type of internalizing problem	24	79					$F(2,76) = 0.364$
Other (RC)	7	12	0.416	2.000*			
Anxiety	11	26	0.320	2.209*	−0.096	−0.427	
Depression	16	38	0.259	1.829+	−0.156	−0.702	
Study characteristics							
Authors	24	79					$F(1,77) = 1.842$
Independent (RC)	12	36	0.148	0.871			
Dependent	12	43	0.468	2.857**	0.320	1.357	
Design	24	79					$F(1,77) = 6.518^*$
RCT (RC)	19	69	0.235	1.805+			
Quasi-experimental	6	11	0.589	3.572***	0.354	2.553*	
Type comparison group	24	79					$F(1,77) = 0.135$
No intervention/activity (RC)	14	35	0.289	2.030*			
Some intervention or activity	12	44	0.346	2.352*	0.059	0.367	
Informant	24	79					$F(1,77) = 2.150$
Self-report (RC)	22	65	0.280	2.278*			
Other informant	5	14	0.529	2.792**	0.249	1.466	
Follow-up time (continuous)	4	9	0.134	0.241	0.028	1.471	$F(1,7) = 2.164$
Sample characteristics							
Sample type	24	79					$F(2,76) = 1.484$
Community (RC)	10	24	0.194	1.147			
Clinical	10	40	0.528	3.100**	0.334	1.536	
Obese	5	15	0.143	0.581	−0.051	−0.172	
Clinical diagnose	24	79					$F(1,77) = 5.832^*$
No (RC)	20	61	0.195	1.545			
Yes	4	18	0.981	3.268**	0.786	2.415*	
Proportion males (continuous)	23	77	0.292	2.305*	−0.452	−4.325***	$F(1,77) = 18.705^{***}$
Proportion minority (continuous)	16	56	0.394	2.544*	−0.123	−0.291	$F(1,54) = 0.084$
Intervention characteristics							
Type of intervention	24	79					$F(1,77) = 0.715$
Physical activity only (RC)	12	38	0.429	2.364*			
Comprehensive intervention	12	41	0.218	1.281	−0.211	−0.846	
Duration (continuous)	24	79	0.291	2.390*	0.026	1.280	$F(1,77) = 1.639$
Frequency (continuous)	21	73	0.290	2.264*	0.003	0.060	$F(1,71) = 0.004$
Type of physical activity	24	79					$F(1,77) = 0.451$
Sports (RC)	9	23	0.211	1.060			
Exercise	15	56	0.381	2.436*	0.107	0.672	
Team vs. individual	23	77					$F(1,75) = 0.064$
Team physical activity (RC)	7	18	0.278	1.177			
Individual physical activity	16	59	0.350	2.217*	0.072	0.252	
Instructor/therapist	20	65					$F(1,63) = 1.841$
Pedagogical background(RC)	11	33	0.565	2.845**			
Non-pedagogical background	9	32	0.171	0.803	−0.395	−1.357	

Note. s = number of independent studies; k = number of effect sizes; β_0 = intercept/mean effect size (d); t_0 = difference in mean d with zero; β_1 = estimated regression coefficient; t_1 = difference in mean d with reference category; $F(df_1, df_2)$ = omnibus test; (RC) = reference category.
$^+ p < .10$, $^* p < .05$, $^{**} p < .01$, $^{***} p < .001$

3.4. Effect of physical activity interventions on self-concept

The meta-analysis on the effect of physical activity interventions on self-concept contained 33 independent studies (s), with 68 effect sizes (k), and a total sample of $N = 2647$. The total sample contained $n = 1374$ in the intervention groups, and $n = 1273$ in the comparison groups.

3.4.1. Overall effect on self-concept

Physical activity interventions increased positive self-concept in adolescents, indicated by a significant small-to-medium effect size ($d = 0.297$). Publication bias was not found, since the trim-and-fill procedure did not impute effect sizes on the left side (see Fig. 3 in Appendix C). As the variance was significant on the third level, we conducted moderator analyses of study, sample, and intervention characteristics to examine which factors moderated the effect of physical activity interventions on self-concept. Table 4 reports on the results of these moderator analyses.

3.4.2. Results of moderator analyses on self-concept

3.4.2.1. Study characteristics. Whether the authors were independent or not, the design of the study, the type of comparison group, and the follow-up time did not moderate the effect of physical activity interventions on self-concept.

3.4.2.2. Sample characteristics. None of the sample characteristics (sample type, proportion of males in the sample, and proportion of youth from ethnic minority groups in the sample) moderated the effect of physical activity interventions on self-concept.

3.4.2.3. Intervention characteristics. We found a significant moderating effect of the type of physical activity (sports vs. exercise) used in the

Table 4
Moderator effect of physical activity interventions on self-concept.

Moderator variables	*s*	*k*	β_0 (mean *d*)	t_0	β_1	t_1	$F(df_1, df_2)$
Study characteristics							
Authors	33	68					$F(1,66) = 0.005$
Independent (RC)	23	41	0.294	2.741*			
Dependent	10	27	0.308	2.069*	0.013	0.072	
Design	33	68					$F(1,65) = 3.158^{+}$
RCT (RC)	20	43	0.415	3.887***			
Quasi-experimental	13	25	0.116	0.896	−0.299	−1.777+	
Type comparison group	33	68					$F(1,66) = 0.057$
No intervention/activity (RC)	20	39	0.284	2.673**			
Some intervention or activity	15	29	0.317	2.736**	0.033	0.239	
Follow-up time (continuous)	11	5	0.509	1.076	0.004	0.209	$F(1,9) = 0.044$
Sample characteristics							
Sample type	33	68					$F(1,64) = 0.145$
Community (RC)	15	26	0.245	1.874+			
Clinical	6	13	0.358	1.653	0.113	0.446	
Mental disability	3	7	0.251	0.761	0.005	0.015	
Obese	9	22	0.367	2.237*	0.122	0.580	
Proportion males (continuous)	31	66	0.254	3.038**	−0.087	−0.482	$F(1,64) = 0.232$
Proportion minority (continuous)	16	38	0.275	1.831+	−0.054	−0.122	$F(1,36) = 0.015$
Intervention characteristics							
Type of intervention	33	68					$F(1,66) = 0.843$
Physical activity only (RC)	20	39	0.368	3.202**			
Comprehensive intervention	13	29	0.208	1.590	−0.160	−0.918	
Duration (continuous)	32	67	0.311	3.59***	−0.007	−1.077	$F(1,65) = 1.161$
Frequency (continuous)	28	62	0.271	3.155**	−0.005	−0.331	$F(1,60) = 0.110$
Type of physical activity	32	64					$F(1,62) = 4.957^{*}$
Sports (RC)	12	26	0.071	0.534			
Exercise	20	38	0.450	4.183***	0.379	2.226*	
Team vs. individual	30	63					$F(1,61) = 2.099$
Team physical activity (RC)	11	22	0.174	1.230			
Individual physical activity	21	42	0.417	3.850***	0.243	1.449	
Instructor/therapist	26	55					$F(1,53) = 1.136$
Pedagogical background(RC)	13	25	0.213	1.703+			
Non-pedagogical background	14	30	0.387	3.099**	0.174	0.997	

Note. s = number of independent studies; k = number of effect sizes; β_0 = intercept/mean effect size (d); t_0 = difference in mean d with zero; β_1 = estimated regression coefficient; t_1 = difference in mean d with reference category; $F(df_1, df_2)$ = omnibus test; (RC) = reference category.
$^{+}$ $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

intervention. Larger effects of physical activity interventions on self-concept were found when the intervention consisted of (aerobic) exercise. No moderating effects were found for the type of intervention, the duration and frequency of the intervention, whether the intervention consisted of team or individual physical activities, and whether or not the instructor/therapist had any pedagogical background.

3.5. Effect of physical activity interventions on academic achievement

The meta-analysis on the effect of physical activity interventions on academic achievement contained 10 independent studies (s), with 34 effect sizes (k), and a total sample of $N = 1488$. The total sample contained $n = 729$ in the intervention groups, and $n = 759$ in the comparison groups.

3.5.1. Overall effect on academic achievement

A significant small-to-medium effect ($d = 0.367$) was found for physical activity interventions on academic achievement, indicating that physical activity interventions significantly increased academic achievement in adolescents, compared to comparison groups. The trim-and-fill plot did not show any imputed effect sizes of missing data on the left side (see Fig. 4 in Appendix C), indicating that the presence of publication bias is unlikely. Since the variance was significant on the third level, we conducted moderator analyses of outcome, study, sample, and intervention characteristics to examine which factors moderated the effect of physical activity interventions on academic achievement. Table 5 shows the results of the moderator analyses.

3.5.2. Results of moderator analyses on academic achievement

3.5.2.1. Outcome characteristics. The type of academic achievement (language achievement, science achievement, or overall achievement/other grades) did not moderate the effect of physical activity interventions on academic achievement. We found that the type of measure (standardized achievement tests vs. grades) did moderate the effect of physical activity interventions. Stronger effects were found if academic achievement was measured through grades.

3.5.2.2. Study characteristics. No study characteristics were found to be a moderating factor. The design of the study and the type of comparison group did not influence the effect of physical activity intervention on academic achievement.

3.5.2.3. Sample characteristics. The proportion of youth from an ethnic minority group and the proportions of males in the sample did not moderate the effect of physical activity interventions.

3.5.2.4. Intervention characteristics. No significant moderating effects were found for intervention characteristics (type of intervention,

Table 5
Moderator effect of physical activity interventions on academic achievement.

Moderator variables	*s*	*k*	β_0 (mean *d*)	t_0	β_1	t_1	$F(df_1, df_2)$
Outcome characteristics							
Type of academic achievement	10	34					$F(2,31) = 0.598$
Overall achievement/other	7	15	0.387	2.237*			
Language achievement	5	11	0.280	1.483	−0.108	−0.730	
Science achievement	5	8	0.418	2.105	0.030	0.190	
Type of measure	10	34					$F(1,32) = 4.359^*$
Achievement tests (RC)	4	13	0.167	0.838			
Grades	8	21	0.477	2.617*	0.310	2.088*	
Study characteristics							
Design	10	34					$F(1,32) = 0.375$
RCT (RC)	7	21	0.438	2.158*			
Quasi-experimental	3	13	0.215	0.717	−0.223	−0.612	
Type comparison group	10	34					$F(1,32) = 0.014$
No intervention/activity (RC)	5	23	0.344	1.385			
Some intervention or activity	5	11	0.389	1.646	0.045	0.132	
Sample characteristics							
Proportion males (continuous)	10	34	0.401	2.662*	1.285	1.715	$F(1,32) = 2.940$
Proportion minority (continuous)	8	21	0.351	1.554	−0.203	−0.339	$F(1,19) = 0.115$
Intervention characteristics							
Type of intervention	10	34					$F(1,32) = 0.049$
Physical activity only (RC)	7	25	0.344	1.657			
Comprehensive intervention	3	9	0.428	1.363	0.084	0.222	
Duration (continuous)	10	34	0.330	2.099*	−0.008	−1.171	$F(1,32) = 1.372$
Frequency (continuous)	9	30	0.271	1.678	−0.109	−1.965+	$F(1,28) = 3.863^+$
Type of physical activity	10	34					$F(1,32) = 0.003$
Sports (RC)	8	28	0.363	2.123*			
Exercise	3	6	0.377	1.498	0.011	0.045	
Team vs. individual	9	32					$F(1,30) = 0.705$
Team physical activity (RC)	5	19	0.510	2.503*			
Individual physical activity	5	13	0.321	1.546	−0.189	−0.843	

Note. s = number of independent studies; k = number of effect sizes; β_0 = intercept/mean effect size (d); t_0 = difference in mean d with zero; β_1 = estimated regression coefficient; t_1 = difference in mean d with reference category; $F(df_1, df_2)$ = omnibus test; (RC) = reference category.
$^+ p < .10$, $^* p < .05$, $^{**} p < .01$, $^{***} p < .001$

duration and frequency, type of physical activity, and whether the activities were either team or individual activities).

4. Discussion

By conducting four separate meta-analyses, the current study aimed to assess the effect of physical activity interventions on four psychosocial outcomes in adolescents: externalizing problems, internalizing problems, self-concept, and academic achievement. Further, it was aimed to examine which outcome, study, sample, and intervention characteristics influenced the strength of the effect of physical activity interventions on psychosocial outcomes. Overall, we found significant small-to-moderate effect sizes of physical activity interventions on externalizing problems ($d = 0.345$), internalizing problems ($d = 0.316$), self-concept ($d = 0.297$), and academic achievement ($d = 0.367$), indicating that the physical activity intervention groups benefited more than the comparison groups. Therefore, we conclude that physical activity interventions were effective in reducing externalizing and internalizing problems, and in improving self-concept and academic achievement. These findings are consistent with findings of previous reviews (Ahn & Fedewa, 2011; Biddle & Asare, 2011; Chamberlain, 2013; Fedewa & Ahn, 2011; Liu et al., 2015; Rasberry et al., 2011). No indications of publication bias were found. In the four meta-analyses, significant variance was present at the third and/or the second level, indicating that the effect size distribution was heterogeneous, and that moderating variables may explain differences in the strength of the effect sizes.

For the meta-analysis of the effect of physical activity interventions on externalizing problems, the results showed a moderating effect of the type of comparison group. Stronger effects were found when the physical activity group was compared to a comparison group that received some other form of intervention (i.e., psychosocial interventions or group activities). This rather remarkable result may be explained by the fact that in 12 out of 14 studies the intervention group interacted with the comparison group, for example, in case both groups were selected from the same school or the same residential facility. Since physical activity is generally a popular activity for adolescents (Kjønniksen, Anderssen, & Wold, 2009), exclusion from the physical activity may have frustrated the adolescents from the control group resulting in higher levels of acting out behaviors. More specifically, close inspection of studies reporting on pretest scores and where the experimental groups interacted showed that five studies found increased levels of externalizing problems in the comparison group. In four studies the scores remained the same, and in one study the scores of the comparison group decreased. This may (partly) support our explanation. However, it was not possible to test whether these changes were significant. An alternative explanation may be that samples of studies in which the comparison group did not receive any (additional) intervention consisted of children with mild problems. In general, it is perceived unethical to withhold interventions from children who experience serious problem behaviors. Possibly, smaller effect sizes in comparison groups without any intervention were found due to a ceiling effect (Freeman, Sullivan, & Fulton, 2003), as these children displayed smaller changes in their

behavior. Although sample characteristics did not significantly moderate the effects of physical activity interventions on externalizing problems, we do believe that this possibility should be mentioned.

The design of the study, whether or not the sample had a clinical diagnosis, and the proportion of males in the sample influenced the strength of the effect of physical activity interventions on internalizing problems. The stronger effects in the current study in samples with fewer males and in clinical samples are in line with previous reviews, showing that physical activity interventions are more effective in reducing internalizing problems in samples with more females, and more severe/clinical cases (Ahn & Fedewa, 2011; Calfas & Taylor, 1994; Craft & Landers, 1998; Dunn & Jewell, 2010; Phillips et al., 2003). The findings of stronger effects of physical activity interventions on internalizing problems in quasi-experimental studies may be explained by larger biases and less rigorous designs of quasi-experimental studies compared to RCT-studies, leading to stronger effect sizes (James, Stams, Asscher, De Roo, & Van der Laan, 2013; MacLehose et al., 2000; Welsh, Peel, Farrington, Elffers, & Braga, 2011).

The strength of the effect of physical activity interventions on self-concept was moderated by the type of physical activity. Larger effects were found for interventions with (aerobic) exercise elements compared to interventions with sports components. This finding is in line with the previous meta-analysis on the effect of physical interventions on mental health in children, showing larger effects for exercise in comparison to sports in RCT-studies (Ahn & Fedewa, 2011). Exercise interventions often focus on generating a minimum level of physical exertion, obtaining the physiological effects of exercise, and developing strength and stamina (Lubans, Plotnikoff & Lubans, 2012). This may more strongly improve the sense of "feeling well about yourself" than sports activities, which are more focused on the social environment and the competitive element (Fraser-Thomas, Cote, & Deakin, 2005). The sports element of winning a game can lead to increased self-esteem, whereas losing the game may have adverse effects on self-esteem.

For the meta-analysis of the effect of physical activity interventions on academic achievement, moderating effects were found for the type of measure of academic achievement. Larger effects were found for grades compared to studies with standardized achievement tests. Standardized achievement tests and grades differ to the extent that standardized achievement tests better predict IQ, whereas grades better predict academic behaviors (Duckworth, Quinn, & Tsukayama, 2012). The moderating result of measurement type may implicate that physical activity interventions have larger effect on the academic behavior component than on the intellectual component of academic achievement. On the other hand, IQ is perceived as a relatively stable concept across time (Deater-Deckard et al., 2009), which may also explain smaller effects for standardized achievement tests, and larger effects for grades.

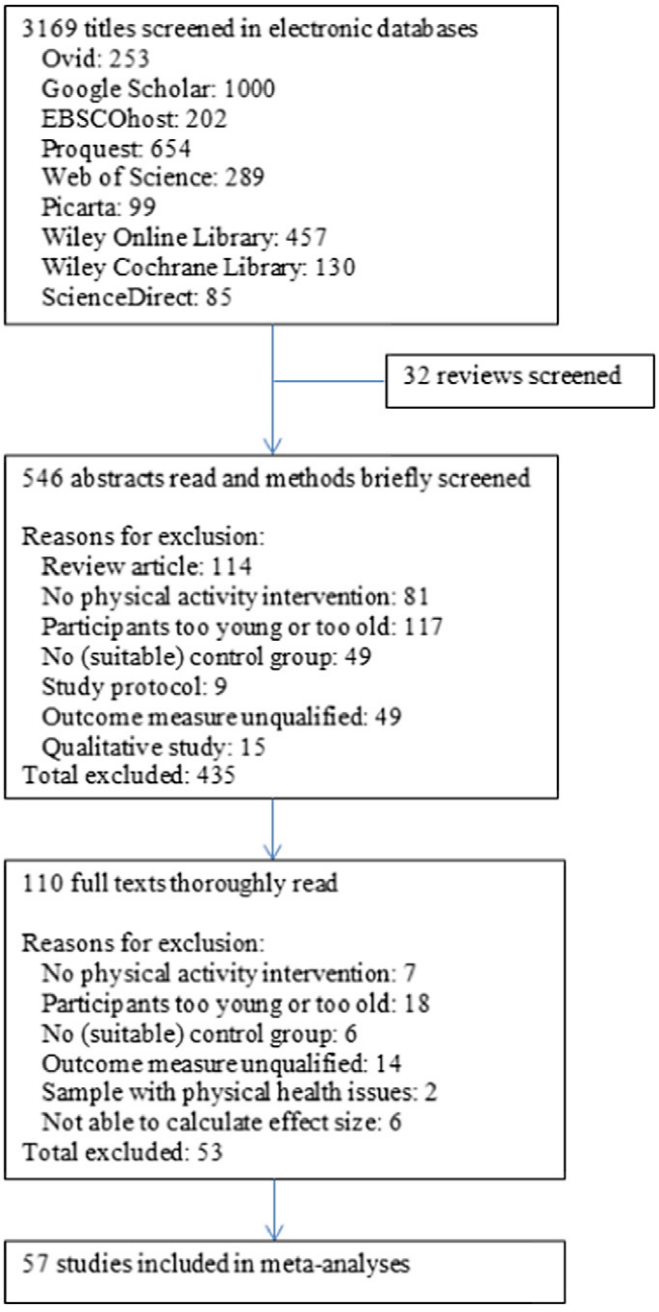
The current study has some limitations that need to be mentioned. First, the quality of some of the included studies was low. Many studies had small samples, and did not always provide enough information to code all the moderators. As a result, there might be a power problem in identifying moderators with a small or moderate influence. This may be the case for the moderator *authors* in the meta-analysis of externalizing problems, and for *background of instructor* in the meta-analysis of internalizing problems. Differences between effect sizes of independent and dependent authors seem quite considerable for the meta-analysis of externalizing problems (respectively, $d = 0.184$ vs. $d = 0.671$), but was not identified as a significant moderator. The same was observed for the pedagogical background of instructors in the meta-analysis of internalizing problems (respectively, $d = 0.565$ vs. $d = 0.171$). Second, none of the primary studies controlled for the amount of physical activity of the intervention and comparison groups during leisure time of the participants. Physical activity is a fairly common leisure activity for adolescents (Linver, Roth, & Brooks-Gunn, 2009), and prior differences in physical activities between intervention and comparison groups may influence the strength of the intervention effects. Third, we acknowledge that the outcome measures of interest in the current study are closely associated to one another. For example, a negative self-concept is a risk factor for both internalizing and externalizing problems, and internalizing problems have been shown to be predictors of externalizing problems in adolescents (Ybrandt, 2008). Furthermore, high academic competence has been related to lower levels of externalizing and internalizing problems (Moilanen, Shaw, & Maxwell, 2010). Thus, the effect of physical activity interventions on a particular psychosocial outcome may be influenced by the effect of these interventions on other outcomes. The results of each meta-analysis can therefore not be interpreted independently, as the psychosocial outcomes overlap to a certain extend. Finally, the meta-analysis of the effect of physical activity on externalizing problems and academic achievement was based on a small number of studies (14 and 10 studies respectively), which may negatively influence generalizability.

The current study yields important implications for future research and practice concerning physical activity interventions. According to the outcomes of the meta-analyses, physical activity interventions appear to be effective in reducing both internalizing and externalizing problems, and in improving self-concept and academic achievement. All in all, the main results of the current study provide justifications for the increasing use of physical activity interventions in adolescent mental health care practice. On the other hand, we do want to stress the danger of indiscriminately implementing physical activity interventions when the purpose is to improve psychosocial health of adolescents. Although physical activity interventions are generally effective, empirical and theoretical insights from the current study showed that these interventions may be harmful in certain situations. It seems to be important that physical activity interventions should be carefully designed for specific target groups and specific psychosocial goals.

More empirical research into the effects of physical activity interventions on psychosocial outcomes is desirable in order to gain knowledge on when, how, and why physical activity interventions positively influence psychosocial outcomes in adolescents. Especially intervention studies with robust designs (i.e., RCT-designs and large samples), conducted by independent researchers, evaluating well documented and well described interventions are necessary. The included studies in the current meta-analyses provided little information on the contexts of the physical activity interventions, while previous research does indicate the importance of contextual influences of physical activity interventions on psychosocial outcomes (Ntoumanis, Taylor, & Thøgersen-Ntoumani, 2012; Rutten et al., 2007, 2011). Rutten et al. (2007, 2011) showed that the prosocial and antisocial behaviors of young athletes can be explained by the moral atmosphere of the sporting environment, and the presence of supportive coach–athlete relationships. Also, specific characteristics of the instructor/coach of the physical activity interventions (i.e., the level of moral reasoning, the extent of motivational behaviors of the instructor, the experience and knowledge with the target group) may influence the effects on emotional well-being and behaviors of participants of physical activity interventions (Côté & Gilbert, 2009; Ntoumanis et al., 2012; Rutten et al., 2007).

In sum, the current study showed that physical activity interventions can be effective in improving psychosocial outcomes. However, high quality intervention evaluations are necessary to gain more understanding of how, when, and why physical activity interventions yield positive psychosocial outcomes. Future research should focus on the influence of contextual factors of physical activity interventions on psychosocial outcomes, as it is expected that increasing the quality of the physical activity context can improve the effects of physical activity interventions.

Appendix A. Flow chart of search results



Appendix B. Characteristics of included studies

Authors	Year	Design	Type of sample	Gender	Type of outcome
Allen	2013	RCT	Community	Male	Academic achievement
Ardoy et al.	2014	RCT	Community	Mixed	Academic achievement
Barenholtz	1995	RCT	Community	Male	Self-concept
Bartelink et al.	2015	QE	Obese	Mixed	Self-concept
Beffert	1993	RCT	Community	Mixed	Internalizing, academic achievement
Blackman et al.	1988	QE	Community	Male	Self-concept
Boyd & Hrycaiko	1997	QE	Community	Female	Self-concept
Brown et al.	1992	RCT	Clinical	Mixed	Externalizing, internalizing, self-concept
Cameron	1999	QE	Obese	Mixed	Self-concept
Carl	1983	RCT	Clinical	Mixed	Internalizing
Casey et al.	2013	RCT	Community	Female	Internalizing
Christ	1994	RCT	Community	Mixed	Externalizing, self-concept, academic achievement
Coe et al.	2006	RCT	Community	Mixed	Academic achievement
Cohen-Kahn	1994	RCT	Clinical	Mixed	Externalizing, internalizing
D'Andrea et al.	2013	QE	Clinical	Female	Externalizing, internalizing
Daley et al.	2006	RCT	Obese	Mixed	Internalizing, self-concept
Fullerton et al.	2007	RCT	Obese		Internalizing
Gately et al.	2005	QE	Obese	Mixed	Self-concept
Gençöz	1997	RCT	Mental disability		Externalizing
Green	2010	QE	Community	Mixed	Academic achievement
Hilyer et al.	1982	RCT	Clinical	Male	Internalizing, self-concept
HoganBruen	1998	QE	Community	Female	Internalizing, self-concept
Hulecki	1988	QE	Clinical	Mixed	Internalizing, self-concept, academic achievement
Jelalian et al.	2011	RCT	Obese	Mixed	Internalizing, self-concept
Kanner	1990	RCT	Clinical	Mixed	Internalizing
Koniak-Griffin	1994	QE	Community	Female	Internalizing, self-concept
Lai et al.	2009	QE	Community	Mixed	Self-concept
Lau et al.	2004	RCT	Obese	Mixed	Internalizing
Lubans et al.	2012	RCT	Community	Female	Self-concept
Maïano et al.	2001	RCT	Mental disability	Male	Externalizing, self-concept
Marsh & Peart	1988	RCT	Community	Female	Self-concept
Marvul	2012	RCT	Clinical	Male	Externalizing
Mayorga-Vega et al.	2012	RCT	Community	Mixed	Self-concept
McGowan et al.	1974	RCT	Community	Male	Self-concept
MacMahon & Gross	1988	RCT	Clinical	Male	Internalizing, self-concept
Melnyk et al.	2009	RCT	Community	Mixed	Internalizing
Melnyk et al.	2013	RCT	Community	Mixed	Internalizing, academic achievement
Mulkens et al.	2007	RCT	Obese	Mixed	Self-concept
Munson	1988	RCT	Clinical	Male	Self-concept
Munson et al.	1985	RCT	Clinical	Male	Self-concept
Nahme-Huang et al.	1977	RCT	Clinical		Externalizing
Nathan et al.	2013	QE	Clinical	Mixed	Internalizing
Ninot et al.	2000	QE	Mental disability	Female	Self-concept
Norris et al.	1992	RCT	Community	Mixed	Externalizing, internalizing
Özer et al.	2012	RCT	Community and mental disability	Male	Externalizing, internalizing
Percy et al.	1981	RCT	Community		Self-concept
Poole	2009	QE	Clinical	Male	Externalizing, self-concept
Richard et al.	2014	RCT	Community	Mixed	Internalizing
Schneider et al.	2008	QE	Community	Male	Self-concept
Schranz et al.	2014	RCT	Obese	Male	Self-concept
Simpson & Meaney	1979	QE	Mental disability		Self-concept
Skolnick	1980	RCT	Community	Mixed	Internalizing, academic achievement
Spruit et al.	2016	QE	Community	Mixed	Externalizing, academic achievement

(continued on next page)

(*continued*)

Authors	Year	Design	Type of sample	Gender	Type of outcome
Staïano et al.	2013	RCT	Obese	Mixed	Self-concept
Velez et al.	2010	RCT	Community	Mixed	Self-concept
Wagener et al.	2012	RCT	Obese	Mixed	Externalizing, internalizing, self-concept
Zivin et al.	2001	RCT	Community	Male	Externalizing, internalizing

Note. RCT = randomized control trial; QE = quasi-experimental design.

Appendix C

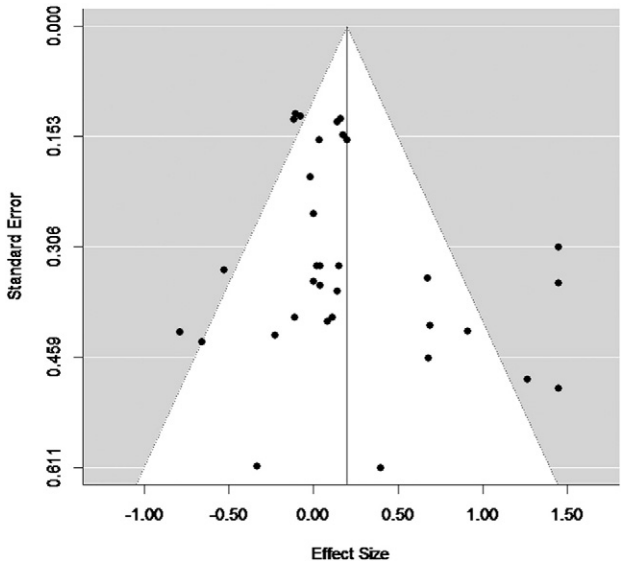


Fig. 1. Trim-and-fill plot for the effect of physical activity interventions on externalizing problems.

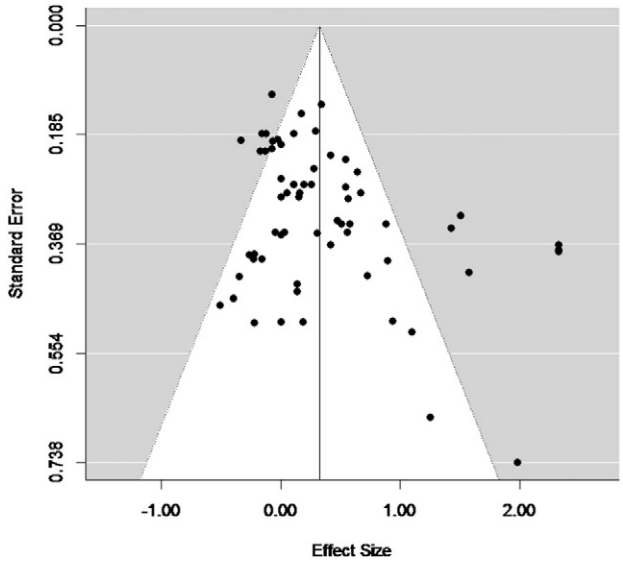


Fig. 2. Trim-and-fill plot for the effect of physical activity interventions on internalizing problems.

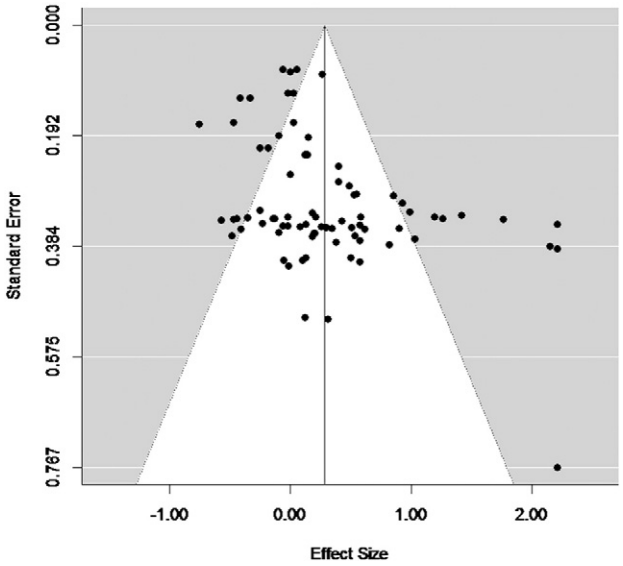


Fig. 3. Trim-and-fill plot for the effect of physical activity interventions on self-concept.

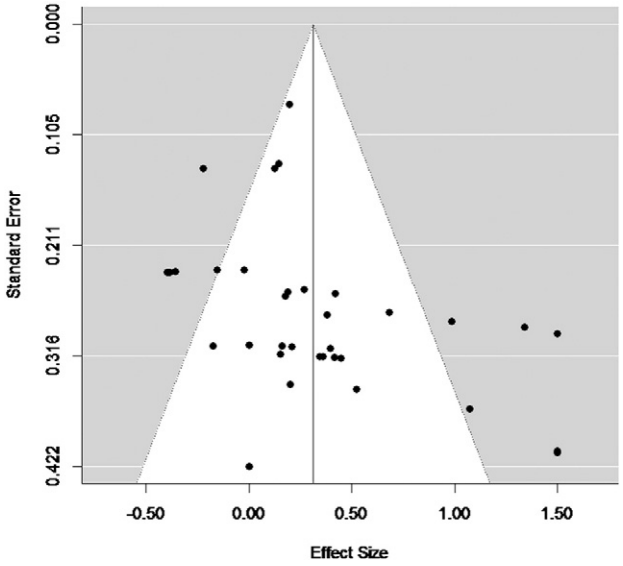


Fig. 4. Trim-and-fill plot for the effect of physical activity interventions on academic achievement.

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