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Effects of school-based interventions on motivation towards physical activity in children and adolescents: A systematic review and meta-analysis

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ABSTRACT

Introduction: Assuming that motivation is the key to initiate and sustain beneficial health behaviors, the aim of this systematic review was to analyze the effects of school-based physical activity interventions on a variety of motivational outcomes towards PA in school-aged children and adolescents.

Methods: A comprehensive literature search was carried out in six electronic databases to identify randomized controlled trials and quasi-experimental trials examining the effects of PA interventions implemented during the regular school day, e.g., during physical education lessons or lunch breaks. Primary outcomes of interest were students' motivation, basic psychological needs, goal orientation, enjoyment, and motivational teaching climate in physical education. Meta-analyses were conducted for these outcomes using Comprehensive Meta-analysis software. Secondarily, intervention effects on students' PA behaviors were examined and the findings summarized narratively. Methodological quality of studies was evaluated using the Cochrane Collaboration's tool for assessing risk of bias for randomized trials; certainty of evidence on outcome level was evaluated using the GRADE approach.

Results: In total, 57 studies carried out between 2001 and 2018 were included in this review. Sixteen individual meta-analyses were performed and revealed significant pooled effects for the outcomes enjoyment ($g = 0.310$), perceived autonomy ($g = 0.152$), identified regulation ($g = 0.378$), intrinsic motivation ($g = 0.419$), self-determination index ($g = 0.672$), task/mastery climate ($g = 0.254$), ego/performance climate ($g = -0.438$), autonomy supportive climate ($g = 0.262$), task goal orientation ($g = 1.370$), ego goal orientation ($g = -0.188$). The narrative data synthesis indicated an increase in students' PA behavior. The overall risk of bias was high across all studies and certainty of evidence of meta-analyzed outcomes ranged from very low to moderate. Moderate certainty of evidence was found for ego/performance climate and ego goal orientation. **Conclusions**: Meta-analyses suggest that school-based PA interventions may be effective in increasing a variety of motivational outcomes. However, the certainty of evidence was limited in the majority of outcomes. Further research is needed to identify effective intervention strategies that increase students' motivation towards PA.

Abbreviations: PA, physical activity; MVPA, moderate-to-vigorous physical activity; PE, physical education; SDT, Self-Determination Theory; AGT, Achievement Goal Theory; TARGET, task authority Recognition Grouping Evaluation Time; TGfU, Teaching Games for Understanding; IG, intervention group; CG, Control group; RCT, randomized controlled trial; CT, controlled trial; BCT, behaviour change technique; SDI, self-determination index; RAI, relative autonomy index.

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1. Introduction

Regular exercise and physical activity (PA) have been shown to benefit physical, mental, and social health as well as academic performance (Singh et al., 2012; Penedo and Dahn, 2005; Eime et al., 2013; Janssen and Leblanc, 2010). The World Health Organization has recommended 60 min of daily moderate-to-vigorous physical activity (MVPA) for children and adolescents aged five to 17 years (World Health Organization, 2010). However, in most European countries less than 50% of children and adolescents follow these guidelines according to self-reported PA data (Van Hecke et al., 2016). PA data collected in 13 to 15-year-old adolescents from 105 countries worldwide, revealed that 80.3% did not meet the recommended activity guidelines (Hallal et al., 2012).

The school setting is ideal for implementing PA interventions because entire groups of children and adolescents regardless of their socio-economic or migration status can be addressed (Demetriou et al., 2014) either in physical education (PE), regular academic lessons (Demetriou and Honer, 2012), recess (Ickes et al., 2013) or after school (Pate and O'Neill, 2009). Interventions promoting PA during PE, for example, have shown to increase the time spent being physically active as well as the overall participation in PE (van Sluijs et al., 2007). In addition to improved PA and motor performance, PA interventions implemented in the school setting were also found to benefit health outcomes and exercise knowledge in children and adolescents (Demetriou and Honer, 2012; van Sluijs et al., 2007; Demetriou et al., 2015). Examining the mediating factors of school-based PA behavior in youth, van Stralen et al., 2011 found evidence for a mediated effect of self-efficacy, intention, self-regulation, enjoyment, intrinsic motivation, and autonomy support on PA (van Stralen et al., 2011). Mediating variables explain the causal sequence between the intervention and the outcome, therefore the identification of relevant mediators can increase the effectiveness of future interventions (van Stralen et al., 2011). Intervention developers are advised to disclose the theoretical base of their intervention including the mediating variables and intervention strategies. It is then possible to draw conclusions as to which strategies are effective in changing mediators of a certain health behavior (van Stralen et al., 2011).

There are several theories that try to explain how a specific health behavior, such as PA, can be initiated and increased based upon a persons' motivation. The Self-Determination Theory (SDT) has been found suitable for developing health intervention programs and understanding the motivation of children and adolescents towards PA (Ng et al., 2012; Owen et al., 2014; Deci and Ryan, 2000). Within this theory, different types of motivation are characterized along the autonomy-control continuum, depending on the degree to which autonomous or controlled regulations are present (Deci and Ryan, 2000; Ryan and Deci, 2017). Amotivation is non-regulated and describes a state of passiveness with a lack of intentionality and motivation to act. Within extrinsic motivation, four types of regulation are described in which the degree of autonomous regulation increases from external regulation, introjected regulation, identified regulation to integrated regulation. Intrinsic motivation characterizes self-determined, autonomous behavior (Deci and Ryan, 2000; Ryan and Deci, 2017).

In order to develop more autonomous forms of motivation and engage in the desired behavior, SDT assumes that three basic psychological needs must be satisfied: autonomy, competence and relatedness (Deci and Ryan, 2000; Ryan et al., 2008). Autonomy describes the need to feel that the behavior is self-regulated and in accordance with the individual's values. Competence refers to a feeling of mastery and performing effectively. Relatedness refers to the need of feeling socially connected (Ryan and Deci, 2017). Autonomy and competence are crucial for the processes of internalization and integration of health beneficial behaviors such as PA (Deci and Ryan, 2000; Ryan et al., 2008). Relatedness further supports the process of internalization because individuals may be more responsive to behaviors that are promoted by persons which the individual feels connected to (Ryan et al., 2008). The satisfaction of these psychological needs has been associated with better health-related outcomes, such as increased PA (Ryan et al., 2008).

The Hierarchical Model of Intrinsic and Extrinsic Motivation by Vallerand (1997) considers intrinsic, extrinsic motivation and amotivation on a situational, contextual and global level. Motivation not only varies in its type but also in its level of generality. Specifically, situational motivation can be described as motivation during a specific task in PE, whereas contextual motivation can be described as motivation towards PE in general. Global motivation describes the general motivation personality. The different types of motivation exist within the individual at the three different levels of generality (Vallerand, 1997). Almolda Tomas et al., 2014 assume that interventions successful in changing situational motivation could affect contextual motivation, *i.e.* PE in general and finally global motivation, leading to a healthy lifestyle.

A theory focusing on motivation within the classroom context is the Achievement Goal Theory (AGT), which links the classroom learning environment to classroom goals and student motivation (Ames and Archer, 1988). The goal orientations are grouped into performance and mastery goal orientation. Performance goal orientation is characterized by being successful without much effort, outperforming others, and being judged based upon ability. Mastery goal orientation is characterized by developing new skills, valuing the process of learning and attainment of mastery (Ames and Archer, 1988). These opposing goal orientations are evoked by different situational demands in the classroom and result in different motivational patterns (Ames and Archer, 1988). Goudas and Biddle (1994) examined the perception of achievement environment in PE, also referred to as motivational climate, and found that class learning orientation, perception of teacher support and perception of choice formed a mastery climate, which was the main predictor of intrinsic motivation in PE. A performance climate, characterized by class competition and worries about mistakes, was not a predictor of intrinsic motivation (Goudas and Biddle, 1994).

Based upon the introduced theories, several motivational teaching strategies have been developed to increase students' motivation towards PA within PE. These include amongst others: the Task, Authority, Recognition, Grouping, Evaluation, Time (TARGET) approach (Ames, 1992; Epstein et al., 1989), the Sport Education Model (Siedentop, 1994), and the Teaching Games for Understanding (TGfU) approach (Bunker and Thorpe, 1982).

Several studies have examined the effects of school-based PA interventions on selected motivational outcomes. For example, Dudley et al. (2011) evaluated the effects of PA interventions on enjoyment, which is linked to intrinsically motivated behavior (Ryan and Deci, 2017), and found inconclusive results due to poor methodological quality of the reviewed studies and their statistical power (Dudley et al., 2011). A meta-analysis by Burns et al. (2017) indicated significant effects of school-based intervention strategies on PA enjoyment with a true population effect of small-to-moderate magnitude. The examined studies focused on a student-centered approach, in which students were involved in decision-making and were offered choices regarding their activities. However, their results were limited due to the methodological heterogeneity of the evaluated studies (Burns et al., 2017). Braithwaite et al. (2011) showed that motivational climate interventions in PE had small overall treatment effects ($g = 0.103$) in groups exposed to mastery motivational climates. The largest treatment effects were found for behavioral outcomes (e.g. exercise frequency) ($g = 0.39$–0.49), followed by affective (e.g. enjoyment) ($g = -0.27$ to 0.59) and cognitive outcomes (e.g. competence, perception of motivational climate) ($g = -0.25$ to 0.32) (Braithwaite et al., 2011).

In summary, the literature suggests that theory-based PA interventions (van Stralen et al., 2011; Ng et al., 2012; Owen et al., 2014) implementing motivational strategies may have positive effects on PA behavior (Demetriou and Honer, 2012; Dudley et al., 2011; Burns et al.,

2017; Braithwaite et al., 2011). However, an evaluation of school-based PA intervention effects on different types of motivation, which are assumed to effect the quality and dynamics of behavior (Ryan and Deci, 2017; Quested et al., 2017), has not yet been performed. Therefore, the primary aim of this systematic review was to analyze the effects of school-based PA interventions on a variety of motivational outcomes towards PA in school-aged children and adolescents. Secondarily, the effects on students' PA behavior were examined.

2. Methods

2.1. Inclusion criteria

In this systematic review, any randomized (parallel group or cluster randomized) and quasi-experimental (controlled) trial examining the effects of a school-based PA intervention on students' motivation towards PA was included. The PA components were offered either in addition to regular PE, e.g. during morning, lunch or afternoon breaks, or as modified PE classes during the regular school day. Intervention components provided primarily after school or outside the school setting, e.g. community-based programs, were excluded. The studies had to aim their interventions at healthy school-aged children and adolescents between the ages of six to 19 years. Studies targeting populations with known health issues, e.g. students with overweight/obesity or mental disorders, were not considered. To determine intervention effects, the intervention group (IG) was compared to a control group (CG), which received the standard, traditional school curriculum or PE program. The outcomes of interest were measured before (at baseline) and after the intervention (post-test, follow-up). Studies not published in English language or in scientific journals, and grey literature were excluded from this review.

2.2. Outcome measures

Primarily, the eligible studies were required to provide a quantitative assessment of at least one aspect of students' motivation (e.g. intrinsic, extrinsic motivation, amotivation), basic psychological needs (autonomy, competence, relatedness), students' goal orientation, motivational climate in PE (task or performance climate), or enjoyment measured using questionnaires.

Secondary outcomes regarding PA behavior included the reporting of physical activity levels, step counts, exercise frequency and exercise duration in three domains: in-class, during the school day and in leisure time. Measurement tools were questionnaires, accelerometers, pedometers and direct observation.

2.3. Literature search

The literature search was carried out on October 18th, 2018 in the following six databases: Scopus (ELSEVIER), MEDLINE (Ovid), Eric (EBSCO), PsycInfo (EBSCO), Psyndex (EBSCO), SportDiscus (EBSCO). A comprehensive search strategy with a combination of keywords in the categories population, setting, sport, intervention method, and intervention objective was developed (Demetriou et al., 2019). An example of the search strategy for MEDLINE (Ovid) can be found in additional file 1. Contrary to the search strategy described in previously published systematic review protocol (Demetriou et al., 2019), we did not perform a search in the database Physical Education Index (ProQuest). This systematic review was registered in the PROSPERO international prospective register of systematic reviews (registration number: CRD42018110306).

2.4. Study selection

The database searches found 4453 publications, excluding duplicates. A minimum of two reviewers (YD, AK, and/or DR) independently screened and identified relevant articles. First, titles and abstracts were scanned based on the inclusion criteria. Then, full texts were examined in detail and screened for eligibility (Fig. 1). The reference lists of included articles were hand-searched to identify further relevant publications missed in the database searches. Any disagreements were resolved through discussion to meet a consensus among the reviewers. Ultimately, 57 studies were included for data extraction and risk of bias assessment. Records were managed with EndNote x8 (Clarivate Analytics, Philadelphia, PA, United States).

2.5. Data extraction

Two review authors (AK, DR) independently extracted the study details using a piloted data extraction form without being blinded to journals and authors. Extracted study details were: publication information, study design (as described in primary study), study population (*i.e.* participants' characteristics), intervention details for IG and CG (including study duration and frequency, theoretical background, teaching approach), measurement instruments, and results on primary and secondary outcomes. Additionally, the intervention strategies implemented at the student level (IG) were coded using the behavior change technique (BCT) taxonomy (BCT Taxonomy v1) described by Michie et al., 2013). A minimum of two reviewers (AK and MA, LS, CCB or DM) independently performed the coding of BCTs after an initial piloting. Reliability statistics were not calculated, inconsistencies were resolved by discussion. If information was missing or clarification of data was required, the authors of the primary studies were contacted via e-mail with a maximum of two contact attempts.

2.6. Quality assessment

Although this review was not limited to randomized controlled trials (RCT), the Cochrane Collaboration's tool for assessing risk of bias in randomized trials (Higgins and Green, 2011; Higgins et al., 2011) was used to assess methodological quality within studies. The review authors AK and DR performed the assessment of methodological quality independently. In cases of disagreements, a third review author (YD) was consulted, and uncertainties were discussed until a consensus was reached.

A critical assessment of selection bias (random sequence generation and allocation sequence concealment), performance bias (blinding of participants and personnel), detection bias (blinding of outcome assessment), attrition bias (incomplete outcome data), reporting bias (selective outcome reporting), and other potential sources of bias (baseline group differences, similar timing of measurements for all groups) was performed. Each entry was rated with either low, high or unclear risk of bias, the latter indicating a lack of information or uncertainty about potential bias. Studies claiming to perform a random group allocation to the IG and CG within the same school were rated with a high risk of bias. Studies describing a quasi-experimental study design, *i.e.* controlled trial (CT), were also rated with a high risk of bias regarding random sequence generation and allocation concealment; unless strict allocation concealment was described. In evaluating performance bias, a high risk of bias was determined when teachers conducted the intervention and/or students were aware of their group allocation. Studies with a follow-up of up to six months that reported less than 20% of attrition were rated with a low risk of bias for incomplete outcome data. For studies with a longer follow-up, the attrition rate should not have exceeded 30% to ensure a low risk of bias. Detection bias was rated high since questionnaires, *i.e.* self-report measures, were used to measure motivational outcomes and it was assumed that treatment groups were aware of a possible intervention. If the study did not report a comparison of baseline differences between groups, or if the reported differences in outcome variables were significant, a high risk of bias was presumed.

The certainty of evidence across studies was assessed on outcome

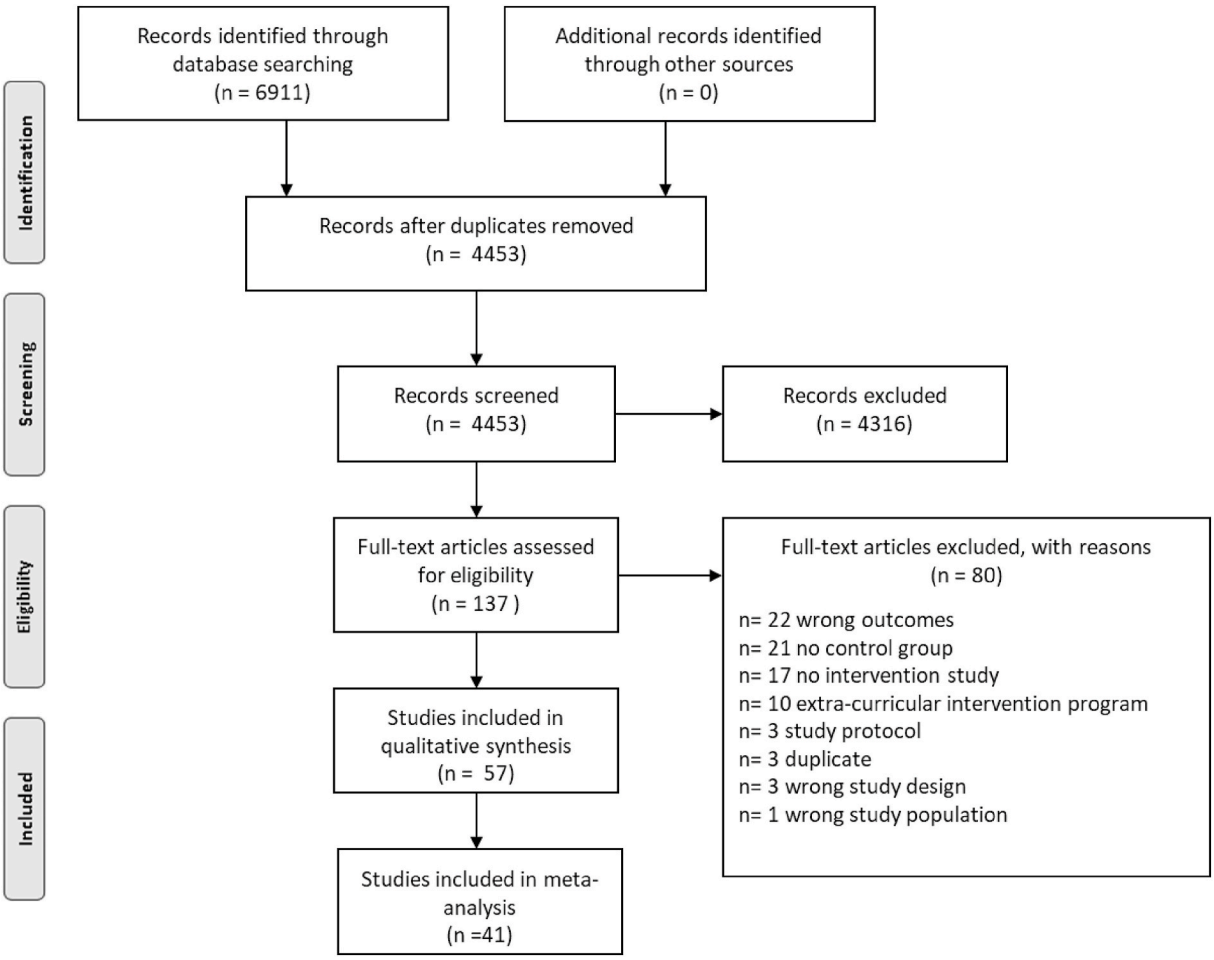

Fig. 1. Flowchart of the identification of included studies.

level using the GRADE approach (Guyatt et al., 2008; Schünemann et al., 2013). The certainty of evidence was graded per outcome based on the evaluation of following domains: study limitations (risk of bias), imprecision, heterogeneity, indirectness, and suspicion of publication bias. The GRADEpro GDT: GRADEpro Guideline Development Tool (McMaster University,2020, developed by Evidence Prime, Inc.) available from gradepro.org was used to create the evidence table.

2.7. Data synthesis-primary outcomes

Meta-analytic procedures of primary outcomes were performed using Comprehensive Meta-analysis Software (version 3) (Biostat Inc. Englewood, New Jersey, USA) and included a calculation of pooled effect estimates, test of heterogeneity and analysis of publication bias.

Given that the outcomes of interest were continuous variables, the effect size Hedges' *g* was used to represent the standard mean difference between the means of the IG and CG at post-test. Follow-up measurements were not considered. Hedges' *g* has the advantage to be more accurate for small numbers of participants (Hedges and Olkin, 1985). Similar to Cohens' *d*, effect sizes of 0.8 were assumed to be large, effect sizes of 0.5 to be moderate, and effect sizes of 0.2 to be small (Cohen, 1988). Positive effect estimates indicated that IGs had increased, larger scores than CGs; negative effects indicated that IGs had reduced, smaller scores than CGs. For outcomes such as amotivation, ego goal orientation and ego/performance climate, negative effect estimates indicate better results of the IG compared to the CG. The main data entry format used for effect size calculation was mean, standard deviation and sample size for each group. If studies provided insufficient data to calculate Hedges' *g*, they were excluded from the analyses. A random effects model was chosen to do justice to heterogeneity across the studies (Hedges and Olkin, 1985; Hedges and Vevea, 1998). In cases of two subgroups for one outcome within the IG and CG, all data were extracted and combined to form one pooled effect size based on the Cochrane formulae for combining groups (Higgins and Green, 2011). When more than one IG was compared to a single CG within one study, they were considered as separate comparisons. Therefore, each comparison group was handled as a single study within the calculation process. To avoid double counting of controls in these cases, the sample size of the CG was divided by the number of the intervention groups (mean and standard deviation remained the same). A second IG participating in performance climate conditions was excluded from meta-analyses.

Heterogeneity was analyzed by calculating the *Q*-statistic and the I^2-statistic. I^2 is an indicator of heterogeneity on percentages. A value of 0% indicates no observed heterogeneity, and larger values show increasing heterogeneity, with 25% as low, 50% as moderate, and 75% as high heterogeneity (Higgins et al., 2003).

Publication bias was tested by a) visual inspection of the funnel plot on primary outcome measures (an asymmetric, as opposed to a symmetric inverted funnel shape, indicated potential publication bias); b) performing Egger's test of the intercept to quantify the bias captured by the funnel plot and tested whether it was significant ($p \leq 0.05$).

The main analyses included effect size calculations for enjoyment, basic psychological needs, motivation,motivational climate, and goal orientation. The effect sizes were calculated for studies overall (combining CTs and RCTs) and for CTs and RCTs separately. In addition, subgroup-moderator analyses were conducted according to the mixed

effect model. In this model, studies within subgroups are pooled with the random effects model, while tests for significant differences between subgroups are conducted with the fixed effects model. Two analyses concerning outliers were calculated by excluding a) studies with the highest and lowest effect size and b) studies with values of Hedges' *g* not located within the 95% confidence interval of the random-effects model. Three further subgroup analyses were conducted: theory-based (yes/no), age of participants (children/adolescents) and study design (RCT/CT). To do justice to the different study designs, the subgroup analyses were repeated for CTs only. Due to large differences in the numbers of comparisons in the meta-analyses, not all subgroup-moderator analyses were calculated for each variable.

2.8. Data synthesis-secondary outcomes

The results on PA outcomes were summarized narratively due to variances in the data collection tools (device-based and self-report measures), measurement time, and reported PA outcomes. The narrative summary was based on the reported effect estimates of included studies; p values ≤ 0.05 were considered significant.

3. Results

3.1. General study characteristics

The included studies in this systematic review were carried out between the years 2001 and 2018 (Barzouka, Sotiropoulos, & Kioumourtzoglou, 2015; Blatsis et al., 2016; Braga, De Lima, Moyses, Moyses, & Werneck, 2017; Brankovic & Hadzikadunic, 2017; Bush, Laberge, & Laforest, 2010; Chang, Chen, & Tu, 2016; Chatzisarantis & Hagger, 2009; Chiva-Bartoll, Salvador-García, & Ruiz-Montero, 2018; Christodoulidis, Papaioannou, & Digelidis, 2001; Cuevas, García- López, & Serra- Olivares, 2016; Di Cagno, Crova, & Pesce, 2006; Digelidis, Papaioannou, Laparidis, & Christodoulidis, 2003; Dudley, Okely, Pearson, & Peat, 2010; Elbe et al., 2017; S. Fairclough & Stratton, 2005; S.J. Fairclough et al., 2016; Franco & Coterón, 2017; Fu et al., 2013; Fu, Gao, Hannon, Burns, & Brusseau, 2016; González-Cutre, Sierra, Beltrán-Carrillo, Peláez-Pérez, & Cervelló, 2018; Gorely, Nevill, Morris, Stensel, & Nevill, 2009; Harrington et al., 2018; Hobin, Subramaniam, & Wuest, 2018; Hortigüela Alcalá & Garijo, 2017; Jamner, Spruijt-Metz, Bassin, & Cooper, 2004; Jones, Marshall, & Peters, 2010; Kokkonen, Yli-Piipari, Kokkonen, & Quay, 2018; Lonsdale et al., 2013, 2019; Méndez-Giménez, Fernández-Río, & Méndez-Alonso, 2015; Meng & Keng, 2016; Meng, Whipp, Dimmock, & Jackson, 2013; Miller et al., 2016; Moreno, Gonzalez-Cutre, Martin-Albo, & Cervello, 2010; Moreno-Murcia & Sànchez-Latorre, 2016; Nation-Grainger, 2017; Palmer, Bycura, & Warren, 2018; Pardo, Bengoechea, Clemente, & Lanaspa, 2016; Patmanoglou, Mantis, & Digelidis, 2008; D. Perlman, 2010; D.J. Perlman, 2011, 2015; Prusak, Treasure, Darst, & Pangrazi, 2004; Salmon, Hume, & Crawford, 2008; Sevil, Abos, Aibar, Julián, & Garcia-Gonzalez, 2016; Shannon et al., 2018; J.J. Smith et al., 2018; L. Smith et al., 2015; Spittle & Byrne, 2009; J. Todorovich R. & Curtner-Smith, 2002; J.R. Todorovich & Curtner-Smith, 2003; T. Wallhead L., Garn, & Vidoni, 2014; T.L. Wallhead & Ntoumanis, 2004; Wang, Baranowski, Lau, Buday, & Gao, 2017; Weigand & Burton, 2002; Yli-Piipari, Layne, Hinson, & Irwin, 2018; Zach, Raviv, & Meckel, 2016). Most studies were performed in the USA (n = 13), followed by Spain (n = 10), the UK (n = 8), Australia (n = 8), and Greece (n = 5). Regarding the study design, ten studies were identified as RCTs, 47 studies were CTs. Six studies included only female students, two studies only male students, and one further study did not describe the gender of included participants. The youngest participants were between six and seven years old (Di Cagno et al., 2006); the oldest students were aged 16.57 years (Dudley et al., 2010). We grouped the studies according to the students' age: participants with a mean age (±SD) < 12.5 years were categorized as children and participants with a mean age (±SD) > than 12.5 years were categorized as adolescents. In total, 20 studies aimed their intervention at children, 37 studies targeted adolescents.

Regarding the study duration, most studies were of short duration (≤three months (n = 43)), 11 studies of moderate duration (4–12 months) and three studies were longer than 12 months (Harrington et al., 2018; Pardo et al., 2016; Wallhead, Garn, & Vidoni, 2014). Of the short-term studies, two examined motivational outcomes before the end of the intervention period, and the data from these intermediate measurements were used as post-values to examine possible intervention effects. This shortened the actual intervention period between baseline and final measurement to three and four weeks, respectively (Fairclough et al., 2016; Yli-Piipari et al., 2018). The sample sizes ranged from 10 students (Nation-Grainger, 2017) to 1752 (Harrington et al., 2018).

In total, 47 studies implemented modified PE classes and ten studies (Bush et al., 2010; Elbe et al., 2017; Fairclough et al., 2016; Gorely et al., 2009; Harrington et al., 2018; Pardo et al., 2016; Salmon et al., 2008; Shannon et al., 2018; Smith et al., 2018; Wang et al., 2017) offered additional PA programs throughout the school day. One of the studies providing modified PE classes additionally offered extracurricular PA components (González-Cutre et al., 2018). Diverse personnel including classroom and PE teachers, research staff, external health professionals and peers delivered the intervention components.

Eleven studies did not refer to an underlying theoretical framework. The two most commonly mentioned theories were SDT (Deci and Ryan, 2000) (n = 30) and AGT (Ames and Archer, 1988; Ames, 1992) (n = 11). Additionally, studies modified their teaching approaches to increase students' motivation towards PA. Most studies implemented self-designed teaching strategies, while others applied recognized approaches such as TARGET (Epstein et al., 1989) (n = 5), Sport Education Model (Siedentop, 1994) (n = 7), or TGfU (Bunker and Thorpe, 1982) (n = 6).

In all studies, the IG was compared to a CG. The majority of studies reported that the CG participated in a regular, traditional PE condition or in a PE program without intervention components (n = 49). Eighteen studies provided some information on the contents of the control condition and largely described a traditional teacher-centered and teacher-directed approach focusing on skill development (Barzouka et al., 2015; Blatsis et al., 2016; Chang et al., 2016; Cuevas et al., 2016; Di Cagno et al., 2006; Fu et al., 2013; Hortigüela Alcalá and Garijo, 2017; Kokkonen, Yli-Piipari, Kokkonen, & Quay, 2018; Méndez-Giménez et al., 2015; Meng et al., 2013; Perlman, 2010, 2011; Smith et al., 2015; Spittle and Byrne, 2009; Wallhead, Garn, & Vidoni, 2014; Wallhead and Ntoumanis, 2004).

The included studies are described in detail in Table 1 and Table 2, separately for children and adolescents.

3.2. Behavior change techniques

It was possible to link at least one BCT to the described intervention components in all but four studies (Braga et al., 2017; Fu et al., 2016; Jones et al., 2010; Yli-Piipari et al., 2018). These four studies did not provide a detailed description of intervention components. The BCTs and corresponding clusters that were used in each study are shown in Tables 1 and 2. In total, 36 techniques were identified and allocated to twelve of the 16 main BCT clusters. The frequency of applied techniques within the main clusters varied across studies: 'Comparison of behavior' (n = 39); 'Shaping knowledge' (n = 38); 'Repetition and substitution' (n = 37); 'Feedback and monitoring' (n = 28); 'Goals and planning' (n = 20); 'Social support' (n = 12); 'Reward and threat' (n = 10); 'Natural consequences' (n = 6); 'Associations' (n = 3); 'Identity' (n = 3); 'Self--belief' (n = 1).

Studies grounded on the SDT most commonly applied BCTs within the clusters 'Comparison of behavior' (n = 20); 'Shaping knowledge' (n = 19); 'Antecedents' (n = 19); 'Repetition and substitution' (n = 18); 'Feedback and monitoring' (n = 16).

Studies based on the AGT most frequently applied techniques within

Table 1
Description of reviewed studies targeting children with examined outcomes at a minimum of two time points (pre to post).

Author; CountryDesign	Participants	Theoretical background/ Pedagogical approach	Intervention description	Behavior change techniques	Behavior change technique cluster	Motivational outcomes	Physical activity outcomes
Blatsis et al. (2016); GreeceCT	N=215 (99 boys) 5th and 6th grade students, age:11.61 (0.49) years. IG: n=106 (44 boys); CG: n=109 (55 boys).	SDT/Teaching Games for Understanding (TGfU)	IG: over 12 weeks, students participated in the International Association of Athletics Federation (IAAF) Kids' Athletics program promoting Track and Field in schools and sport clubs. 24 x 45-minute sessions were offered twice per week. Instructions were based on a games-centered-approach. CG: students participated in track and field lessons following a traditional skill teaching approach.	4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior 6.2. Social comparison 8.1. Behavioral practice/ rehearsal12.2. Restructuring the social environment	4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution12. Antecedents	intrinsic motivation**identified regulation**introjected regulationexternal regulation amotivation SDI** enjoyment/interest	x
Braga et al. (2017); BrazilCT	N=117 (57 boys) 3rd and 5th grade students. IG: n=60 (26 boys), age: 10 (0.9) years; CG: n=57 (31 boys), age= 10 (2.3) years.	Flow: Psychology of optimal experience	IG: over 12 weeks, students participated in weekly PE classes using Exergames (visual gaming). CG: students participated in traditional PE classes.	No information	No information	motivation at beginning and end of each PE class	in-class MPA (observation) (%)**
Di Cagno et al. (2006); ItalyCT	N=178 (94 boys) six to seven year old primary school students. IG: n= 90, CG: n=88.	child-centered teaching involving indirect creative methods and/or reciprocal and guided discovery styles	IG: over three months, students participated in PE lessons twice a week (2.5 hours each) following a student-centered teaching style based on creative discovery and variability of coordination demands coupled with a problem-solving approach to motor learning. CG: students participated in regular PE classes with a teacher-focused style of teaching motor skills via demonstration and command.	1.2. Problem solving4.1. Instruction on how to perform the behavior 6.1. Demonstration of the behavior8.1. Behavioral practice/rehearsal12.5. Adding objects to the environment	1. Goals and planning4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution12. Antecedents	enjoyment rhythmic gymnastics** enjoyment track and field task**	x
Digelidis et al. (2003); GreeceCT	N=783 7th grade students. IG: n=262 (130 boys), age: 11.88 (0.6); CG: n=521 (245 boys), age: 12.14 (0.77).	Goal Perspectives Theory/ TARGET	IG: over one year, students took part in PE lessons 3 times a week for 45 minutes based on the TARGET model, cognitive strategies (e.g. mental rehearsal), and a personal goal-setting program. Teachers participated in	1.3. Goal setting (outcome) 2.2. Feedback on behavior 4.1. Instruction on how to perform the behavior 5.1. Information about health consequences5.6. Information about emotional consequences6.1. Demonstration of the	1. Goals and planning2. Feedback and monitoring4. Shaping knowledge5. Natural consequences 6. Comparison of behavior8. Repetition and substitution12.	task-involving climate*ego-involving climate**task orientation ego orientation* athletic ability/competenceenjoyment	self-reported exercise frequency

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Table 1 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical approach	Intervention description	Behavior change techniques	Behavior change technique cluster	Motivational outcomes	Physical activity outcomes
			seminars and meetings in order to successfully implement the task involving teaching climate. CG: students participated in PE.	behavior8.1. Behavioral practice/rehearsal12.2. Restructuring the social environment15.2. Mental rehearsal of successful performance15.4. Self-talk	Antecedents15. Self-belief		
Elbe et al. (2017); DenmarkRCT	N=300 3rd grade students (47.3% boys), age: 9.30 (0.35). IG_1: n=111 (51 boys), IG_2: n=104 (49 boys), CG: n=85 (42 boys).	no information	IG_1: over 10 months, students participated in a team sport intervention of small-sided football and other ball games. In half of the schools team sports were conducted in 3 sessions per week, 40 minutes each. The other half of schools received 5 sessions per week, 12 minutes each. IG_2: students participated in an individual sport intervention (circuit strength training, interval running). Strength training sessions were held 3 times a week for 40 minutes. Interval running took place 5 times a week, 12 minutes per session. Training sessions were held by instructors (university staff) in addition to regular PE (90 minutes per week). CG: students continued with regular PE.	4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior8.1. Behavioral practice/rehearsal12.2. Restructuring the social environment	4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution12. Antecedents	enjoymentsocial cohesion (relatedness)	x
Fairclough & Stratton (2005); EnglandCT	N=26 7th grade female students, age: 11-12 years. IG: n=12; CG: n=14.	no information	IG: students participated in 6 lesson units of gymnastics once a week, 120 minutes each. The teacher was instructed to enhance PA following the unit of work and planning lessons according to the objectives: organization of groups and use of space, equipment and resources; teaching approaches; lesson pace; teacher positioning; active learning; having fun. CG: students	2.2. Feedback on behavior4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior8.1. Behavioral practice/ rehearsal12.2. Restructuring the social environment	2. Feedback and monitoring4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution12. Antecedents	intrinsic motivation competence	in-class MVPA (%) (observation)*

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Table 1 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical approach	Intervention description	Behavior change techniques	Behavior change technique cluster	Motivational outcomes	Physical activity outcomes
			participated in regular PE classes.				
Fairclough et al. (2016); EnglandCT	N=139 year six students: IG: n=73, age: 10.7; CG: n=66, age: 10.7 years.	Youth Physical Activity Promotion Model	IG: over 6 weeks, students received a PA intervention called "Born to Move (BTM) twice a week for 30 minutes. BTM is an age-adapted portfolio of class-based PA and fitness programs set to music with an emphasis on enjoyable and inclusive activity. BTM lessons were offered in addition to regular PE and led by a trained BTM instructor.CG: students received regular PE classes twice a week for 30-45 minutes.	4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior8.1. Behavioral practice/ rehearsal10.2. Material reward (behavior) 12.1. Restructuring the physical environment	4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution10. Reward and threat12. Antecedents	At mid-term (3 weeks)enjoyment*competence	At mid-term (3 weeks)in-class PA levels (accelerometer): LPA % lesson time/ min per lesson** MPA % lesson time**/ min per lesson**VPA % lesson time/ min per lessonMVPA % lesson time/ min per lesson**total PA % lesson time/ min per lesson**sedentary % lesson time/ min per lessonLPA whole day**/ school day**/ after schoolMPA whole day*/ school day**/ after schoolVPA whole day/ school day**/ after schoolMVPA whole day*/ school day**/ after schoolsedentary whole day/ school day**/ after school steps/day (pedometer) **MVPA min/day (accelerometer)**
Gorely et al. (2009); EnglandCT	N=589 primary school students. IG: n=310 (150 boys), age: 8.8 years;CG: n=279 (137 boys), age: 8.9 years	Social Cognitive Theory	IG: over 10 months, students participated in the "GreatFun2Run" program containing PE lessons, PA events and classroom activities. PE lessons were held twice a week. The program was multifaceted and comprised a CD-ROM learning and teaching resource for teachers; an interactive website for students, teachers, and parents; two highlight PA events (1 mile school runs/walks); a local media campaign; and a summer activity wall planner and record. CG: students continued with usual PE and health curriculum, two hours per week.	1.1. Goal setting (behavior) 2.3. Self-monitoring of behavior3.2. Social support (practical) 5.1. Information about health consequences8.1. Behavioral practice/ rehearsal8.2. Behavior substitution8.3. Habit formation8.4. Habit reversal	1. Goals and planning 2. Feedback and monitoring3. Social support5. Natural consequences8. Repetition and substitution	competenceenjoyment of PA intrinsic motivationextrinsic motivation*	

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Table 1 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical approach	Intervention description	Behavior change techniques	Behavior change technique cluster	Motivational outcomes	Physical activity outcomes
Kokkonen et al. (2018);FinlandCT	N=382 4th to 6th grade students. IG: n=196 (103 boys), age: 10.84 (0.95) years; CG: n=186 (109 boys), age: 10.9 (0.9) years.	SDT, AGT/Creative physical education	IG: over 1 year, students participated in Creative Physical Education classes. 4th and 5th grade students participated in 88 x 45 minutes PE classes, and 6th grade students in 40 x 45 minute PE classes. Teachers were trained to implement intervention. CG: students participated in traditional sport-technique based PE classes.	2.2. Feedback on behavior 3.1. Social support (unspecified)4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior8.1. Behavioral practice/ rehearsal12.2. Restructuring the social environment	2. Feedback and monitoring3. Social support4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution12. Antecedents	task-supportive climate**ego-supportive climate**	self-reported PA participation
Miller et al. (2016); Australia RCT	N=107 Stage 2 and Stage 3 students, age: 10.7 (0.87) years. IG: n=52 (27% boys), age: 10.55 (1.0) years; CG: n=55 (32% boys), age: 10.78 (0.7) years.	Competence motivation theory student-centered games-based approach (GCA)	IG: over 6 weeks, students participated in the PLUNGE program (Professional Learning for Understanding Games Education), 60 minutes per week. Teachers were trained to use the game-centered approach. CG: teachers taught lessons from the Games and Sports strand of the syllabus (Board of Studies NSW, 2007) to match the strand of the intervention curriculum. No specific pedagogical approach was used.	3.3. Social support (emotional) 4.1. Instruction on how to perform the behavior 6.1. Demonstration of the behavior 8.1. Behavioral practice/ rehearsal 12.2. Restructuring the social environment	3. Social support 4. Shaping knowledge 6. Comparison of behavior 8. Repetition and substitution 12. Antecedents	enjoyment	in-class MVPA (%) (observation)**
Moreno-Murcia &Sànchez-Latorre (2016);SpainCT	N=145 5th and 6th grade students (71 boys), age: 10.73 (0.62) years. IG: n=91 (51 boys); CG: n=54 (20 boys).	SDT	IG: over 4 months, students received 21 autonomy-supportive PE classes twice a week. The teacher conducting the lessons participated in an individual workshop on autonomy support. CG: pursued same academic competences and didactic program corresponding to fifth and sixth grade of primary schools; students participated in regular PE.	5.6. Information about emotional consequences12.2. Restructuring the social environment	5. Natural consequences12. Antecedents	teacher autonomy support**autonomy**competencerelatednessintrinsic motivation**	self-reported regular PA*
Palmer et al. (2018); USACT	N=300 7th grade students (149 boys), IG_1: n=79 (50.6% boys), CG_1: n=181 (49.2% boys), CG_2: n= 40 (55% boys).	SDT	IG_1: over 4 weeks, students participated in a modified mountain biking unit targeting perceptions of environmental safety, perceptions of access to	1.2. Problem solving 1.3. Goal setting (outcome)1.4. Action planning2.4. Self-monitoring of outcome(s) of behavior 4.1. Instruction on how to perform the	1. Goals and planning2. Feedback and monitoring4. Shaping knowledge6. Comparison of	RAIsport competence	self-reported weekly PA activity

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Table 1 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical approach	Intervention description	Behavior change techniques	Behavior change technique cluster	Motivational outcomes	Physical activity outcomes
			equipment, efficacy for removing barriers, perceived sport competence, and sport ability beliefs. Teachers co-designed the learning activites.CG_1: students participated in regular PE classes. CG_2: students did not participate in any PE classes.	behavior6.1. Demonstration of the behavior8.1. Behavioral practice/ rehearsal	behavior8. Repetition and substitution		
Pardo et al. (2016); SpainCT	N=553 secondary school students (292 boys). Cohort 1: age= 12.03 (0.16) years. IG: n=104, CG: n=100. Cohort2: age= 12.07 (0.26) years. IG: n= 96, CG: n=80. Cohort3: age= 12.05 (0.21) years, IG: n=10, CG: n=71.	SDT, Social ecological model of health-related behavior	IG: over three school years, students took part in a PA intervention operationalized through curricular and non-curricular channels. Curricular channel: classroom teachers received training in PA promotion, which involved students in designing of PA-related activities and initiatives (e.g., at recess, during or after school hours), specific actions targeting teacher behavior in PE and a student project. Non-curricular channel: information dissemination of activities through which school members, families, and the community were updated on the intervention; participation in institutional programs and special PA events in the community to connect schools with community organizations and programs. CG: schools did not receive intervention.	7.1. Prompts/cues 12.2. Restructuring the social environment	7. Associations12. Antecedents	enjoyment**intrinsic motivation**extrinsic motivation*amotivation* autonomy**competence**relatedness	MVPA (min/day) (accelerometer)**

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Table 1 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical approach	Intervention description	Behavior change techniques	Behavior change technique cluster	Motivational outcomes	Physical activity outcomes
Patmanoglou et al. (2008);GreeceCT	N= 307 5th and 6th grade students (160 boys), age: 11 (0.5) years.	Spectrum of teaching styles	IG_1: over three months, students participated in 10 weekly lessons of tennis in accordance with the command teaching style. IG_2: students attended 10 tennis lessons following the self-check teaching style. CG: students did not receive intervention.	2.3. Self-monitoring of behavior4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior8.1. Behavioral practice/ rehearsal	2. Feedback and monitoring4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution	enjoyment* athletic ability/competence**	x
Salmon et al. (2008); AustraliaRCT	N=295 5th grade students (49% boys), age: 10.8 years. IG_1: n=74; IG_2: n=66; IG_3: n=93; CG: n=62.	Social cognitive theory, Behavioral choice theory	Over 1 school year, PA intervention components were delivered in addition to usual PE and sport classes by one PE teacher. IG_1: students participated in 19 behavioral modification lessons delivered in the classroom, 40-50 minutes each. IG_2: students took part in 19 lessons focusing on fundamental movement skills (indoors or outdoors), 40-50 minutes each. Games and activities developed for this intervention focused on mastery of six fundamental movement skills. IG_3: students participated in combined intervention conditions (behavioral and fundamental movement skill condition), receiving 38 intervention lessons. CG: students received usual school curriculum.	1.8. Behavioral contract 2.3. Self-monitoring of behavior3.2. Social support (practical) 4.1. Instruction on how to perform the behavior5.1. Information about health consequences6.1. Demonstration of the behavior 8.1. Behavioral practice/rehearsal8.2. Behavior substitution	1. Goals and planning2. Feedback and monitoring3. Social support4. Shaping knowledge5. Natural consequences6. Comparison of behavior8. Repetition and substitution	enjoyment*	counts/day** (accelerometer) MPA (min/ day)** VPA (min/day)**
Shannon et al. (2018);Northern IrelandCT	N=155 children (44% boys), age: 8.7 (0.5) years. IG: n=84 (33 boys); CG: n=71 (36 boys).	SDT	IG: over 10 weeks, students participated in the "Healthy Choice Program" in addition to regular PE. Weekly 60-minute sessions were delivered by a sport student volunteer under supervision of the classroom teacher. Additionally, teachers conducted a 15-minute walk with the students	1.1. Goal setting (behavior) 1.4. Action planning2.2. Feedback on behavior3.3. Social support (emotional) 5.1. Information about health consequences	1. Goals and planning2. Feedback and monitoring3. Social support5. Natural consequences	teacher autonomy support* autonomy*competence relatednessintrinsic motivationidentified regulationintrojected regulationexternal regulation	school day MVPA (min/ day) (accelerometer)*

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Table 1 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical approach	Intervention description	Behavior change techniques	Behavior change technique cluster	Motivational outcomes	Physical activity outcomes
			every school day. Sport student volunteers and classroom teachers received a needs-supportive teaching training prior to the intervention. CG: students received intervention after the posttest.				
Smith et al. (2015); EnglandCT	N=72 students (42 boys), age boys: 11.22 (0.4) years, age girls: 11.4 (0.5) years. IG: n=36 (23 boys); CG: n=36 (19 boys)	SDT Tactical Games Model (TGfU)	IG: over 12 weeks, students participated in weekly PE classes following the Tactical Games Model teaching approach. Girls participated in activities such as netball and football. Boys participated in rugby and football. CG: students participated in PE classes taught using a traditional, direct skill instruction approach.	1.2. Problem solving4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior8.1. Behavioral practice/rehearsal	1. Goals and planning4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution	autonomycompetencerelatednessintrinsic motivationenjoyment	girls' in-class MVPA (%) (observation) boys in-class MVPA (%)*girls' in-class MVPA (accelerometer)* boys' in-class MVPA**
Todorovich & Curtner-Smith (2002);USACT	N=72 (45 boys) 6th grade students, age: 11 (3.3) years. IG_1: n=25 (16 boys); IG_2: n=23 (13 boys); CG: n=24 (16 boys).	AGTTARGET	IG_1: over two weeks, students participated in a modified field hockey unit within a high ego-involving motivational climate, Lessons were held daily, 30 minute each. IG_2: participants took part in a unit of modified field hockey unit (10 x 30 minutes for two weeks) within a high task-involving motivational climate. The components of intervention lessons were based on TARGET. CG: a PE assistant taught 10 x 30 minute lessons of softball.	1.1 Goal setting (behavior) 2.3. Self-monitoring of behavior2.7. Feedback on outcome(s) of behavior4.1 Instruction on how to perform the behavior6.1. Demonstration of the behavior6.2. Social comparison8.1. Behavioral practice/rehearsal10.3. Non-specific reward12.2. Restructuring the social environment	1. Goals and planning2. Feedback and monitoring4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution10. Reward and threat12. Antecedents	ego orientation**task orientation**	x
Todorovich &Curtner-Smith (2003);USACT	N=80 (40 boys) 3rd grade students. IG_1: n=28 (15 boys); IG_2: n=26 (13 boys); CG: n=26 (12 boys).	AGTTARGET	IG_1: students participated in a modified field hockey unit (10 lessons) within a high task-involving climate. The components of the lessons were based on TARGET. IG_2: students	1.1. Goal setting (behavior) 2.3. Self-monitoring of behavior2.7. Feedback on outcome(s) of behavior4.1. Instruction on how to perform the behavior6.1. Demonstration of the	1. Goals and planning2. Feedback and monitoring4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution10.	task orientation**ego orientation**	x

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Table 1 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical approach	Intervention description	Behavior change techniques	Behavior change technique cluster	Motivational outcomes	Physical activity outcomes
			participated in a 10-lesson modified field hockey unit within a high ego-involving climate. CG: a PE assistant taught 10 x 30 minutes lessons of softball.	behavior6.2. Social comparison8.1. Behavioral practice/rehearsal10.3. Non-specific reward12.2. Restructuring the social environment	Reward and threat12. Antecedents		
Wang et al. (2017); China CT	N=179 primary school students (103 boys), age: 10.2 years. IG: n=95 (57 boys); CG: n=84 (46 boys).	SDT, Self-efficacy theory	IG: students played the video game Diab, designed based on social cognitive, self-determination, and elaboration-likelihood models regarding PA and diet. Students played Diab either at 2 x 40-minute morning sessions before classes (2 schools) or at one 90-minute afternoon session after school (in other 2 schools). The intervention lasted 8 to 10 weeks, depending on completion of the game (9 episodes, with 3 to 4 mini-games). CG: no intervention, children adopted general diet and PA information and behavior as usual.	1.1. Goal setting (behavior) 1.2. Problem solving 1.4. Action planning 1.5. Review behavior goal(s) 2.2. Feedback on behavior 5.1. Information about health consequences 10.1. Material incentive (behavior)	1. Goals and planning 2. Feedback and monitoring 5. Natural consequences 10. Reward and threat	autonomous motivation controlled motivation	self-reported PA* sedentary time (min) (accelerometer) LPA (min) MVPA (min)

Note: AGT= achievement goal theory; CT= controlled trial; CG= control group; IG= intervention group; LPA: light physical activity; MPA: moderate physical activity; MVPA: moderate-to-vigorous physical activity; N= Total sample size at baseline; n= subgroup sample size; PA= physical activity; PE= physical education; RAI= relative autonomy index; RCT= randomized controlled trial; SDI= self-determination index; SDT= self-determination theory; TARGET= Task, Authority, Recognition, Grouping, Evaluation, Time; VPA= vigorous PA.* indicates significant effects (pre to post) with a p-value< 0.05; ** p-value< 0.01.

Table 2
Description of reviewed studies targeting adolescents with examined outcomes at a minimum of two time points (pre to post).

Author; CountryDesign	Participants	Theoretical background/ Pedagogical model	Intervention description	Behavior change techniques	Behavior change technique clusters	Motivational outcomes	Physical activity outcomes
Barzouka et al. (2015); GreeceCT	N=63 high school students, age: 13.1 (0.89) years. IG_1: n=20; IG_2: n=21; CG: n=22.	Social cognitive theory/ Observational learning	Over 5 weeks, students received a PE intervention twice a week for 45 minutes. IG_1: students observed a videotaped expert model, which was a student/athlete the same age of the participants with experience in volleyball, and received verbal instructions from PE teacher. IG_2: students observed a videotaped expert model plus their own video recording (self-monitoring) and verbal instructions were given. CG: students received traditional feedback with verbal instructions on correct skill execution.	2.2. Feedback on behavior2.4. Self-monitoring of behavior 4.1. Instruction on how to perform the behavior 6.1. Demonstration of the behavior 8.1. Behavioral practice/rehearsal	2. Feedback and monitoring4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution	task goal orientation*ego goal orientation	X
Brankovic & Hadzikadunic (2017); Bosnia & HerzegovinaCT	N=74 8th grade students (40 male), age: 13 to 15 years. IG: n=53; CG: n=21.	Flow: Psychology of optimal experience, SDT	IG: students participated in 10 PE lessons twice a week, designed to ignite perception of self-competence (creative thinking, self-potentials and interests). Lessons were held by the PE teacher. CG: students participated in activities of traditional PE lesson.	2.2. Feedback on behavior3.2. Social support (practical)5.6. Information about emotional consequences12.2. Restructuring the social environment	2. Feedback and monitoring3. Social support5. Natural consequences12. Antecedents	competence	X
Bush et al. (2010); CanadaCT	N=221 7th-8th grade students (40.7% boys). IG: n=131 (62 boys), age boys: 13.9 (0.7) years, age girls: 13.8 (0.9) years; CG: n=90 (28 boys), age boys:12.5 (0.6) years, age girls:12.5 (0.6) years.	participant centered approach	IG: over 16 weeks, students participated in the FunAction PA program 3-5 times a week for 45 minutes. FunAction was delivered during the first 45 minutes of lunch period, held by university students. Participants and teachers were surveyed at beginning and middle of the program in order to make modifications according to their preferences and reduce barriers. CG: no information on control condition.	6.1. Demonstration of behavior7.1. Prompts/ Cues10.1. Material Incentive (behavior)10.2. Material reward (behavior) 12.2. Restructuring the social environment	6. Comparison of behavior7. Associations10. Reward and threat12. Antecedents	enjoyment	self-reported leisure time PA
		SDT					X

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Table 2 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical model	Intervention description	Behavior change techniques	Behavior change technique clusters	Motivational outcomes	Physical activity outcomes
Chang et al. (2016); TaiwanCT	N=126 6th grade students; age=13.7 (0.5) years. IG: n=61 (30 boys); CG: n=65 (35 boys)		IG: over 6 weeks, students took part in autonomy supportive PE classes twice a week for 40 minutes. Participants decided on sequence of content by consensus and chose their partners. CG: students took part in identical PE content and skill instructions, the sequence of content was determined by the teacher and group partners were assigned by the PE teacher for each lesson.	4.1. Instruction on how to perform6.1. Demonstration of the behavior8.1. Behavioral practice/ rehearsal12.2. Restructuring the social environment	4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution12. Antecedents	perceived teaching autonomy**autonomy in PE**intrinsic motivation*amotivationexternal motivationintrojected regulationidentified regulation	
Chatzisarantis &Hagger (2009); EnglandRCT	N=215 students from 10 classes, age: 14.84 (0.40) years. IG: n=5 classes; CG: n=5 classes.	SDT	IG: over 5 weeks, teachers adopted an autonomous inter-personal teaching style during PE. Teachers provided positive feedback, rationale and choice and acknowledged difficulties associated with PE. CG: teachers used a less autonomy supportive instruction style providing rationale and feedback only.	2.2. Feedback on behavior5.1. Information about health consequences5.6. Information about emotional consequences	2. Feedback and monitoring5. Natural consequences	teacher autonomy support**RAI*	X
Chiva-Bartol et al. (2018);SpainCT	N=96 secondary school students (46 boys), age: 15 (0.7) years. IG: n=31 (15 boys), age:15 (0.4) years; CG: n=65 (31 boys), age:15 (0.6) years.	AGT, SDT/ Teaching Games for Understanding (TGfU), Cooperative Learning	IG: over 8 weeks, students participated in a handball teaching unit in accordance with the Cooperative Learning and TGfU approaches (hybrid approach). Lessons were held twice a week for 55-60 minutes. CG: students participated in a teaching unit according to the traditional teaching approach.	1.2. Problem solving2.2. Feedback on behavior; 4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior8.1. Behavioral practice/rehearsal12.2. Restructuring the social environment13.1 Identification of self as role model	1. Goals and planning2. Feedback and monitoring4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution12. Antecedents13. Identity	global motivational climate scoretask-involving climate**ego-involving climate**	X
Christodoulidis et al. (2001);GreeceCT	N=634 10th grade students, age: 16 (0.5) years. IG: n=105 (47 boys); CG: n=529 (189 boys).	AGT	IG: over one academic year, 25 developed lesson plans were implemented. Teachers used different teaching styles: practice teaching style, inclusion style and reciprocal teaching style. Goal oriented activities were used, cooperative	1.3. Goal setting (outcome) 2.4. Self-monitoring of outcome(s) of behavior4.1. Instruction on how to perform the behavior5.1. Information about health consequences 6.1. Demonstration of the behavior 7.1. Prompts/ Cues8.1. Behavioral	1. Goals and planning2. Feedback and monitoring4. Shaping knowledge5. Natural consequences6. Comparison of behavior7. Associations8. Repetition and	teachers' emphasis on task-involvement*teachers' emphasis on ego-involvement**ego goal orientationtask goal orientationenjoyment	self-reported duration/time of sport/exercise participation**self-reported frequency of sport/exercise involvement

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Table 2 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical model	Intervention description	Behavior change techniques	Behavior change technique clusters	Motivational outcomes	Physical activity outcomes
			activities preferred over competitive activities, and an individualized goal-setting program was applied: students documented their performance and set personal improvement goals. Health related information was provided through short lectures on positive effects of PA on health. CG: students participated in regular PE.	practice/rehearsal12.2. Restructuring the social environment	substitution12. Antecedents		
Cuevas et al. (2016); SpainCT	N=86 secondary school students (37 boys), age: 15.65 (0.78) years. IG: n=43; CG: n=43.	SDT/Sport Education Model	IG: over 3 months, students participated in 19 teaching units of volleyball in accordance with the Sport Education Model twice a week for 55 minutes. The model introduces several elements of the individual sport in the units of PE learning (preseason, regular competition, and final championship; regular teams; final party; etc.). Students experienced different roles in team sports and games (referee, coach, player, etc.). CG: students took part in 19 units of volleyball following the traditional teaching model.	4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior6.2. Social comparison8.1. Behavioral practice/rehearsal10.4. Social reward12.2. Restructuring the social environment	4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution10. Reward and threat12. Antecedents	intrinsic motivation*identified regulationintrojected regulationexternal regulationamotivationSDIthwarting of autonomythwarting competencethwarting relatednesssatisfaction-enjoyment	X
Dudley et al. (2010); AustraliaRCT	N=38 year 11 female students. IG: n=17, age: 16.45 (0.22) years; CG: n=21, age: 16.57 (0.28) years.	Social Cognitive Theory	IG: over 11 weeks, students participated in six 90 minute PE sessions, which included enjoyable, challenging, and new activities such as yoga/ pilates/dance sessions, an introductory tennis-coaching course, and aquatic games. Activities were discussed with participants prior and during the intervention. CG: continued with the existing sport program.	3.2 Social support (practical)4.1. Instruction on how to perform the behavior5.6 Information about emotional consequences 6.1. Demonstration of the behavior8.1. Behavioral practice/rehearsal12.1. Restructuring physical environment	3. Social support4. Shaping knowledge5. Natural consequences6. Comparison of behavior8. Repetition and substitution12. Antecedents	enjoymentsporting competencestrength competence	in-class PA counts (accelerometer)

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Table 2 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical model	Intervention description	Behavior change techniques	Behavior change technique clusters	Motivational outcomes	Physical activity outcomes
Franco & Coterón (2017);SpainCT	N=53 secondary school students (30 boys), age: 13.35 (0.62) years. IG: n=30; CG: n=23.	SDT	IG: students participated in 24 PE sessions of rugby in accordance with a need supportive environment. The teacher was trained to appropriately implement the teaching strategies. CG: students participated in regular PE classes (rugby) taught by the school teacher. PE classes were held twice a week.	2.2. Feedback on behavior3.1. Social support (unspecified)	2. Feedback and monitoring3. Social support	autonomy*competencerelatednessintrinsic motivation	X
Fu et al. (2013); USACT	N=61 middle school students (25 boys), age: 12.6 (0.6) years. IG: n=31 (12 boys); CG: n=30 (13 boys)	No information provided	IG: over 6 weeks, students participated in health-related physical fitness basketball units offered weekly for 50 minutes. Lessons were implemented according to the SPARK Program (Sports, Play and Active Recreation for Kids Program). The teacher was trained to use SPARK. Most decisions on choice of tasks, team structure, and rate of progression were determined by the teacher. CG: students participated in traditional PE classes.	4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior8.1. Behavioral practice/rehearsal12.2. Restructuring the social environment	4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution12. Antecedents	enjoyment**competence	in-class PA (pedometer)
Fu et al. (2016); USACT	N=174 middle-school students (82 boys), age: 12.06 (0.85) years.	No information provided	IG: over 9 weeks students participated in PE classes in accordance with the SPARK Program (Sports, Play and Active Recreation for Kids Program). Lessons were offered weekly and lasted approximately 40 minutes. CG: students participated in traditional PE.	No information provided	No information provided	competenceenjoyment	boys' in-class PA (pedometer)** girls' in-class PA**
Gonzalez-Cutre et al. (2018);SpainCT	N=88 (36 boys) aged 14-17 years, mean age: 14.67 (0.66); IG: n=29 (15 boys); CG: n=59 (21 boys).	SDT	IG: over 6 months, students participated in a PE intervention with 3 components: A) fitness and health teaching unit of 15 one-hour PE classes taught by PE teacher trained in motivational strategies to satisfy basic psychological needs. Lessons were held twice a week for 8 weeks.	1.1. Goal setting (behavior) 2.7. Feedback on outcome (s) of behavior3.2. Social support (practical) 4.1. Instruction on how to perform the behavior5.1. Information about health consequences 6.1. Demonstration of the behavior8.1. Behavioral practice/ rehearsal12.2.	1. Goals and planning2. Feedback and monitoring3. Social support4. Shaping knowledge5. Natural consequences6. Comparison of behavior8. Repetition and substitution12. Antecedents	after completion of teaching unit:teacher autonomy support autonomy in PE/leisure-time PA*competence in PE/leisure-time PArelatedness in PE/leisure-time PAintrinsic motivation in PE/leisure-time PA**integrated regulation in PE/leisure-time PAidentified regulation in PE/leisure-time PAintrojected regulation in PE/leisure-time PAexternal regulation in PE**/ leisure-time PAamotivation in PE*/leisure-time PA	after completion of teaching unit:self-reported PA (min/day) LPAMPA**hard PAvery hard PA

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Table 2 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical model	Intervention description	Behavior change techniques	Behavior change technique clusters	Motivational outcomes	Physical activity outcomes
			B) extracurricular PA program offered 3 times a week for 90 minutes over 6 months, content consistent with PE classes. C) Three parent meetings and family trekking excursion. CG: students participated in 15 one-hour PE sessions of fitness and health twice per week with usual teaching approach.	Restructuring the social environment			
Harrington et al. (2018); UK CT	N=1752 female secondary school students, age: 12.8 (SD 0.8) years. IG: n= 867, age: 12.8 (0.8) years; CG: n= 885, age: 12.8 (0.8) years.	Social cognitive theory	IG: over 14 months, schools participated in the 'Girls Active' program. Key elements of intervention were: formation of a girls leadership and peer marketing group to empower girls to influence PE, sport and PA in their school, develop as role models, and promote and market PA to other girls. CG: schools were not given specific guidance or advice and conducted usual PE and sport provision.	12.2. Restructuring the social environment 13.1. Identification of self as role model	12. Antecedents 13. Identity	At 7 months: enjoyment of PA intrinsic motivation identified motivation introjected regulation extrinsic motivation amotivation	At 7 months: PA levels (min/day) (accelerometer) LPA all days*/school days*/weekends/ during school/after school MVPA school days/ weekend/during school/ after school/mean min per day* sedentary time all days/ school days/ weekends/ during school/after school* students achieving ≥ 60 min MVPA/day (all days)
Hobin et al. (2018); USACT	N=191 high school students (104 male) from eight classes. IG: n=4 classes; CG: n=4 classes.	SDT	IG: students participated in a 6-week PE teaching unit of the novelty sport *disc golf*. CG: students engaged in a 6-week teaching unit of softball. All lessons were held twice a week, 40 minutes each.	4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior8.1. Behavioral practice/rehearsal	4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution	sports motivation** amotivation**	X
Hortigüela-Alcalá &Hernando-Garijo (2017);SpainCT	N=237 high school students (58.3% boys), age: 13.32 (2.31) years. IG: n=128; CG: n=109.	Teaching Games for Understanding (TGfU)	IG: students participated in 24 PE lessons conducted according to TGfU. The teacher was trained to implement lessons accordingly. Three team sport units were taught including basketball, floorball and handball. CG: students participated in PE classes according to the traditional technical	2.3 Self-monitoring of behavior2.7. Feedback on outcome(s) of behavior4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior8.1. Behavioral practice/rehearsal12.2. Restructuring the social environment	2. Feedback and monitoring4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution12. Antecedents	motivationachievement orientation	X

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Table 2 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical model	Intervention description	Behavior change techniques	Behavior change technique clusters	Motivational outcomes	Physical activity outcomes
			approach. Each lesson was 45 minutes long.				
Jamner et al. (2004); USACT	N=47 10th and 11th grade female students (sedentary), age: 14.94 (0.79) years. IG: n=25; CG: n=22.	No information provided	IG: over 4 months, students took part in special PE classes held daily for 60 minutes. Activities were selected based on decision of focus groups with members of target population: aerobic dance, basketball, swimming and Tae Bo. A weekly lecture was held on health benefits of PA and strategies to become more active. Students were exempted from PE uniform requirement and periodic 1-mile run test administered in usual PE. Classes were led by PE teacher or a hired instructor. CG: no information.	1.1 Goal setting (behavior) 1.2. Problem solving2.3. Self-monitoring of behavior 5.1. Information about health consequences	1. Goals and planning2. Feedback and monitoring5. Natural consequences	enjoyment	self-reported LPA*self-reported MPA**self-reported total PA*self-reported lifestyle activity**
Jones et al. (2010); EnglandCT	N=202 secondary school students (99 boys), age: 11-14 years.	Teaching Games for Understanding (TGfU)	IG: over 6 weeks, teachers implemented the TGfU model, corresponding to one unit of work of game invasion. CG: students participated in traditional, skill-based PE lessons.	No information provided	No information provided	interest/enjoyment**choice/autonomy**competence	X
Lonsdale et al. (2013); AustraliaRCT	N=288 year 8 students from 16 classes (50.4% boys, age: 13.6 years. IG_1: n=4 classes, 60 students; IG_2: n=4 classes, 77 students; IG_3: n=4 classes, 71 students; CG: n=4 classes, 80 students	SDT	Within 3 months, three IGs participated in PE with different intervention strategies. IG_1: 'Relevance', explaining rationale and importance of activities to students' lives; IG_2: 'Providing choice', students had 2-4 opportunities of choice within lessons; IG_3:'Free choice', providing students with equipment, but refraining from giving instructions. Teachers were given examples, such as a number of options for warm-up activities and organizing two games near end of the lesson –one 'competitive' game with	5.1. Information about health consequences5.6. Information about emotional consequences6.2. Social comparison12.2. Restructuring the social environment12.5. Adding objects to the environment	5. Natural consequences6. Comparison of behavior12. Antecedents	SDIautonomy**competence*relatednessteacher autonomy support (provided choice)**	in-class MVPA (accelerometer)*in-class sedentary time**

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Table 2 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical model	Intervention description	Behavior change techniques	Behavior change technique clusters	Motivational outcomes	Physical activity outcomes
			keeping score, and one 'social' game with no recording of score. Teachers were instructed on implementation of teaching strategies. CG: teachers continued with usual teaching practice.				
Lonsdale et al. (2019); AustraliaRCT	N=1421 grade 8 students. IG: n=693 (51.9% boys), age: 12.96 (0.56) years; CG: n=728, age=12.9 (0.52) years.	based on self-determination theory tenets to increase students' satisfaction of basic psychological needs	IG: over one school year, students participated in "Activity and Motivation in Physical Education" classes. To maximize MVPA, teachers' learnt strategies in: (A) 'Maximizing Movement and Skill Development' and (B) 'Reducing Transition Time'. Strategies to enhance student motivation were organized under: (C) 'Building Competence' and (D) 'Supporting Students'. Teachers were training through face-to-face workshops, the internet and a mobile app. CG: students participated in usual PE classes.	2.2. Feedback on behavior3.1. Social support (unspecified)4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior8.1. Behavioral practice/rehearsal12.2. Restructuring the social environment	2. Feedback and monitoring3. Social support4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution12. Antecedents	amotivation in PE/ leisure timeautonomous motivation in PE/ leisure timecontrolled motivation in PE/ leisure time**autonomy in PEcompetence in PErelatedness in PEsupportive teacher behavior in PEcontrolled teacher behavior in PE	in-class LPA (%)** (accelerometer)in-class MPA (%)**in-class VPA (%)**in-class MVPA (%)** in-class sedentary time (%) **leisure time LPA (%) (accelerometer)leisure time MPA (%)**leisure time MVPA (%)**leisure time VPA (%)leisure time sedentary time (%)self-reported leisure time PA frequencyself-reported leisure time PA duration
Méndez-Giménez et al. (2015); SpainCT	N=295 7th to 11th grade students (159 boys); age: 14.2 (1.68). IG_1: n=107; IG_2: n=78; CG: n=110.	AGT, SDT/ Sport Education Model	IG_1: over 12 sessions, students participated in PE classes conducted according to Sport Education Model in an Ultimate-Frisbee unit with conventional resources, 50 minutes each session. IG_2: students participated in PE classes conducted in accordance with the Sport Education Model in an Ultimate-Frisbee unit with self-made flying rings. CG: students participated in traditional PE classes.	2.2. Feedback on behavior6.2. Social comparison10.10. Reward (outcome) 12.2. Restructuring the social environment	2. Feedback and monitoring6. Comparison of behavior10. Reward and threat12. Antecedents	mastery approach and mastery avoidance performance approach and performance avoidanceautonomy**competencerelatedness	X
Meng et al. (2013); AustraliaCT	N=257 students year 8 students, age:12.91 (0.29) years. IG: n=120, Option 1 n=55 (35 boys), Option 2	SDT	Over 15 weeks the groups participated in 3 x 5-week-units of netball, tennis, and tee-ball. IG: students had 3 options to choose from 1) participating in	12.2. Restructuring the social environment	12. Antecedents	SDIteacher autonomy support	boys in-class MVPA (%) (accelerometer)**girls in-class MVPA**

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Table 2 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical model	Intervention description	Behavior change techniques	Behavior change technique clusters	Motivational outcomes	Physical activity outcomes
	n=31 (11 boys), Option 3 n=34 (18 boys); CG: n=137		the unit as presented by PE teacher, 2) acting as a "PE development officer", or 3) planning and undertaking own personal PA program. Option 3 required: (a) minimum of 30 minutes of continuous aerobic activity; (b) whole body or large muscle activities; (c) predominantly moderate to high intensity (using perceived exertion ratings); (d) activities performed within view of teacher. CG: students took part in regular PE classes with units of netball, tennis and tee-ball.				
Meng & Keng (2016); SingaporeCT	N=648 secondary school students (334 boys), age:14.35 years; IG_1: n=173; IG_2: n=239; CG: n=236.	SDT	IG_1: over 10 weeks, students participated in an Autonomy-Supportive Teaching Structure-PE program during their PE classes. IG_2: students took part in PE lessons with an autonomy-supportive motivational teaching style only (AS). The teachers of both intervention groups received training, training hours depended on the intervention. CG: students participated in regular PE classes. All lessons were 60 minutes long.	1.1. Goal setting (behavior) 2.2. Feedback on behavior3.2. Social support (practical) 4.1. Instruction on how to perform the behavior5.1. Information about health consequences6.1. Demonstration of the behavior8.1. Behavioral practice/ rehearsal	1. Goals and planning2. Feedback and monitoring3. Social support4. Shaping knowledge5. Natural consequences6. Comparison of behavior8. Repetition and substitution	teacher autonomy support**autonomy**competence**relatedness*RAI**	overall in-class MVPA % (accelerometer)* boys in-class MVPA%** girls in-class MVPA%*
Moreno et al. (2010);SpainCT	N=363 students (227 boys), age: 13.21 (0.9) years. IG_1: n=121; IG_2: n=121; CG: n=12.1.	SDT	During one session, two groups were manipulated regarding their ability beliefs during a motor task. Both groups received different information using football players as models. IG_1: experimental-incremental group; manipulation based on the fact that sport abilities can be developed through learning, practice and training. IG_2:	4.1. Instruction on how to perform the behavior13.2. Framing/reframing	4. Shaping knowledge 13. Identity	task competencesituational intrinsic motivation**	X

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Table 2 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical model	Intervention description	Behavior change techniques	Behavior change technique clusters	Motivational outcomes	Physical activity outcomes
			experimental-entity group; manipulation based on the fact that people are born with a certain gift for some sports, this gift is innate and difficult to modify. CG: students were only told how to perform the task, no further information was provided.				
Nation-Grainger (2017);Abu DhabiCT	N=10 year 10 male students, age:14-15 years	SDT	IG: over 6 weeks, students participated in weekly PE classes receiving positive biofeedback post PE-lessons by means of a smartwatch. CG: students participated in 6 PE classes wearing a smartwatch without receiving biofeedback.	2.6. Biofeedback	2. Feedback and monitoring	intrinsic motivationidentified regulationintrojected regulationexternal regulationamotivationRAI	X
Perlman (2010); USA CT	N=78 amotivated year 9 students (24 boys). IG: n=40 (14 boys); CG: n=38 (10 boys).	SDT/ Sport Education Model	IG: over 4 weeks, students participated in PE according to the Sport Education Model. Classes were held 3-4 times a week for 60 minutes. The teaching model of sport-based invasion games focused on six key features: team affiliation record keeping, seasons, formal competition, festivity and culminating event. CG: participants took part in traditional PE classes.	1.8. Behavioral contract 2.2. Feedback on behavior 4.1. Instruction on how to perform the behavior 6.1. Demonstration of the behavior 6.2. Social comparison 8.1. Behavioral practice/ rehearsal 10.4. Social reward 12.2. Restructuring the social environment	1. Goals and planning 2. Feedback and monitoring 4. Shaping knowledge 6. Comparison of behavior 8. Repetition and substitution 10. Reward and threat 12. Antecedents	enjoyment* autonomy competence relatedness*	X
Perlman (2011); USACT	N=182 grade 9 students (91 boys). IG: n=94 (43 boys); CG: n=88 (48 boys).	SDT/Sport Education Model	IG: over 4 weeks students participated in 20 x 60 minute PE lessons of volleyball 4 times a week. Lessons were taught according to the Sport Education Model including the key features of affiliation, record keeping, seasons, formal competition, festivity and culminating event. CG: students participated in	4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior6.2. Social comparison8.1. Behavioral practice/rehearsal10.4. Social reward12.2. Restructuring the social environment	4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution10. Reward and threats12. Antecedents	SDI*intrinsic motivation (to know)identfied regulationexternal regulationamotivationautonomy competencerelatedness*	X

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Table 2 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical model	Intervention description	Behavior change techniques	Behavior change technique clusters	Motivational outcomes	Physical activity outcomes
			traditional lessons of volleyball.				
Perlman (2015); USACT	N=48 amotivated high-school students (18 boys). IG: n=24 (9 boys); CG: n=24 (9 boys).	SDT	IG: students participated in 16 PE lessons, approximately 4 weeks, of basketball with a high level of autonomy support. The teacher received an autonomy-supportive workshop. CG: students took part in 16 PE classes of basketball with a consistent level of autonomy-supportive and controlling instruction.	4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior8.1. Behavioral practice/rehearsal	4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution	teacher autonomy-support** SDI**autonomycompetencerelatedness**	X
Prusak et al. (2004); USACT	N=1110 7th and 8th grade female students from 42 classes. IG: n=21 classes; CG: n=21 classes.	SDT, Hierarchical model of motivation	IG: over 10 days, students participated in walking activities, 50 minutes each day during their regular PE classes. Students were allowed to make choices during the units on which activities they would be participating in and with whom. The teachers of the CG and IG received a workshop on instructional and experimental procedures specific for each treatment group. CG: students took part in walking activities during their regular PE classes, without having a choice as to which activity they would participate in and with whom.	4.1. Instruction on how to perform the behavior5.1. Information about health consequences6.1. Demonstration of the behavior8.1. Behavioral practice12.2. Restructuring the social environment	4. Shaping knowledge5. Natural consequences6. Comparison of behavior8. Repetition and substitution12. Antecedents	contextual self-determination (including intrinsic motivation, extrinsic motivationamotivation)	X
Sevil et al. (2016); SpainCT	N=224 secondary school students (105 boys), age: 12.37 (0.64) years. IG: n=109 (51 boys); CG: n=115 (54 boys).	SDT, AGT/ Tactical games model (TGM), TARGET	IG: students participated in 10 sessions of rope-skipping activities in PE geared towards corporal expression, twice a week for 50 minutes each. Lessons were conducted in accordance with TARGET strategies. The teacher took part in a 5-week training program prior to the intervention. CG: students took part in 10 sessions of rope skipping activities. TGM was used	2.4. Self-monitoring of outcome(s) of behavior 2.7. Feedback on outcome(s) of behavior4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior8.1. Behavioral practice/rehearsal12.2. Restructuring the social environment	2. Feedback and monitoring 4. Shaping knowledge 6. Comparison of behaviour 8. Repetition and substitution 12. Antecedents	task-oriented climate**ego-oriented climate**autonomy*competence**relatednessintrinsic motivation**identified regulation**enjoyment/ satsifaction**extrinsic regulationamotivation	X

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Table 2 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical model	Intervention description	Behavior change techniques	Behavior change technique clusters	Motivational outcomes	Physical activity outcomes
			as the pedagogical model in both groups.				
Smith et al. (2018); AustraliaRCT	N=607 grade 9 students (50.4% boys), age:14.1 (0.5) years. IG: n=353, age:14.1 (0.4) years; CG: n=254, age:14.2 (0.5) years.	SDT/SAAFE teaching principles	IG: over 10 weeks, students participated in resistance training and other health and fitness activities. Intervention components were: an introductory seminar for students, weekly PA sessions (about 90 minutes) during PE, PA, and Sport Studies elective class, lunch-time activity sessions (5 x 20 min), and a web-based smartphone application to supplement face-to-face components. Teachers received a workshop to deliver intervention program. CG: students and teachers received intervention after the study period.	1.1. Goal setting (behavior) 1.5. Review behavior (goals)2.3. Self-monitoring of behavior 4.1. Instruction on how to perform the behavior5.1. Information about health consequences6.1. Demonstration of the behavior8.1. Behavioral practice/rehearsal12.2. Restructuring the social environment12.5. Adding objects to the environment	1. Goals and planning2. Feedback and monitoring4. Shaping knowledge5. Natural consequences6. Comparison of behavior8. Repetition and substitution12. Antecedents	intrinsic motivation identified regulation	X
Spittle & Byrne (2009); AustraliaCT	n=115 year 8 students (97 boys), age=13-14 years. IG: n=41 (32 boys); CG: n=74 (65 boys).	AGT/Sport Education Model	IG: over 10 weeks, students in the Sport Education condition took part in one double period of PE (100 minutes) once a week. The intervention incorporated 6 features: seasons, affiliation, formal competition, record keeping, festivity, and a culminating event. It followed a 3-phase format 1) initial, teacher-directed, skill development phase; 2) student-led activities and games phase; 3) formal competition phase. CG: participants took part in traditional PE classes.	4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior6.2. Social comparison8.1. Behavioral practice/rehearsal10.4. Social reward12.2. Restructuring the social environment	4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution10. Reward and threat12. Antecedents	competence**interest/enjoymenttask goal orientation**ego goal orientation mastery climate**performance climate	X
Wallhead &Ntoumanis (2004); EnglandCT	N=51 male high school students, age: 14.3 (0.48) years. IG: n=26; CG: n=25.	AGT/Sport Education Model	IG: over 8 weeks, students participated in weekly 1-hour PE classes following the Sport Education Model. The teaching approach followed a three-phase format: a teacher-directed skill development phase, a preseason	1.8. Behavioral contract4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior 6.2. Social comparison8.1. Behavioral practice/rehearsal12.2.	1. Goals and planning4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution12. Antecedents	enjoyment**autonomycompetence task goal orientationego goal orientationtask climateperformance climate	X

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Table 2 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical model	Intervention description	Behavior change techniques	Behavior change technique clusters	Motivational outcomes	Physical activity outcomes
			scrimmage phase, a formal competition phase. During each phase students acted in the roles of being a coach, referee, captain, and scorer. Students on each team selected individuals to fulfill each role. CG: students participated in traditional PE.	Restructuring the social environment			
Wallhead et al. (2014);USACT	N=538 high school students, age:14.75 (0.48) years. IG: n=261; CG: n=277.	SDT/Sport Education Model	IG: over two years, students participated in 4 seasons (each 25 lessons) of team sport activities in accordance with the Sport Education Program. Lessons were held 90 minutes, 2-3 times per week. Following the initial management phase, each season followed a protocol of teacher-directed skill development, a preseason coach-directed phase, a formal tournament, and postseason culminating event. Student role responsibilities included coach, referee and scorer. CG: students participated in a multi-activity program during their PE lessons. Instructions were provided by the teacher; feedback during game play was limited, students were not accountable for game performance.	4.1. Instruction on how to perform the behavior6.1. Demonstration of the behavior6.2. Social comparison8.1. Behavioral practice/rehearsal12.2. Restructuring the social environment	4. Shaping knowledge6. Comparison of behavior8. Repetition and substitution12. Antecedents	enjoyment**	self-reported leisure time PA*
Weigand & Burton (2002);EnglandCT	N=40 students (32 boys), age:15.9 (0.51) years. IG: n=20; CG: n=20.	AGT/TARGET	IG: over 5 weeks, students participated in 1-hour PE classes promoting a mastery climate using the TARGET approach. CG: students participated in regular PE classes with same lesson content.	1.1. Goal setting (behavior) 2.7. Feedback on outcome (s) of behavior4.1 Instruction on how to perform the behavior 6.1 Demonstration of the behavior8.1. Behavioral practice/rehearsal12.2. Restructuring the social environment	1. Goals and planning2. Feedback and monitoring4. Shaping knowledge5. Natural consequences 6. Comparison of behavior8. Repetition and substitution12. Antecedents	task goal orientation** ego goal orientation** competence**perceived satisfaction/enjoyment**	X
Yli-Piipari et al. (2018); USARCT	N=408 middle school students (192 boys),	Trans-contextual model of motivation	IG: over 8 weeks, students participated in autonomy supportive PE classes. The	No information provided	No information provided	During week 4:autonomy supportive climate**RAI (PE)**	self-reported PA**

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Table 2 (*continued*)

Author; CountryDesign	Participants	Theoretical background/ Pedagogical model	Intervention description	Behavior change techniques	Behavior change technique clusters	Motivational outcomes	Physical activity outcomes
	age:12.29 (0.99) years. IG: n=198 (98 boys); CG: n=210 (102 boys).		teachers were instructed on how to implement autonomy supportive teaching strategies. CG: students participated in regular PE classes. The teachers took part in workshops focusing on the curriculum. Teaching strategies that would compromise treatment effects were not addressed.				
Zach et al. (2016); IsraelCT	N=154 female students, age: 16-18 years. IG_1: n=54; IG_2: n=46; CG: n=54.	AGT, Social efficacy theory	IG_1: over 12 weeks, students participated in training sessions during regular PE where they received explanations on importance/contribution of PA for health and guidelines for independent PA in the afternoons. Students gave weekly reports on their independent activities to the class forum on the school website. A weekly debriefing was held at the end of PE class. IG_2: participants followed regular PE curriculum, reported on PA during PE using a smart-phone application after each lesson and received information about the importance of PA during leisure time. CG: students participated in standard PE classes with recommendations on independent practice sessions and explanations on importance/ contribution of PA for health. All PE lessons were held twice a week.	1.2. Problem solving2.3. Self-monitoring of behavior 3.3. Social support (emotional) 4.1. Instruction on how to perform the behavior5.1. Information about health consequences 5.6. Information about emotional consequences	1. Goals and planning2. Feedback and monitoring3. Social support4. Shaping knowledge5. Natural consequences	learning orientation climateperformance orientation climate	X

Note: AGT= achievement goal theory; CT= controlled trial; CG= control group; IG= intervention group; LPA: light physical activity; MPA: moderate physical activity; MVPA: moderate-to-vigorous physical activity; N= Total sample size at baseline; n= subgroup sample size; PA= physical activity; PE= physical education; RAI= relative autonomy index; RCT= randomized controlled trial; SDI= self-determination index; SDT= self-determination theory; TARGET= Task, Authority, Recognition, Grouping, Evaluation, Time; VPA= vigorous PA.* indicates significant effects (pre to post) with a p-value <0.05; ** p-value <0.01.

the clusters 'Shaping knowledge', 'Comparison of behavior' and 'Antecedents' (all n = 10) followed by the clusters 'Repetition and substitution' (n = 9), 'Feedback and monitoring' (n = 9) and 'Goals and planning' (n = 7).

3.3. Primary outcomes

The most frequently evaluated motivational outcomes were perceived competence (n = 30), enjoyment and satisfaction of PE or PA (n = 26), students' perceived motivational climate in PE (n = 19), perceived autonomy (n = 18), intrinsic motivation (n = 18), and perceived relatedness (n = 16). A few studies (n = 4) determined the level of autonomous motivation by measuring the relative autonomy index (RAI), calculated as: (external regulation * (−2) + introjected regulation* (−1) + identified regulation * (+1) + intrinsic motivation * (+2)). A higher score represents a higher level of intrinsic motivation (Chatzisarantis and Hagger, 2009). Another index, frequently referred to, was the self-determination index (SDI) (n = 6) to measure the level of self-determination. Lonsdale et al., 2013 calculated this similarly to the RAI: (2 * intrinsic motivation + identified motivation – external regulation – 2 * amotivation). Cuevas et al., 2016 determined global self-determination by calculating the SDI as: (2 * intrinsic motivation) + identified regulation – (introjected regulation + external regulation)/2–2* amotivation). Tables 1 and 2 show the outcomes of interest measured in the IG and CG at a minimum of two time-points (pre to post intervention). Significant results at post-test are indicated where applicable.

3.4. Secondary outcomes

Physical activity behavior was measured in 30 studies during PE lessons (n = 13), during the school day (n = 3), and in leisure time by means of questionnaires (n = 12), observations (n = 4), and measurement tools such as accelerometers and pedometers (n = 16). Of these studies, 28 conducted pre-post analyses of PA between groups. Tables 1 and 2 show the PA outcomes measured in these studies in IG and CG at a minimum of two time-points (pre to post intervention). Significant results at post-test are indicated where applicable.

3.5. Methodological quality

An overview of risk of bias for all included studies and each category is given in Fig. 2. Additional file 2 shows the risk of bias for each individual study. The study with the lowest risk of bias, was the RCT by Salmon et al. (2008). None of the RCTs had a low risk of bias in all eight categories, a minimum of two domains were rated with a high risk of bias in each examined study. Nearly all of the studies had a high risk of bias in the domains performance bias, *i.e.* blinding of participants and personnel, and detection bias, *i.e.* blinding of outcome assessment. The lowest risk of bias across studies was found in the domains reporting bias and other risk of bias, *i.e.* timing of measurement, the latter is not included in the standard Cochrane Collaboration's tool for assessing risk of bias in randomized trials.

3.6. Intervention effects primary outcomes

Overall, meta-analyses of 16 outcomes were performed with the number of included comparisons (*k*) ranging between 4 and 28. Table 3 shows an overview of all calculated meta-analyses including the effect size statistic, the heterogeneity statistic and analysis of publication bias.

Enjoyment. The overall analysis of enjoyment resulted in a significant and small to moderate effect size ($g = 0.310$, 95% CI = 0.080 to 0.541, $p = 0.008$) with high heterogeneity ($I^2 = 87.730\%$). The effect size in CTs was small to moderate ($g = 0.404$, 95% CI = 0.148 to 0.660, $p = 0.02$) and heterogeneity was high ($I^2 = 88.896\%$) A non-significant, negative effect size was found in RCTs ($p = 0.113$) with low heterogeneity ($I^2 = 15.979\%$).

Basic psychological needs. The analyses of perceived competence and relatedness resulted in non-significant, trivial effect sizes and high heterogeneity ($I^2 = 96.530\%$ and $I^2 = 75.727\%$, respectively). The overall analyses of perceived autonomy resulted in a significant and small effect size ($g = 0.152$, 95% CI = 0.013 to 0.290, $p = 0.032$) and moderate to high I^2 (69.328%). A significant and small effect size was further found in CTs ($g = 0.196$, 95% CI = 0.020 to 0.371, $p = 0.029$), whereas non-significant results were found in RCTs ($p = 0.827$, $I^2 = 0.000\%$).

Motivation. The overall analyses of amotivation, external regulation, introjected regulation and RAI resulted in non-significant effect sizes. The analysis of identified regulation showed a small to moderate significant effect ($g = 0.378$, 95% CI = 0.041 to 0.714, $p = 0.028$). A small to moderate significant effect size was also found for intrinsic motivation ($g = 0.419$, 95% CI= 0.085 to 0.752, $p = 0.014$). An overall moderate to large significant effect size was found for SDI ($g = 0.672$, 95% CI = 0.112 to 1.232, $p = 0.019$) with a large and significant effect size in the CTs ($g = 1.161$, 95% CI = 0.321 to 2.001, $p = 0.007$). Overall heterogeneity was high in all variables, except for introjected regulation ($I^2 = 28.488\%$) and moderate to high for RAI ($I^2 = 69.138\%$)

Motivational climate. The analysis of these outcomes showed significant effects. The highest effect size was found for ego/performance oriented teaching climate ($g = -0.438$, 95% CI = −0.646 to −0.230, $p < 0.01$), meaning students in the IG had significantly lower values in their perception of ego/performance climate at post-test than the CG. The lowest effect size was found for task/mastery oriented teaching climate ($g = 0.254$, 95% CI = 0.097 to 0.411, $p = 0.001$), meaning students in the IG had significantly larger scores in their perception of a mastery/task climate at post-test than the CG. The heterogeneity was moderate ($I^2 = 60.509\%$ (task/mastery climate) to high $I^2 = 87.195\%$ (autonomy supportive climate). A small and significant effect size was found in RCTs for autonomy supportive climate ($g = 0.340$, 95% CI = 0.053 to 0.627, $p = 0.020$), results in CTs were non-significant ($p = 0.436$).

Goal Orientation. A large and significant effect size was found for task goal orientation ($g = 1.370$, 95% = CI 0.694 to 2.045, $p < 0.01$) with high heterogeneity ($I^2 = 92.718\%$). The analysis of ego/performance goal orientation resulted in a small, significant effect size ($g = -0.188$, 95% CI= -0.327 to −0.050, $p = 0.008$) with low heterogeneity ($I^2 = 4.438\%$).

3.7. Publication bias

The inspection of the Funnel Plot and the Eggers' Test indicated no publication bias for most of the variables. The Eggers' Test was significant for introjected regulation ($p = 0.039$, two-tailed) and task goal orientation ($p = 0.024$, two-tailed) and indicated an asymmetric funnel plot.

3.8. Subgroup analyses

A series of pre-specified subgroup-moderator analyses were conducted. A summary of the calculated effect sizes and the heterogeneity statistic is presented in Table 4.

Studies examining enjoyment that were theory-based showed a significant and moderate effect size ($g = 0.465$, 95% CI = 0.199 to 0.732, $p = 0.001$) while the effect size for studies that were not theory-based was trivial and non-significant ($g = -0.064$, 95% CI = −0.475 to 0.347, $p = 0.759$). A moderate, significant effect size was found in adolescents ($g = 0.471$, 95% CI= 0.147 to 0.796, $p = 0.004$) but not in children ($g = 0.114$, 95% CI = −0.249 to 0.478, $p = 0.537$). A moderate and significant effect size was found in CTs ($g = 0.402$, 95% CI = 0.153 to 0.651, $p = 0.002$) but not in RCTs ($g = -0.157$, 95% CI = −0.716 to 0.402, $p = 0.582$). *Q*-statistics revealed significant differences only between the moderators theory-based and non-theory based studies ($p < 0.05$) but not between age groups or the different study designs ($p > 0.05$).

Basic psychological needs. Excluding outliers and comparisons with

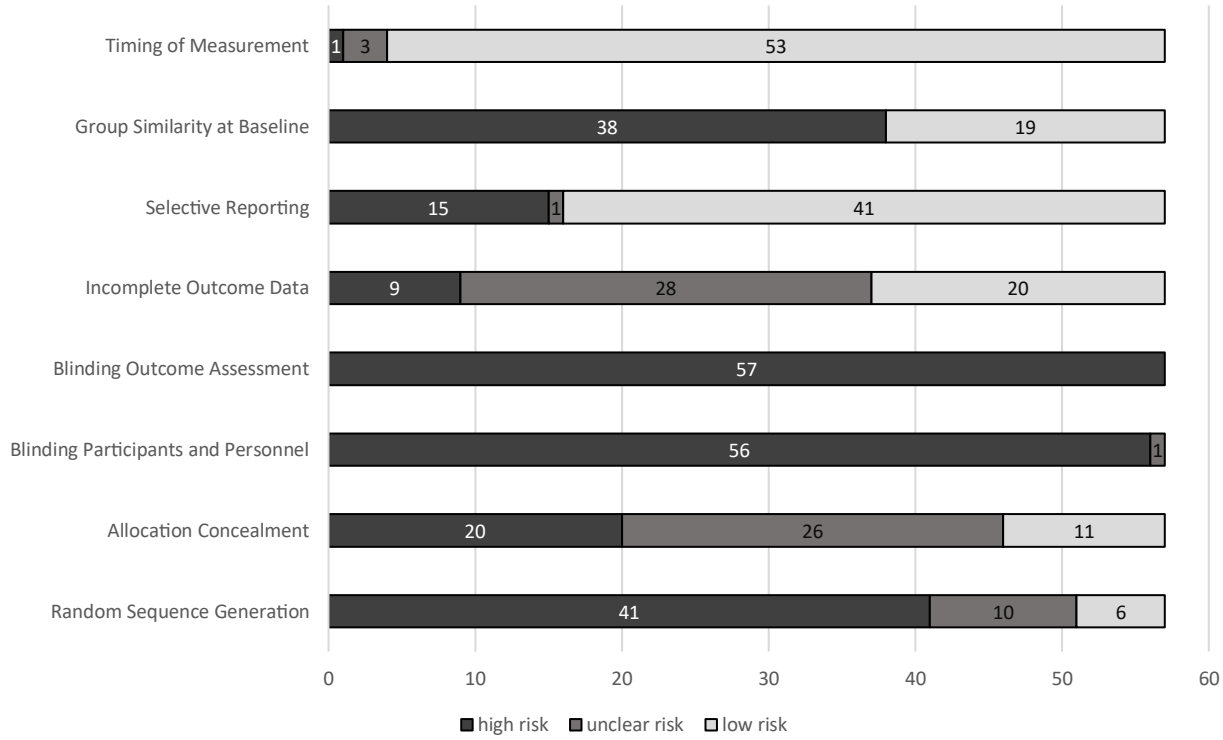

Fig. 2. Risk of bias across all included studies.

the highest and lowest effect sizes resulted in a reduction of heterogeneity. For perceived autonomy the effect size was larger and significant for children ($g = 0.407$, 95% CI = 0.144 to 0.671, $p = 0.002$) compared to adolescents ($g = 0.074$, 95% CI = −0.070 to 0.219, $p = 0.314$) and for CTs ($g = 0.196$, 95% CI = 0.037 to 0.355, $p = 0.016$) compared to RCTs ($g = 0.001$, 95% CI = −0.291 to 0.294, $p = 0.934$). Heterogeneity was further explained in children and in RCTs for perceived autonomy. *Q*-statistics showed significant differences only between the moderators children and adolescents ($p < 0.05$).

Motivation. The exclusion of the highest and lowest effect sizes ($g = 0.404$, 95% = CI -0.062 to 0.869, $p = 0.089$) clearly decreased the effect size for SDI and resulted in non-significant effect estimates. Decreased effect sizes were also found for amotivation, external regulation, identified regulation, intrinsic motivation, and RAI. For intrinsic motivation the subgroup analyses revealed a small effect size in children ($g = 0.290$, 95% CI = −0.104 to 0.683, $p = 0.149$) and a moderate effect size for adolescents (g = 0.557, 95% CI = −0.057 to 1.212, $p = 0.074$). Both results were non-significant and heterogeneity was high. *Q*-statistics showed significant differences between the moderators CT and RCT for identified regulation ($p < 0.05$), intrinsic motivation ($p < 0.05$), SDI ($p < 0.01$), and RAI ($p < 0.01$).

Motivational climate. The exclusion of outliers and comparisons with the highest and lowest effect size decreased heterogeneity for all three variables. The effect size of the variable autonomy supportive climate increased with the exclusion of outliers and highest/lowest effect sizes, while the effect size of ego/performance climate slightly decreased. The effect estimates remained significant. *Q*-statistics showed significant differences between the moderators children and adolescents ($p < 0.01$) for autonomy supportive climate.

Goal orientation. For the variable task goal orientation neither the exclusion of the highest and lowest effect sizes ($g = 1.118$, 95% CI = 0.414 to 1.822, $p = 0.002$) nor the exclusion of outliers ($g = 0.763$, 95% CI = 0.304 to 1.222, $p = 0.01$) changed effect estimates; a large, significant Hedges' *g* remained.

Additional file 3 shows the results of the subgroup analyses performed for CTs only. The direction of the results was similar to those presented in Table 4. Due to the small number of RCTs included in the various outcomes, the subgroup analyses were not repeated for RCTs.

3.9. Secondary outcomes

Of the 28 studies examining intervention effects in both motivational and PA outcomes, significant results in PA behavior were reported in 22 studies (Braga et al., 2017; Christodoulidis et al., 2001; Fairclough and Stratton, 2005; Fairclough et al., 2016; Fu et al., 2016; González-Cutre et al., 2018; Gorely et al., 2009; Harrington et al., 2018; Jamner et al., 2004; Lonsdale et al., 2013, Lonsdale et al., 2019; Meng et al., 2013; Meng and Keng, 2016; Miller et al., 2016; Moreno-Murcia and Sànchez-Latorre, 2016; Pardo et al., 2016; Salmon et al., 2008; Shannon et al., 2018; Smith et al., 2015; Wallhead, Garn, & Vidoni, 2014; Wang et al., 2017; Yli-Piipari et al., 2018). Significant results in both motivational and PA outcomes were identified in 13 of these studies (Christodoulidis et al., 2001; Fairclough et al., 2016; González-Cutre et al., 2018; Gorely et al., 2009; ; Lonsdale et al., 2013, Lonsdale et al., 2019; Meng and Keng, 2016; Moreno-Murcia and Sànchez-Latorre, 2016; Pardo et al., 2016; Salmon et al., 2008; Shannon et al., 2018; Wallhead, Garn, & Vidoni, 2014; Yli-Piipari et al., 2018). Intervention effects in favor of the IG were found for self-reported PA behavior (Christodoulidis et al., 2001; González-Cutre et al., 2018; Jamner et al., 2004; Moreno-Murcia and Sànchez-Latorre, 2016; Wallhead, Garn, & Vidoni, 2014; Wang et al., 2017; Yli-Piipari et al., 2018), PA levels in-class (Braga et al., 2017; Fairclough and Stratton, 2005; Fairclough et al., 2016; Fu et al., 2016; Lonsdale et al., 2013, Lonsdale et al., 2019; Meng et al., 2013; Meng and Keng, 2016; Miller et al., 2016; Smith et al., 2015), during the school day (Fairclough et al., 2016; Shannon et al., 2018) and over several days (Gorely et al., 2009; Harrington et al., 2018; Lonsdale et al., 2019; Pardo et al., 2016; Salmon et al., 2008). Along with increasing in-class PA levels, two studies were also effective in decreasing in-class sedentary time (Lonsdale et al., 2013, Lonsdale et al., 2019).

Table 3
Summary of effect size statistic and heterogeneity for all motivational outcome analyses.

Variables	Study design	Effect size statistic						Heterogeneity statistic		Publication bias
		k	g	SE	95% CI	Z	p	Q	I^2	p^A
Enjoyment	Overall	17	0.310	0.118	0.080, 0.541	2.641	0.008	130.405	87.730	0.096
	CT	14	0.404	0.131	0.148, 0.660	3.092	0.002	117.080	88.896	
	RCT	3	−0.216	0.137	−0.484, 0.051	−1.585	0.113	2.380	15.979	
Basic psychological needs										
Perceived autonomy	Overall	18	0.152	0.071	0.013, 0.290	2.144	0.032	55.426	69.328	0.368
	CT	14	0.196	0.089	0.020, 0.371	2.189	0.029	45.201	71.240	
	RCT	4	−0.011	0.052	−0.114, 0.091	−0.219	0.827	0.783	0.000	
Perceived competence	Overall	28	0.080	0.167	−0.247, 0.407	0.480	0.631	778.120	96.530	0.133
	CT	23	0.095	0.216	−0.327, 0.518	0.442	0.659	759.587	97.104	
	RCT	5	−0.009	0.052	−0.110, 0.093	−0.166	0.868	2.104	0.000	
Perceived relatedness	Overall	19	0.064	0.076	−0.084, 0.212	0.844	0.398	74.157	75.727	0.643
	CT	13	0.140	0.112	−0.080, 0.361	1.250	0.211	65.476	81.673	
	RCT	6	−0.043	0.088	−0.215, 0.129	−0.485	0.628	8.569	41.653	
Motivation										
Amotivation	Overall	6	−0.208	0.116	−0.436, 0.019	−1.794	0.073	23.509	78.732	0.597
	CT	5	−0.241	0.173	−0.580, 0.097	−1.396	0.163	23.506	82.983	
	RCT	1	−0.155	0.057	−0.266, −0.045	−2.751	0.006	0.000	0.000	
External Regulation	CT	5	−0.114	0.256	−0.616, 0.389	−0.443	0.657	51.822	92.281	0.329
Introjected Regulation	CT	4	0.102	0.102	−0.098; 0.301	1.000	0.317	4.195	28.488	0.039
Identified Regulation	Overall	7	0.378	0.172	0.041, 0.714	2.199	0.028	59.177	89.861	0.101
	CT	6	0.456	0.202	0.060, 0.851	2.258	0.024	45.301	88.963	
	RCT	1	−0.024	0.082	−0.185, 0.137	−0.294	0.769	0.000	0.000	
Intrinsic Motivation	Overall	11	0.419	0.170	0.085, 0.752	2.460	0.014	108.884	90.816	0.259
	CT	10	0.471	0.190	0.099, 0.842	2.483	0.013	90.076	90.008	
	RCT	1	−0.033	0.090	−0.209, 0.143	−0.371	0.710	0.000	0.000	
SDI	Overall	8	0.672	0.286	0.112, 1.232	2.353	0.019	111.137	93.701	0.088
	CT	5	1.161	0.429	0.321, 2.001	2.708	0.007	98.572	95.942	
	RCT	3	−0.061	0.131	−0.317, 0.196	−0.463	0.643	0.055	0.000	
RAI	Overall	5	0.086	0.113	−0.135, 0.307	0.765	0.444	12.961	69.138	0.515
	CT	4	−0.003	0.008	−0.160, 0.153	−0.043	0.996	3.660	18.043	
	RCT	1	0.367	0.062	0.019, 0.264	2.270	0.023	0.000	0.000	
Motivational climate										
Task/Mastery	CT	9	0.254	0.080	0.097, 0.411	3.177	0.001	20.258	60.509	0.851
Ego/Performance	CT	9	−0.438	0.106	−0.646, −0.230	−4.121	0.000	38.182	79.048	0.589
Autonomy supportive climate	Overall	9	0.262	0.122	0.022, 0.501	2.140	0.032	62.477	87.195	0.521
	CT	4	0.180	0.231	−0.273, 0.634	0.778	0.436	32.352	90.727	
	RCT	5	0.340	0.147	0.053, 0.628	2.318	0.020	22.501	82.223	
Goal Orientation										
Task	CT	8	1.370	0.345	0.694, 2.045	3.972	0.000	96.124	92.718	0.024
Ego	CT	8	−0.188	0.071	−0.327, −0.050	−2.668	0.008	7.325	4.438	0.764

Note: k = number of effect sizes; g = effect size (Hedges' g); SE = standard error; *95% CI* = 95% confidence intervals lower limit, upper limit; Z = test of the null hypothesis; I^2 = total variance explained by moderators; ^{A} two-tailed p-value (Eggers' test); SDI = self-determination index; RAI = relative autonomy index.

3.10. Certainty of evidence

The certainty of evidence was assessed in accordance with GRADE for the meta-analyzed outcomes enjoyment, basic psychological needs, motivation, motivational climate, and goal orientation (Table 5). The certainty of evidence was initially set at high for RCTs and CTs and downgraded one point for each item rated 'serious' and two points for each item rated 'very serious'; the optimal information size was set at n > 400.

Every meta-analyzed outcome was downgraded one, two or three levels. Reasons for downgrading were serious risk of bias, serious or very serious inconsistency, serious imprecision and/or publication bias. Moderate certainty of evidence was shown for ego/performance climate and ego goal orientation. Low certainty of evidence was determined in autonomy supportive climate, task/mastery climate, RAI, SDI, amotivation, perceived autonomy, and enjoyment. Very low certainty of evidence was found for perceived competence and relatedness, external regulation, introjected and identified regulation, intrinsic motivation, and task goal orientation. There was no indication of indirectness regarding the population, intervention, comparator, or outcome in any variable. Publication bias was strongly suspected in the outcomes introjected regulation and task goal orientation. The explanations for each judgement can be found in Table 5.

4. Discussion

The aim of this study was to provide information on the effects of school-based PA interventions on students' motivation towards PA. Secondarily, effects on PA behavior were analyzed.

4.1. Main findings-primary outcomes

The results of the meta-analyses on motivational outcomes indicated that the overall pooled effect size of school-based PA interventions was small to moderate, and statistically significant, for enjoyment, perceived autonomy, identified regulation, intrinsic motivation, motivational climate and ego goal orientation. Significant moderate to large effects were also identified for SDI and task goal orientation. Non-significant effect estimates were found in the meta-analyses of perceived competence, perceived relatedness, amotivation, external regulation, introjected regulation and RAI. A further inspection of the data revealed large heterogeneity across studies in the meta-analyzed outcomes except for the outcomes ego goal orientation and introjected regulation.

These results are in line with previous findings on the effectiveness of PA interventions implemented in the school setting on motivational outcomes. For example, the meta-analysis by Burns et al. (2017) revealed small to moderate effects of school-based PA interventions on enjoyment . Braithwaite et al. (2011) found that PA interventions

Table 4
Moderator statistics.

Variables		Effect size statistic						Heterogeneity statistic	
		k	g	SE	95% CI	Z	p	Q	I^2
Enjoyment		17	0.310	0.118	0.080, 0.541	2.641	0.008	130.405	87.730
	High/Low	15	0.261	0.104	0.058, 0.464	2.515	0.012	79.383	82.364
	Outlier	13	0.202	0.077	0.051, 0.354	2.618	0.009	28.353	57.677
	Theory-based							4.497[A]*	
	Yes	12	0.465	0.136	0.199, 0.732	3.427	0.001	102.957	89.306
	No	5	−0.064	0.210	−0.475, 0.347	−0.307	0.759	9.503	57.909
	Age							2.060[A]	
	Children	7	0.114	0.185	−0.249, 0.478	2.534	0.537	62.357	90.378
	Adolescents	10	0.471	0.166	0.147, 0.796	2.846	0.004	63.102	85.737
	Study design							3.209[A]	
	CT	14	0.402	0.127	0.153, 0.651	2.167	0.002	117.080	88.896
	RCT	3	−0.157	0.285	−0.716, 0.402	−0.551	0.582	2.380	15.979
Basic psychological needs									
Perceived autonomy		18	0.152	0.071	0.013, 0.290	2.144	0.032	55.426	69.328
	High/Low	16	0.137	0.061	0.017, 0.257	2.245	0.025	34.199	56.139
	Age							4.718[A]*	
	Children	4	0.407	0.134	0.144, 0.671	3.031	0.002	1.713	0.000
	Adolescents	14	0.074	0.074	−0.070, 0.219	1.006	0.314	40.602	67.982
	Study design							1.320[A]	
	CT	14	0.196	0.081	0.037, 0.355	2.418	0.016	45.201	71.240
	RCT	4	0.001	0.149	−0.291, 0.294	0.008	0.934	0.783	0.000
Perceived competence		28	0.080	0.167	−0.247, 0.407	0.480	0.631	778.120	96.530
	High/Low	26	0.114	0.069	−0.022, 0.250	1.648	0.099	100.550	75.235
	Outlier	24	0.095	0.048	0.001, 0.189	1.973	0.048	39.405	41.632
	Theory-based							0.016[A]	
	Yes	26	0.075	0.175	−0.268, 0.417	0.426	0.670	767.923	96.744
	No	2	0.156	0.630	−1.078, 1.391	0.248	0.804	2.112	52.647
	Age							1.550[A]	
	Children	7	−0.079	0.322	−0.710, 0.552	−0.245	0.806	574.947	98.956
	Adolescents	20	0.179	0.191	−0.196, 0.554	0.937	0.349	57.411	66.906
	Study design							0.015[A]	
	CT	23	0.093	0.201	−0.300, 0.486	0.464	0.643	759.587	97.104
	RCT	5	0.035	0.433	−0.813, 0.884	0.081	0.935	2.104	0.000
Perceived relatedness		19	0.064	0.076	−0.084, 0.212	0.844	0.398	74.157	75.727
	High/Low	17	0.032	0.067	−0.100, 0.164	0.476	0.634	49.518	67.689
	Outlier	16	0.020	0.057	−0.093, 0.132	0.340	0.734	29.420	49.014
	Theory-based							1.623[A]	
	Yes	17	0.097	0.080	−0.060, 0.254	1.215	0.224	68.960	76.798
	No	2	−0.214	0.231	−0.666, 0.238	−0.927	0.354	1.148	12.884
	Age							0.008[A]	
	Children	6	0.075	0.138	−0.195, 0.346	0.545	0.586	11.382	56.070
	Adolescents	13	0.061	0.095	−0.126, 0.248	0.636	0.525	62.630	80.840
	Study design							1.395[A]	
	CT	13	0.133	0.099	−0.061, 0.328	1.342	0.180	65.476	81.673
	RCT	6	−0.075	0.145	−0.360, 0.210	−0.514	0.607	8.569	41.653
Motivation									
Amotivation		6	−0.208	0.116	−0.436, 0.019	−1.794	0.073	23.509	78.732
	High/Low	4	−0.147	0.047	−0.240, −0.054	−3.106	0.002	1.726	0.000
	Outlier	5	−0.111	0.053	−0.215, −0.007	−2.083	0.037	4.633	13.654
	Study design							0.222[A]	
	CT	5	−0.241	0.173	−0.580, 0.097	−1.396	0.163	23.506	82.983
	RCT	1	−0.155	0.057	−0.266, −0.045	−2.751	0.006	0.000	0.000
External Regulation		5	−0.114	0.256	−0.616, 0.389	−0.443	0.657	51.822	92.281
	High/Low	3	−0.009	0.117	−0.237, 0.220	−0.074	0.941	3.494	42.753
	Outlier	4	0.097	0.139	−0.176, 0.370	0.697	0.486	8.407	64.315
Introjected Regulation		4	0.102	0.102	−0.098; 0.301	1.000	0.317	4.195	28.488
	High/Low	2	0.144	0.125	−0.101, 0.388	1.154	0.249	0.394	0.000
Identified Regulation		7	0.378	0.172	0.041, 0.714	2.199	0.028	59.177	89.861
	High/Low	5	0.291	0.153	−0.008, 0.591	1.907	0.057	24.414	63.616
	Outlier	6	0.218	0.137	−0.050, 0.485	1.594	0.111	29.507	83.282
	Study design							4.850[A]*	
	CT	6	0.456	0.202	0.060, 0.851	2.258	0.024	45.301	88.963
	RCT	1	−0.024	0.082	−0.185, 0.137	−0.294	0.769	0.000	0.000
Intrinsic Motivation		11	0.419	0.170	0.085, 0.752	2.460	0.014	108.884	90.816
	High/Low	9	0.325	0.148	0.035, 0.614	2.198	0.028	60.751	66.831
	Outlier	9	0.339	0.145	0.055, 0.622	2.343	0.019	50.306	84.096
	Theory-based							0.005[A]	
	Yes	10	0.421	0.179	0.071, 0.772	2.355	0.019	108.820	91.729
	No	1	0.391	0.385	−0.364, 1.145	1.015	0.310	0.000	0.000
	Age							0.571[A]	
	Children	6	0.290	0.201	−0.104, 0.683	1.442	0.149	35.758	86.017
	Adolescents	5	0.557	0.324	−0.057, 1.212	1.784	0.074	73.049	94.524
	Study design							5.775[A]*	

(*continued on next page*)

Table 4 (*continued*)

Variables		Effect size statistic						Heterogeneity statistic	
		k	g	SE	95% CI	Z	p	Q	I^2
	CT	10	0.471	0.190	0.099, 0.842	2.483	0.013	90.076	90.008
	RCT	1	−0.033	0.090	−0.209, 0.143	−0.371	0.710	0.000	0.000
SDI		8	0.672	0.286	0.112, 1.232	2.353	0.019	111.137	93.701
	High/Low	6	0.404	0.237	−0.062, 0.869	1.700	0.089	41.348	87.908
	Design							7.430^{A**}	
	CT	5	1.161	0.429	0.321, 2.001	2.708	0.007	98.572	95.942
	RCT	3	−0.061	0.131	−0.317, 0.196	−0.463	0.643	0.055	0.000
RAI		5	0.086	0.113	−0.135, 0.307	0.765	0.444	12.961	69.138
	High/Low	3	0.005	0.089	−0.169, 0.179	0.052	0.958	3.203	37.567
	Study design							8.434^{A**}	
	CT	4	−0.003	0.008	−0.160, 0.153	−0.043	0.996	3.660	18.043
	RCT	1	0.367	0.062	0.019, 0.264	2.270	0.023	0.000	0.000
Motivational climate									
Task/Mastery		9	0.254	0.080	0.097, 0.411	3.177	0.001	20.258	60.509
	High/Low	7	0.259	0.077	0.109, 0.409	3.386	0.001	13.098	54.193
Ego/Performance		9	−0.438	0.106	−0.646, −0.230	−4.121	0.000	38.182	79.048
	High/Low	7	−0.371	0.045	−0.460, −0.282	−8.180	0.000	1.951	0.000
	Outlier	8	−0.355	0.045	−0.442, −0.267	−7.924	0.000	6.919	0.000
Autonomy supportive climate		9	0.262	0.122	0.022, 0.501	2.140	0.032	62.477	87.195
	High/Low	7	0.280	0.121	0.043, 0.516	2.316	0.021	34.131	82.421
	Outlier		0.337	0.119	0.104, 0.570	2.833	0.005	42.270	83.440
	Age							9.486^{A**}	
	Children	2	0.605	0.088	0.433, 0.778	6.871	0.000	0.882	0.000
	Adolescents	7	0.138	0.123	−0.103, 0.380	1.121	0.262	33.931	82.317
	Study design							0.427^{A}	
	CT	4	0.172	0.190	−0.201, 0.545	0.904	0.366	32.352	90.727
	RCT	5	0.341	0.175	−0.003, 0.685	1.943	0.052	22.501	82.223
Goal Orientation									
Task		8	1.370	0.345	0.694, 2.045	3.972	0.000	96.124	92.718
	High/Low	6	1.118	0.359	0.414, 1.822	3.113	0.002	50.449	90.089
	Outlier	4	0.763	0.234	0.304, 1.222	3.260	0.001	6.101	50.824
Ego		8	−0.188	0.071	−0.327, −0.050	−2.668	0.008	7.325	4.438
	High/Low	6	−0.167	0.068	−0.300, −0.034	−2.460	0.014	1.261	0.000

Note: k = number of effect sizes; g = effect size (Hedges' g); SE = standard error; *95% CI* = 95% confidence intervals lower limit, upper limit; Z = test of the null hypothesis; I^2 = total variance explained by moderators; ^{A} between Q-value used to determine significant differences between moderators ($\alpha < 0.05$); RCT = randomized controlled trial; CT = controlled trial; SDI = self-determination Index; RAI = relative autonomy index; * indicates $p < 0.05$, **$p < 0.01$.

conducted exclusively in PE positively affected students' enjoyment, task orientation, and perception of mastery and performance climate. The magnitude of meta-analyzed effects was small to moderate . While Braithwaite et al. (2011) only focused on motivational climate interventions using the TARGET approach in PE, Burns et al. (2017) included studies that focused on student-centered approaches, where students were given choices and incorporated in decision-making; e.g. by using the Sport Education Model. The intervention components were implemented during the regular school day or after school (Burns et al., 2017). In contrast, our review and meta-analysis included studies that implemented established teaching approaches (e.g. TARGET, TGfU, Sport Education Model) as well as self-designed teaching approaches during the regular school day.

For a more comprehensive overview of intervention strategies used across the examined studies, we coded the intervention components using the standardized taxonomy by Michie et al., 2013) . The analysis of BCTs showed that a variety of techniques within 12 of 16 clusters was used among the studies. However, regardless of whether the examined outcome was enjoyment, goal orientation, motivational climate or self-determined motivation, similar techniques were frequently applied and little variation was observed. In the meta-analyzed studies, the most frequently applied techniques were identified within the clusters 'Shaping knowledge' (e.g. instruction on how to perform behavior), 'Comparison of behavior' (e.g. demonstration or social comparison of behavior), 'Repetition and substitution' (e.g. behavioral practice/rehearsal), and 'Antecedents' (e.g. restructuring physical/social environment) . Studies aiming at goal orientation also frequently included 'Goals and planning' strategies, whereas studies aiming at motivational climate additionally employed techniques within the clusters 'Feedback and monitoring' and 'Natural consequences' (e.g. Information about health consequences). Due to the numerous techniques used and the variety of outcomes measured within and across the studies, it is not possible to clearly identify, which individual BCT is essential and truly effective in changing a certain motivational outcome. Further research is needed to clarify which techniques are required to change a particular motivational outcome and thus to develop more effective interventions.

Similar to the meta-analyses by Burns et al. (2017) and Braithwaite et al. (2011), the overall pooled effects were affected by large heterogeneity, giving reason to further explore these in the subgroup analyses. Removing outliers and studies with the highest/lowest effect estimates reduced heterogeneity in most outcomes. Additionally, heterogeneity was explained by study characteristics (*i.e.* use of a theoretical framework), participant characteristics (*i.e.* age group of participants), and/or study design in the outcomes enjoyment, basic psychological needs, autonomy supportive climate, and intrinsic motivation. Significant differences between groups of moderators were found for the use of a theoretical framework in the outcome enjoyment ($p < 0.05$) and participants' age in the outcomes perceived autonomy ($p < 0.05$) and autonomy supportive climate ($p < 0.01$). Regarding the study design, significant differences between RCTs and CTs were confirmed in four out of 16 outcomes, *i.e.* identified regulation, intrinsic motivation (both $p < 0.05$), SDI, and RAI (both $p < 0.01$). However, the confidence in these findings is low since only one RCT was included in the analyses of these variables. This also holds true for SDI, where the underlying RCT by Lonsdale et al. (2013) included three intervention groups, therefore three separate analyses were performed, resulting in $k = 3$. These findings support the combined analysis of CTs and RCTs in this study. Overall, the small number of individual effect sizes for many meta-analyzed outcomes limited the number of examined moderators in the subgroup analyses. Other study features such as study duration or

Table 5
GRADE evidence profile.

Certainty assessment							Impact	Certainty
Nº of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations		
Enjoyment (follow up: range 3 weeks to 3 school years; assessed with: questionnaire)								
17	RCT (n = 3), CT (n = 14)	serious [a]	serious [b]	not serious	not serious	none	Meta-analysis revealed an overall small to moderate effect (Hedges' $g = 0.310$, 95% CI = 0.080; 0.541). Subgroup analyses identified small to moderate and significant effect estimates for theory-based studies (k = 12) ($p < 0.01$), studies in adolescents ($k = 10$) ($p < 0.01$) and in CTs ($k = 14$) ($p < 0.01$).	⊕⊕◯◯ LOW
Perceived autonomy (follow up: range 4 weeks to 7–8 months; assessed with: questionnaire)								
18	RCT(n = 4), CT(n = 14)	serious [a]	serious [c]	not serious	not serious	none	Meta-analysis revealed an overall small effect (Hedges' $g = 0.152$, 95% CI = 0.013; 0.290). Subgroup analyses identified small to moderate and significant effect estimates for studies in children (k = 4) (p < 0.01) and in CTs ($k = 14$) (p < 0.05).	⊕⊕◯◯ LOW
Perceived competence (follow up: range 1 days to 1 school year; assessed with: questionnaire)								
28	RCT(n = 5), CT (n = 13)	serious [a]	serious [d]	not serious	serious [e]	none	Meta-analysis revealed no significant effect (Hedges' $g = 0.080$, 95% CI = −0.247; 0.407).	⊕◯◯◯ VERY LOW
Perceived relatedness (follow up: range 4 weeks to 3 school years; assessed with: questionnaire)								
19	RCT (n = 6), CT (n = 13)	serious [a]	serious [f]	not serious	serious [e]	none	Meta-analysis revealed no significant effect (Hedges' $g = 0.064$, 95% CI = −0.084; 0.212).	⊕◯◯◯ VERY LOW
Amotivation (follow up: range 5 weeks to 1 school year; assessed with questionnaire)								
6	RCT (n = 1), CT (n = 5)	serious [a]	not serious [g]	not serious	serious [e]	none	Meta-analysis revealed no effect (Hedges' $g = -0.208$, 95% CI -0.436, 0.019).	⊕⊕◯◯ LOW
External regulation (follow up: range 5 weeks to 13 weeks; assessed with questionnaire)								
5	CT (n = 5)	serious [a]	serious [h]	not serious	serious [e]	none	Meta-analysis revealed no effect (Hedges' $g = -0.114$, 95% CI = −0.616; 0.389).	⊕◯◯◯ VERY LOW
Introjected regulation (follow up: range 6 weeks to 13 weeks; assessed with questionnaire)								
4	CT (n = 4)	serious [a]	not serious	not serious	serious [e]	publication bias strongly suspected	Meta-analysis revealed no effect (Hedges' $g = 0.102$, 95% CI = −0.098; 0.301).	⊕◯◯◯ VERY LOW
Identified regulation (follow up: range 5 weeks to 13 weeks; assessed with: questionnaire)								
7	RCT (n = 1), CT (n = 6)	serious [a]	very serious [i]	not serious	not serious	none	Meta-analysis revealed an overall moderate effect (Hedges' $g = 0.378$, 95% CI = 0.041; 0.714). Subgroup analysis identified moderate and significant effect estimates for CTs ($k = 6$) ($p < 0.05$).	⊕◯◯◯ VERY LOW
Intrinsic motivation (follow up: range 4 weeks to 13 weeks; assessed with: questionnaire)								
11	RCT (n = 1), CT (n = 10)	serious [a]	very serious [i]	not serious	not serious	none	Meta-analysis revealed an overall small to moderate effect (Hedges' $g = 0.419$, 95% CI = 0.085; 0.752). Subgroup analyses identified small to moderate and significant effect estimates for theory-based studies ($k = 10$) and CTs ($k = 1$) ($p < 0.05$).	⊕◯◯◯ VERY LOW
SDI (follow up: range 4 weeks to 13 weeks; assessed with: questionnaire)								
8	RCT (n = 3), CT (n = 5)	serious [a]	serious [i]	not serious	not serious	none	Meta-analysis revealed an overall moderate to large effect (Hedges' $g = 0.672$, 95% CI = 0.112; 1.232). Subgroup analyses identified large and significant effect estimates for CTs ($k = 5$) ($p < 0.01$).	⊕⊕◯◯ LOW
RAI (follow up: range 4 weeks to 10 weeks; assessed with: questionnaire)								
5	RCT (n = 1), CT (n = 4)	serious [a]	not serious [j]	not serious	serious [e]	None	Meta-analysis revealed a non-significant effect (Hedges' $g = 0.086$, 95% CI = −0.135; 0.307). Subgroup analyses identified a small to moderate and significant effect estimate for RCTs ($k = 1$) ($p < 0.05$).	⊕⊕◯◯ LOW
Task/Mastery climate (follow up: range 5 weeks to 12 months; assessed with: questionnaire)								
9		serious [a]	serious [k]	not serious	not serious	None	Meta-analysis revealed an overall small effect (Hedges' $g = 0.254$, 95% CI = 0.097; 0.411).	⊕⊕◯◯

(*continued on next page*)

Table 5 (*continued*)

Certainty assessment							Impact	Certainty
Nº of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations		
	CT (n = 9)							LOW
Ego/Performance climate (follow up: range 5 weeks to 12 months; assessed with: questionnaire)								
9	CT (n = 9)	serious [a]	not serious	not serious	not serious	None	Meta-analysis revealed an overall moderate effect (Hedges' $g = -0.438$, 95% CI = −0.646; −0.230).	⊕⊕⊕◯ MODERATE
Autonomy supportive climate (follow up: range 4 weeks to 15 months; assessed with: questionnaire)								
9	CT (n = 9)	serious [a]	serious [l]	not serious	not serious	None	Meta-analysis revealed an overall small effect (Hedges' $g = 0.262$, 95% CI = 0.022; 0.501). Subgroup analysis identified a moderate and significant effect estimate for studies in children ($k = 2$) ($p < 0.01$).	⊕⊕◯◯ LOW
Task goal orientation (follow up: range 2 weeks to 1 school year; assessed with: questionnaire)								
8	CT (n = 8)	serious [a]	serious [m]	not serious	not serious	publication bias strongly suspected	Meta-analysis revealed an overall large effect (Hedges' $g = 1.370$, 95% CI = 0.694; 2.045).	⊕◯◯◯ VERY LOW
Ego goal orientation (follow up: range 2 weeks to 1 school year; assessed with: questionnaire)								
8	CT (n = 8)	serious [a]	not serious	not serious	not serious	None	Meta-analysis revealed an overall small effect (Hedges' $g = -0.188$, 95% CI = −0.327; −0.050).	⊕⊕⊕◯ MODERATE

RCT = randomized controlled trial; CT = controlled trial; CI= Confidence interval.

Explanations.

a. Majority of information obtained from studies with high and/or unclear risk of bias in more than one of the assessed items. It was assumed that blinding of participants (and personnel) and outcome assessment would not significantly affect the intervention results, therefore, risk of bias was considered serious and only downgraded one point.

b. Heterogeneity was largely explained in RCTs (k = 3) but remaining subgroups were affected by substantial heterogeneity. Inconsistency was downgraded one point.

c. Heterogeneity was not present in children (k = 4) and in RCTs (k = 4) but remaining subgroups were affected by substantial heterogeneity. Inconsistency was downgraded one point.

d. Heterogeneity decreased after removing outlier studies and was explained in RCTs (k = 5) but remaining subgroups were affected by substantial heterogeneity. Inconsistency was downgraded one point.

e. Although the optimal information size was met (n > 400), the large CI around effect estimate with upper and lower limits included no effect. Imprecision was downgraded one point.

f. Heterogeneity was largely explained in non-theory based studies (k = 2) but remaining subgroups were affected by moderate to substantial heterogeneity. Inconsistency was downgraded one point.

g. Heterogeneity was explained after removing high/low effect studies and outlier studies.

h. Heterogeneity reduced after removing high/low effect studies and outlier studies but remained low to moderate. Inconsistency was downgraded one point.

i. Substantial heterogeneity was not explained in the subgroup analysis. Inconsistency was downgraded two points.

j. Heterogeneity was explained after removing high/low effect studies and in CTs.

k. Heterogeneity reduced after removing high/low effect studies but remained moderate. Inconsistency was downgraded one point.

l. Heterogeneity was explained in children (k = 2) but remaining subgroups were affected by substantial heterogeneity. Inconsistency was downgraded one point.

m. Heterogeneity decreased after removing outlier studies but remained moderate. Heterogeneity was downgraded one point.

intervention frequency may further help explain heterogeneity and should be considered in future studies when pooled effect estimates are based on a larger number of studies (Braithwaite et al., 2011).

4.2. Main findings-secondary outcomes

About 38% of the included studies reported significant results of school-based interventions on PA in favor of the IG. We did not calculate pooled effect estimates due to diversity in PA outcomes, measurement instruments and measurement time across the studies. However, the narrative summary of intervention effects on PA showed that studies reporting increased PA in PE classes predominantly implemented self-designed teaching approaches with BCTs in the clusters 'Antecedents', 'Repetition and substitution', 'Comparison of behavior', and 'Shaping knowledge'. In contrast, studies reporting significant results in PA behavior outside of PE and in leisure time most frequently implemented BCTs within the cluster 'Natural consequences" followed by 'Feedback and monitoring', Repetition and substitution', 'Goals and planning', 'Shaping knowledge', and 'Comparisons of behavior'. This could lead to the assumption that in order to increase situational PA (e.g. in PE) interventions should consider restructuring the physical/social environment or adding objects. When aiming to increase PA behavior over time, interventions should include information about health, social and environmental, or emotional consequences. However, this assumption is based on an uneven distribution of studies using different measurement tools. Future research should further examine which BCTs effectively increase PA of children and adolescents over time.

4.3. Methodological quality and certainty of evidence

Every study included in this review had a high risk of bias in more than one domain and was therefore considered at high risk for bias (see additional file 2). The RCT by Salmon et al. (2008) had the highest methodological quality: low risk of bias was found in each category except for blinding of participants/personnel and blinding of outcome assessment. Since school or research staff mainly provided the intervention components, and the primary outcome data were collected using self-report measures, it is not surprising that these categories were rated with a high risk of bias across all reviewed studies. These limitations lie in the nature of such field-based intervention studies and therefore should not be interpreted too strongly. However, the exclusion of these domains would only reduce the number of studies considered at high risk for bias by a factor of four. The remaining 53 studies had at least one other domain that was rated with high risk of bias. For example, random sequence generation and allocation concealment were insufficiently described or followed in most studies, thereby increasing the risk of an unintended intervention in the CG. Furthermore, many studies did not sufficiently report or examine baseline group differences. Of the 57 studies, only 18 studies reported insignificant baseline group differences, which could lead to an overestimation of intervention effects. In order to improve their methodological quality, future studies should make more effort to thoroughly describe randomization and allocation procedures, examine and report potential baseline group differences and attrition rates throughout the trial.

Although not evaluated using the Cochrane risk of bias tool, the diversity of questionnaires used to measure the same motivational outcomes could further affect the summary of results. In particular, several studies examined self-determined or autonomous motivation by calculating the SDI and RAI. Although we assume that both of these indices represent autonomous motivation and behavior is self-regulated, the studies did not calculate the indices uniformly. Additionally, intervention fidelity is not considered in this evaluation tool, which can have an impact on the effectiveness of interventions (Quested et al., 2017). However, on a positive note, several studies providing a teacher training verified intervention fidelity, e.g. by means of a pilot phase (Jones et al., 2010; Moreno-Murcia and Sànchez-Latorre, 2016; Perlman, 2010, 2011, 2015), videotaping or direct observation of lessons (Digelidis et al., 2003; Franco and Coterón, 2017; González-Cutre et al., 2018; Lonsdale et al., 2019; Meng and Keng, 2016; Smith et al., 2015, 2018; Todorovich & Curtner-Smith, 2002, 2003; Wallhead, Garn, & Vidoni, 2014; Wallhead and Ntoumanis, 2004; Yli-Piipari et al., 2018), weekly reports by the teachers (Hortigüela Alcalá and Garijo, 2017) or weekly meetings with the researchers (Blatsis et al., 2016; Méndez-Giménez et al., 2015). Additionally, the majority of reviewed studies provided little or no information on the tasks of the CG. It is therefore unclear how exactly the contents of a regular and a modified PE class differed. Future intervention developers are advised to disclose the strategies used to actively change their outcomes of interest in the IG and provide a detailed description of the control condition.

The methodological limitations identified on study level affected the certainty of evidence on outcome level. We applied the GRADE approach (Guyatt et al., 2008; Schünemann et al., 2013) to examine the certainty of evidence on meta-analyzed outcomes. A moderate certainty of evidence was found for ego goal orientation and ego/performance teaching climate; limited certainty of evidence was found for enjoyment, basic psychological needs and the various types of motivation and regulation characterized along the autonomy control continuum (Deci and Ryan, 2000; Ryan and Deci, 2017) including indices such as the SDI and RAI. The reasons for this lie in the downgrading of risk of bias, inconsistency, imprecision, and publication bias. Hence, it cannot be confirmed that the results of the meta-analyses provide reliable evidence on the effectiveness or lack of effectiveness of PA interventions on the majority of the examined motivational outcomes. This must be given special consideration when interpreting the results for the different types of motivation. Significant effects were found for intrinsic motivation, identified regulation and SDI, whereas non-significant effects were found for RAI. These conflicting results should not be interpreted too strongly because confidence in both the non-significant and significant findings is very low to low. In summary, it is not possible to draw an overall conclusion about the effectiveness of PA interventions on the different types of motivation and regulation ranging from amotivation to intrinsic motivation.

In addition to the methodological limitations of the primary studies, limitations at the review level must be addressed. It was not possible to include every study in the meta-analysis of motivational outcomes because several studies did not provide sufficient data to calculate Hedges' *g*. Additionally, we did not perform meta-analysis on PA outcomes and the summary of findings is based on a narrative description. Although the search strategy included many psychological variables linked to motivation, it cannot be assumed that a complete assessment of motivation and associated factors has been made. For example, the term intention was not included in the search strategy despite its relation to PA behavior of children and adolescents (Sallis et al., 2000).The search also did not include non-English articles and grey literature, which may result in an incomplete coverage of all studies in this area. Lastly, we did not perform an in-depth analysis of theory use of the included studies. Although the majority of reviewed studies were described as theory-based, we do not know in which way the interventions were guided by the underlying theory. Therefore, the comparison of the effectiveness of non-theory based studies and theory-based studies in the subgroup analyses must be interpreted with caution. Nevertheless, this systematic review and meta-analysis give first insights into the effectiveness of PA interventions on students' motivation towards PA. Using the previously published and comprehensive search strategy, we were able to review 57 studies using an internationally accepted tool for quality assessment within studies (Higgins and Green, 2011) and evaluated the evidence on outcome level using the GRADE methodology (Schünemann et al., 2013). The large inconsistency of findings give reason for future studies to explore moderating factors of motivation in more detail. Different types of motivation and motivational strategies may be of relevance depending on sex/gender, socio-economic status and exercise habits.

5. Conclusion

The results of this systematic review and meta-analysis suggest that school-based PA interventions may be effective on a variety of motivational outcomes such as enjoyment, perceived autonomy, intrinsic motivation, motivational climate, and goal orientation. The certainty of evidence, however, ranged from very low to moderate, depending on the examined outcome. The narrative synthesis of findings on PA also indicated that school-based PA interventions may increase activity levels of children and adolescents in PE as well as in leisure time.

In order to synthesize information on effective intervention components that were used in the reviewed studies, behavior change techniques were coded using a standardized taxonomy. The analysis revealed that the techniques used to increase motivation towards PA varied across the studies and in relation to the examined outcomes. This was also evident for PA outcomes, where intervention strategies varied depending on the domain where information on PA behavior was collected (in class or in leisure time). Further research is needed to investigate which strategies are truly effective and needed to increase motivation towards PA and PA behavior in children and adolescents. To this end, future intervention developers are advised to describe their intervention components in a standardized manner.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and material

Not applicable.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.psychsport.2020.101770.

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References

Almolda-Tomas, F., Sevil-Serrano, J., Julian-Clemente, J., Abarca-Sos, A., Aibar-Solana, A., & Garcia-Gonzalez, L. (2014). Application of teaching strategies for improving students' situational motivation in physical education. *Rev Electron Investig Psicoeduc Psigopedag, 12*(2), 391–417.

Ames, C. (1992). Classrooms: goals, structures, and student motivation. *Journal of Educational Psychology, 84*, 261–271.

Ames, C., & Archer, J. (1988). Achievement goals in the classroom: students' learning strategies and motivation processes. *Journal of Educational Psychology, 80*(3), 260–267.

* Barzouka, K., Sotiropoulos, K., & Kioumourtzoglou, E. (2015). The effect of feedback through an expert model observation on performance and learning the pass skill in volleyball and motivation. *Journal of Physical Education & Sport, 15*(3), 407–416.

* Blatsis, P., Saraslanidis, P., Barkoukis, V., Manou, V., Tzavidas, K., Palla, S., et al. (2016). The effect of IAAF Kids Athletics on the physical fitness and motivation of elementary school students in track and field. *Journal of Physical Education and Sport, 16*(3), 883–896.

* Braga, R. K., De Lima, C. A. F., Moyses, S. J., Moyses, S. T., & Werneck, R. I. (2017). Virtual games assets: strategy potential to promote health and combat obesity school. *Motricidade, 13*(S1), 121–128.

Braithwaite, R., Spray, C. M., & Warburton, V. E. (2011). Motivational climate interventions in physical education: a meta-analysis. *Psychology of Sport and Exercise, 12*(6), 628–638.

* Brankovic, E., & Hadzikadunic, M. (2017). Physical education experimental program to test the effect on perceived competence. *Sport Mont, 15*(2), 25–30.

Bunker, D., & Thorpe, R. D. (1982). A model for the teaching of games in secondary schools. *Bulletin of Physical Education, 18*, 7–10.

Burns, R. D., Fu, Y., & Podlog, L. W. (2017). School-based physical activity interventions and physical activity enjoyment: a meta-analysis. *Preventive Medicine, 103*, 84–90.

* Bush, L. P., Laberge, S., & Laforest, S. (2010). Physical activity promotion among underserved adolescents: "make it fun, easy, and popular". *Health Promot Practice, 11* (3 Suppl. l), 79S–87S.

* Di Cagno, A., Crova, C., & Pesce, C. (2006). Effects of educational rhythm-based learning on coordinative motor performance and sports enjoyment of male and female pupils. *Journal of Human Movement Studies, 51*(3), 143–165.

* Chang, Y. K., Chen, S., Tu, K. W., et al. (2016). Effect of autonomy support on self-determined motivation in elementary physical education. *Journal of Sports Science and Medicine, 15*(3), 460–466.

* Chatzisarantis, N. L. D., & Hagger, M. S. (2009). Effects of an intervention based on self-determination theory on self-reported leisure-time physical activity participation. *Psychol Health, 24*(1), 29–48.

* Chiva-Bartoll, Ó., Salvador-García, C., & Ruiz-Montero, P. J. (2018). Teaching games for understanding and cooperative learning: can their hybridization increase motivational climate among physical education students?. *Croatian Journal of Education, 20*(2), 561–584.

* Christodoulidis, T., Papaioannou, A., & Digelidis, N. (2001). Motivational climate and attitudes towards exercise in Greek senior high school: a year-long intervention. *European Journal of Sport Science, 1*(4), 1.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (second ed.). Hillsdale, NJ: Erlbaum.

* Cuevas, R., García- López, L. M., & Serra- Olivares, J. (2016). Sport education model and self-determination theory: an intervention in secondary school children. *Kinesiology, 48*(1), 30–38.

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227–268.

Demetriou, Y., & Honer, O. (2012). Physical activity interventions in the school setting: a systematic review. *Psychology of Sport and Exercise, 13*(2), 186–196.

Demetriou, Y., Sudeck, G., & Höner, O. (2014). Indirekte Gesundheitseffekte des Unterrichtsprogramms HealthyPEP. *Sportwiss, 44*(2), 86–98.

Demetriou, Y., Sudeck, G., Thiel, A., & Höner, O. (2015). The effects of school-based physical activity interventions on students' health-related fitness knowledge: a systematic review. *Educational Research and Reviews, 16*, 19–40.

Demetriou, Y., Reimers, A. K., Alesi, M., Scifo, L., Borrego, C., Monteiro, D., et al. (2019). Effects of school-based interventions on motivation towards physical activity in children and adolescents: protocol for a systematic review. *Systematic reviews, 8* (113).

* Digelidis, N., Papaioannou, A., Laparidis, K., & Christodoulidis, T. (2003). A one-year intervention in 7th grade physical education classes aiming to change motivational climate and attitudes towards exercise. *Psychology of Sport and Exercise, 4*(3), 195–210.

* Dudley, D. A., Okely, A. D., Pearson, P., & Peat, J. (2010). Engaging adolescent girls from linguistically diverse and low income backgrounds in school sport: a pilot randomised controlled trial. *Journal of Science and Medicine in Sport, 13*(2), 217–224.

Dudley, D., Okely, A., Pearson, P., & Cotton, W. (2011). A systematic review of the effectiveness of physical education and school sport interventions targeting physical activity, movement skills and enjoyment of physical activity. *European Physical Education Review, 17*(3), 353–378.

Eime, R. M., Young, J. A., Harvey, J. T., Charity, M. J., & Payne, W. R. (2013). A systematic review of the psychological and social benefits of participation in sport for children and adolescents: informing development of a conceptual model of health through sport. *International Journal of Behavioral Nutrition and Physical Activity, 10* (98), 98.

* Elbe, A. M., Wikman, J. M., Zheng, M., Larsen, M. N., Nielsen, G., & Krustrup, P. (2017). The importance of cohesion and enjoyment for the fitness improvement of 8-10-year-old children participating in a team and individual sport school-based physical activity intervention. *European Journal of Sport Science, 17*(3), 343–350.

Epstein, J. L. (1989). Family structures and student motivation: a developmental perspective. In C. Ames, & R. Ames (Eds.), *Research on Motivation in Education* (vol. 3, pp. 259–295). New York: Academic Press.

* Fairclough, S., & Stratton, G. (2005). Improving health-enhancing physical activity in girls' physical education. *Health Education Research, 20*(4), 448–457.

* Fairclough, S. J., McGrane, B., Sauders, G., Taylor, S., Owen, M., & Curry, W. (2016). A non-equivalent group pilot trial of a school-based physical activity and fitness intervention for 10-11 year Old English children: born to move. *BMC Public Health, 16*(1).

* Franco, E., & Coterón, J. (2017). The effects of a physical education intervention to support the satisfaction of basic psychological needs on the motivation and intentions to Be physically active. *Journal of Human Kinetics, 59*(1), 5–15.

* Fu, Y., Gao, Z., Hannon, J. C., Schultz, B., Newton, M., & Sibthorp, J. (2013). Influence of a health-related physical fitness model on students' physical activity, perceived competence, and enjoyment. *Perceptual & Motor Skills, 117*(3), 956–970.

* Fu, Y., Gao, Z., Hannon, J. C., Burns, R. D., & Brusseau, T. A. (2016). Effect of the SPARK program on physical activity, cardiorespiratory endurance, and motivation in middle-school students. *Journal of Physical Activity and Health, 13*(5), 534–542.

* González-Cutre, D., Sierra, A. C., Beltrán-Carrillo, V. J., Peláez-Pérez, M., & Cervelló, E. (2018). A school-based motivational intervention to promote physical activity from a self-determination theory perspective. *Journal of Education Research, 111*(3), 320–330.

* Gorely, T., Nevill, M. E., Morris, J. G., Stensel, D. J., & Nevill, A. (2009). Effect of a school-based intervention to promote healthy lifestyles in 7-11 year old children. *International Journal of Behavioral Nutrition and Physical Activity, 6*, 5.

Goudas, M., & Biddle, S. (1994). Perceived motivational climate and intrinsic motivation in school physical education classes. *European Journal of Psychology of Education, 9*(3), 241–250.

Guyatt, G. H., Oxman, A. D., Vist, G. E., Kunz, R., Falck-Ytter, Y., Alonso-Coello, P., et al. (2008). GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ, 336*(7650), 924–926.

Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., Ekelund, U., et al. (2012). Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet, 380*(9838), 247–257.

* Harrington, D. M., Davies, M. J., Bodicoat, D. H., Charles, J. M., Chudasama, Y. V., Gorely, T., et al. (2018). Effectiveness of the 'Girls Active' school-based physical activity programme: a cluster randomised controlled trial. *International Journal of Behavioral Nutrition and Physical Activity, 15*(1), 40.

Van Hecke, L., Loyen, A., Verloigne, M., van der Ploeg, H. P., Lakerveld, J., Brug, J., et al. (2016). Variation in population levels of physical activity in European children and adolescents according to cross-European studies: a systematic literature review within DEDIPAC. *International Journal of Behavioral Nutrition and Physical Activity, 13*, 70.

Hedges, L. V., & Olkin, I. (1985). *Statistical Methods for Meta-Analysis*. Sand Diego, CA: Academic Press.

Hedges, L. V., & Vevea, J. L. (1998). *Fixed and Random Effects Models in Meta-Analysis*. New York: Russel Sage Foundation.

Higgins, J. P. T., & Green, S. (Eds.). (2011). *Cochrane Handbook for Systematic Reviews of Interventions*. The Cochrane Collaboration [updated March 2011] Version 5.1.0. .

Higgins, J. P., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *BMJ, 327*(7414), 557–560.

Higgins, J. P. T., Altman, D. G., Gøtzsche, P. C., Jüni, P., Moher, D., Oxman, A. D., et al. (2011). The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ, 343*.

* Hobin, T. M., Subramaniam, P. R., & Wuest, D. A. (2018). The impact of a novel sports activity on student motivation in high school physical education. *International Journal of Physical Education, 55*(1), 15–27.

* Hortigüela Alcalá, D., & Garijo, A. H. (2017). Teaching games for understanding: a comprehensive approach to promote student's motivation in physical education. *Journal of Human Kinetics, 59*(1), 17–27.

Ickes, M. J., Erwin, H., & Beighle, A. (2013). Systematic review of recess interventions to increase physical activity. *Journal of Physical Activity and Health, 10*(6), 910–926.

* Jamner, M., Spruijt-Metz, D., Bassin, S., & Cooper, D. (2004). A controlled evaluation of a school-based intervention to promote physical activity among sedentary adolescent females: Project FAB. *Journal of Adolescent Health, 34*(4), 279–289.

Janssen, I., & Leblanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity, 7*(1), 40.

* Jones, R., Marshall, S., & Peters, D. (2010). Can we play a game now? The intrinsic benefits of TGfU. *European Journal of Physical and Health Education, 4*(2), 57–63.

* Kokkonen, J., Yli-Piipari, S., Kokkonen, M., & Quay, J. (2018). Effectiveness of a creative physical education intervention on elementary school students' leisure-time physical activity motivation and overall physical activity in Finland. *European Physical Education Review, 25*(3).

* Lonsdale, C., Lester, A., Owen, K. B., White, R. L., Peralta, L., Kirwan, M., et al. (2019). An internet-supported school physical activity intervention in low socioeconomic status communities: results from the Activity and Motivation in Physical Education (AMPED) cluster randomised controlled trial. *British Journal of Sports Medicine, 53*(6), 341–347. https://doi.org/10.1136/bjsports-2017-097904.

* Lonsdale, C., Rosenkranz, R. R., Sanders, T., Peralta, L., Bennie, A., Jackson, B., et al. (2013). A cluster randomized controlled trial of strategies to increase adolescents' physical activity and motivation in physical education: results of the Motivating Active Learning in Physical Education (MALP) trial. *Preventive Medicine, 57*(5), 696–702.

* Méndez-Giménez, A., Fernández-Río, J., & Méndez-Alonso, D. (2015). Sport education model versus traditional model: effects on motivation and sportsmanship. *Revista Internacional de Medicina y Ciencias de la Actividad Fisica y del Deporte, 15*(59), 449–466.

* Meng, H. Y., & Keng, J. W. C. (2016). The effectiveness of an autonomy-supportive teaching structure in physical education. *RICYDE. Revista internacional de ciencias del deporte, 12*(43), 5–28.

* Meng, H. Y., Whipp, P., Dimmock, J., & Jackson, B. (2013). The effects of choice on autonomous motivation, perceived autonomy support, and physical activity levels in high school physical education. *Journal of Teaching in Physical Education, 32*(2), 131–148.

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., et al. (2013). The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Annals of Behavioral Medicine, 46*(1), 81–95.

* Miller, A., Christensen, E., Eather, N., Gray, S., Sproule, J., Keay, J., et al. (2016). Can physical education and physical activity outcomes be developed simultaneously using a game-centered approach?. *European Physical Education Review, 22*(1), 113–133.

* Moreno, J. A., Gonzalez-Cutre, D., Martin-Albo, J., & Cervello, E. (2010). Motivation and performance in physical education: an experimental test. *Journal of Sports Science and Medicine, 9*(1), 79–85.

* Moreno-Murcia, J. A., & Sànchez-Latorre, F. (2016). The effects of autonomy support in physical education classes. *RICYDE. Revista internacional de ciencias del deporte, 12*(43), 79–89.

* Nation-Grainger, S. (2017). "It's just PE 'till' it felt like a computer game": using technology to improve motivation in physical education. *Research Papers in Education, 32*(4), 463–480.

Ng, J. Y. Y., Ntoumanis, N., Thøgersen-Ntoumani, C., Deci, E. L., Ryan, R. M., Duda, J. L., et al. (2012). Self-determination theory applied to health contexts. *Perspectives on Psychological Science, 7*(4), 325–340.

Owen, K., Smith, J., Lubans, D. R., Ng, J. Y. Y., & Lonsdale, C. (2014). Self-determined motivation and physical activity in children and adolescents: a systematic review and meta-analysis. *Preventive Medicine, 67*, 270–279.

* Palmer, S. E., Bycura, D. K., & Warren, M. (2018). A physical education intervention effects on correlates of physical activity and motivation. *Health Promot Practice, 19*(3), 455–464.

* Pardo, B. M., Bengoechea, E. G., Clemente, J. A. J., & Lanaspa, E. G. (2016). Motivational outcomes and predictors of moderate-to-vigorous physical activity and sedentary time for adolescents in the sigue La huella intervention. *International Journal of Behavioral Medicine, 23*(2), 135–142.

Pate, R. R., & O'Neill, J. R. (2009). After-school interventions to increase physical activity among youth. *British Journal of Sports Medicine, 43*(1), 14–18.

* Patmanoglou, S., Mantis, K., Digelidis, N., et al. (2008). The command and self-check styles for more effective teaching of tennis at the elementary school. *International Journal of Physical Education, 45*(1), 26–32.

Penedo, F. J., & Dahn, J. R. (2005). Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry, 18*(2), 189–193.

* Perlman, D. (2010). Change in affect and needs satisfaction for amotivated students within the Sport Education Model. *Journal of Teaching in Physical Education, 29*(4), 433–445.

* Perlman, D. J. (2011). Examination of self-determination within the sport education model. *Asia-Pacific Journal of Health Sport & Physical Education, 2*(1), 79–92.

* Perlman, D. J. (2015). Help motivate the amotivated by being a supportive teacher. *Physical Education & Sport Pedagogy, 20*(2), 204–214.

* Prusak, K. A., Treasure, D. C., Darst, P. W., & Pangrazi, R. P. (2004). The effects of choice on the motivation of adolescent girls in physical education. *Journal of Teaching in Physical Education, 23*(1), 19–29.

Quested, E., Ntoumanis, N., Thogersen-Ntoumani, C., Hagger, M. S., & Hancox, J. E. (2017). Evaluating quality of implementation in physical activity interventions based on theories of motivation: current challenges and future directions. *International Review of Sport and Exercise Psychology, 10*(1), 252–269.

Ryan, R. M., & Deci, E. L. (2017). *Self-Determination Theory: Basic Pyschological Needs in Motivation, Development, and Wellness* (p. 756). New York; London: The Guilford Press.

Ryan, R. M., Patrick, H., Deci, E. L., & Williams, G. C. (2008). Facilitating health behavior change and its maintenance: interventions based on Self-Determination Theory. *The European Health Psychologist, 10*(1), 2–5.

Sallis, J. F., Prochaska, J. J., & Taylor, W. C. (2000). A review of correlates of physical activity of children and adolescents. *Medicine & Science in Sports & Exercise, 32*(5), 963–975.

* Salmon, J., Hume, M., & Crawford, D. (2008). Outcomes of a group-randomized trial to prevent excess weight gain, reduce screen behaviours and promote physical activity in 10-year-old children: switch-play. *International Journal of Obesity, 32*(4), 601–612.

Schünemann, H. B. J., Guyatt, G., & Oxman, A. (Eds.). (2013). *GRADE Handbook for Grading the Quality of Evidence and the Strength of Recommendations*. GRADE Working Group (updated October 2013).

* Sevil, J., Abos, A., Aibar, A., Julián, J. A., & Garcia-Gonzalez, L. (2016). Gender and corporal expression activity in physical education: effect of an intervention on students' motivational processes. *European Physical Education Review, 22*(3), 372–389.

* Shannon, S., Brennan, D., Hanna, D., Younger, Z., Hassan, J., & Breslin, G. (2018). The effect of a school-based intervention on physical activity and well-being: a non-randomised controlled trial with children of low socio-economic status. *Sports Med Open, 4*(1), 16.

Siedentop, D. (1994). *Sport Education : Quality PE through Positive Sport Experiences*. Champaign, IL: Human Kinetics Publishers.

Singh, A., Uijtdewilligen, L., Twisk, J. W., van Mechelen, W., & Chinapaw, M. J. (2012). Physical activity and performance at school-A systematic review of the literature including a methodological quality assessment. *Archives of Pediatrics and Medicine, 166*(1), 49–55.

van Sluijs, E. M., McMinn, A. M., & Griffin, S. J. (2007). Effectiveness of interventions to promote physical activity in children and adolescents: systematic review of controlled trials. *BMJ, 335*(7622), 703.

* Smith, L., Harvey, S., Savory, L., Fairclough, S., Kozub, S., & Kerr, C. (2015). Physical activity levels and motivational responses of boys and girls: a comparison of direct instruction and tactical games models of games teaching in physical education. *European Physical Education Review, 21*(1), 93–113.

* Smith, J. J., Beauchamp, M. R., Faulkner, G., Morgan, P. J., Kennedy, S. G., & Lubans, D. R. (2018). Intervention effects and mediators of well-being in a school-based physical activity program for adolescents: the 'Resistance Training for Teens' cluster RCT. *Mental Health and Physical Activity, 15*, 88–94.

* Spittle, M., & Byrne, K. (2009). The influence of sport education on student motivation in physical education. *Physical Education and Sport Pedagogy, 14*(3), 253–266.

van Stralen, M. M., Yildirim, M., te Velde, S. J., Brug, J., van Mechelen, W., Chinapaw, M. J., et al. (2011). What works in school-based energy balance behaviour interventions and what does not? A systematic review of mediating mechanisms. *International Journal of Obesity, 35*(10), 1251–1265.

* Todorovich, J., R., & Curtner-Smith, M., D. (2002). Influence of the motivational climate in physical education on sixth grade pupils' goal orientations. *European Physical Education Review, 8*(2), 119–138.

* Todorovich, J. R., & Curtner-Smith, M. D. (2003). Influence of the motivational climate in physical education on third grade students' task and ego orientations. *Journal of Classroom Interaction, 38*(1), 36–46.

Vallerand, R. J. (1997). Toward A hierarchical model of intrinsic and extrinsic motivation. *Advances in Experimental Social Psychology, 29*, 271–360.

* Wallhead, T., L, Garn, A., C., & Vidoni, C. (2014). Effect of a sport education program on motivation for physical education and leisure-time physical activity. *Research Quarterly for Exercise & Sport, 85*(4), 478–487.

* Wallhead, T. L., & Ntoumanis, N. (2004). Effects of a sport education intervention on students' motivational responses in physical education. *Journal of Teaching in Physical Education, 23*(1), 4–18.

* Wang, J. J., Baranowski, T., Lau, P. W. C., Buday, R., & Gao, Y. (2017). Story immersion may Be effective in promoting diet and physical activity in Chinese children. *Journal of Nutrition Education and Behavior, 49*(4), 321–329.e1.

* Weigand, Daniel, A., & Burton, Shane (2002). Manipulating achievement motivation in physical education by manipulating the motivational climate. *European Journal of Sport Science, 2*(1), 1.

World Health Organization. (2010). *Global recommendations on physical activity for health*. Geneva: WHO Press.

* Yli-Piipari, S., Layne, T., Hinson, J., & Irwin, C. (2018). Motivational pathways to leisure-time physical activity participation in urban physical education: a cluster-randomized trial. *Journal of Teaching in Physical Education, 37*(2), 123–132.

* Zach, S., Raviv, T., & Meckel, Y. (2016). Using information communication technologies (ICTs) for motivating female adolescents to exercise/run in their leisure time. *Computers in Human Behavior, 60*, 593–601.