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Self-Determination Theory Applied to Physical Education: A Systematic Review and Meta-Analysis

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In this review we examine the evidence regarding self-determination theory within the school physical education context. We applied a multilevel structural equation modeling approach to meta-analyze data from a systematic review that identified 265 relevant studies. In line with theory, autonomous motivation was positively correlated with adaptive outcomes and negatively correlated with maladaptive outcomes. Introjected regulation was modestly correlated with both adaptive and maladaptive outcomes. External regulation and amotivation both showed negative relationships with adaptive outcomes, and positive relationship with maladaptive outcomes. Also supporting SDT, autonomy, competence, and relatedness satisfactions were strongly correlated with autonomous student motivation, and less strongly, but still positively, correlated with introjected regulation. Weak negative correlations were found between autonomy, competence, and relatedness and external regulation. Amotivation had moderate negative correlations with needs satisfaction. Findings further revealed that teachers more greatly impact classroom experiences of autonomy and competence, whereas relatedness in physical education is associated with both peer and teacher influences.

Educational Impact and Implications Statement

We found that the different types of motivation identified in SDT differentially predict student outcomes in predicted ways, and that these motivations are systematically associated with instructor supports for students' basic psychological needs. Although teachers can support all three students' psychological needs, teachers appear to have greater influence on students' autonomy and competence, whereas peers seem to have more impact on students' relatedness. These results have implications for the design of teacher and peer focused interventions.

Keywords: autonomy, classroom learning, meta-analysis, motivation, physical education

Supplemental materials: <http://dx.doi.org/10.1037/edu0000420.supp>

A recent bibliometric study highlighted that motivation is the leading theme within the field of sport and exercise psychology

across different contexts, such as sport, exercise, health psychology, and school physical education (Lindahl, Stenling, Lindwall,

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understanding the potential effect needs support may have on students' outcomes, this review will be able to help delineate what might optimally be a focus in physical education interventions and training.

Self-determination theory (Deci & Ryan, 1985; Ryan & Deci, 2000a, 2017) describes the process through which motivation develops and how it influences human behavior and wellbeing. Embedded within SDT, the basic psychological needs minitheory states that for high quality motivation to develop and for individuals to achieve optimal functioning, three fundamental needs must be fulfilled—the need for autonomy, the need for competence, and the need for relatedness (Garn, McCaughy, Martin, Shen, & Fahlman, 2012; Standage, Duda, & Ntoumanis, 2005; Taylor & Lonsdale, 2010; van Aart, Hartman, Elferink-Gemser, Mombarg, & Visscher, 2015). Autonomy can be defined as one's need to experience a sense of willingness in one's actions. Competence refers to one's need to experience effectiveness in one's interactions with the world, whereas relatedness refers to a need for connectedness with significant others, satisfaction with the social world, and a feeling of being accepted (Ryan & Deci, 2017). If these needs are met, people are more likely to be well, and to be autonomously motivated. In contrast, when these needs are not met (or only partially fulfilled), individuals tend to regulate their behavior based on controlled reasons (McDavid, Cox, & McDonough, 2014; Mouratidis, Barkoukis, & Tsorbatzoudis, 2015; Ntoumanis, 2001; Standage et al., 2005).

SDT also postulates different types of motivation (Ryan & Deci, 2000a). Organismic integration theory is a subtheory within SDT that describes these different types of motivation, known as behavioral regulations. SDT goes beyond a binary conceptualization of intrinsic and extrinsic motivation as it outlines four different types of motivation under the broad category of extrinsic motivation. Figure 1 depicts six types of regulation on what it is known as a self-determination continuum, ranging from amotivation (i.e., lack of motivation) to the most autonomous forms of motivation (e.g., intrinsic motivation, identification; Ntoumanis, 2001; Standage et al., 2005). The four different types of extrinsic motivation vary in their individual characteristics, as well as in the amount of autonomy they represent (e.g., Litalien et al., 2017). The least autonomous form of extrinsic motivation is external regulation (doing an activity for contingent rewards or punishments controlled by others), followed by introjected regulation (acting to avoid sense of guilt or anxiety or to protect contingent self-worth). On the more autonomous side are identified regulation (when the



task is aligned with personal values), and integrated regulation (when activity is fully assimilated with individual's sense of self). Indeed, although these different types of motivation form a continuum, they have also been categorized in some analyses as autonomous motivations (intrinsic motivation, integrated, and identified regulation; e.g., Cheon, Reeve, & Moon, 2012; Haerens, Aelterman, Vansteenkiste, Soenens, & Van Petegem, 2015; Hagger et al., 2009; Shen, McCaughy, Martin, & Fahlman, 2009; Yoo, 2015) and controlled motivations (introjected and external regulation; e.g., Aelterman et al., 2012; De Meyer et al., 2016; Gairns, Whipp, & Jackson, 2015; Karagiannidis, Barkoukis, Gourgoulis, Kosta, & Antoniou, 2015; Lodewyk & Pybus, 2013; Mouratidis et al., 2015; van Aart et al., 2015).

Internalization is often considered one of the most challenging aims in teaching, because not all tasks or activities are intrinsically motivating (Deci, Vallerand, Pelletier, & Ryan, 1991) and yet may be important to students. Helping students develop more internalized value and autonomous motivation for such activities is thus an aim of instruction. SDT hypothesizes that support form basic psychological needs enhances internalization. In the field of physical education, social agents (e.g., teacher and peers) vary in terms of how much they support or thwart students' basic psychological need satisfaction. SDT predicts that this directly influences students' need satisfaction and frustration, which in turn predicts how autonomous or controlled students become in classrooms (Koka, 2013b, 2014; Tessier, Sarrazin, & Ntoumanis, 2010; Van den Bergh, Cardon, Tallir, Kirk, & Haerens, 2016). Finally, more autonomous forms of student motivation are associated with more desirable cognitive, behavioral, and affective outcomes for students (Ntoumanis, 2001; Ntoumanis, Taylor, & Standage, 2010; Standage et al., 2005). This sequence is illustrated in Figure 2—adapted from Vallerand (1997)—in which support from social agents is depicted as a direct predictor of students' perception of need satisfaction, and an indirect predictor of motivation and adaptive experiences and/or learning outcomes.

A needs supportive environment encompasses support for autonomy, competence, and relatedness. In the education context, supporting students' autonomy means nurturing their inner motivational resources by respecting their attitudes and suggestions

(e.g., adopting the students' perspective to do an activity), providing rationales to attribute meaningfulness to learning (e.g., explaining why a task is important and where/when it could be used), relying on noncontrolling language, providing opportunities for choice, displaying patience to allow students the time they need for self-paced learning to occur, and acknowledging and accepting expressions of negative affect (Reeve, 2009). For example, an experimental study of 1,158 physical education students by Cheon et al. (2012) found that students' autonomous motivation, amotivation, classroom engagement, skill development, future intentions to exercise, and academic achievement improved for students whose teachers were more supportive of their autonomy.

Competence support refers to the way the teacher organizes and delivers the activities. Competence support is seen in SDT as supported by structure—when teachers provide clear expectations of the students (e.g., sticking to the rules they have set in the class), demonstrate consistent contingencies for behavior (e.g., not acting differently regardless of students' performance on a task), offer efficacy-relevant feedback and help (e.g., showing different ways for the students to solve a problem), and monitor during the lesson (e.g., checking if students are ready before he or she goes on; Belmont, Skinner, Wellborn, & Connell, 1992). Within the physical education context, for example, an empirical study by Sanchez-Oliva, Sanchez-Miguel, Leo, Kinnafick, and García-Calvo (2014), with 1,692 Spanish students, found that competence support from the teacher predicted students' autonomous motivation, which in turn positively predicted students' enjoyment, perceived importance of physical education, and intentions to further participate in out of school physical activity.

Relatedness support (i.e., involvement) includes teachers taking time to express enjoyment in their interactions with students, showing affection (e.g., demonstrating that he or she cares about the students), displaying attentiveness (e.g., teacher showing that he or she knows the students well), being dependable (e.g., being there for the students when needed), and dedicating resources (e.g., spending time and talking with the students). For example, an experimental study by Sparks, Lonsdale, Dimmock, and Jackson (2017) found teacher relatedness support predicted students' en-

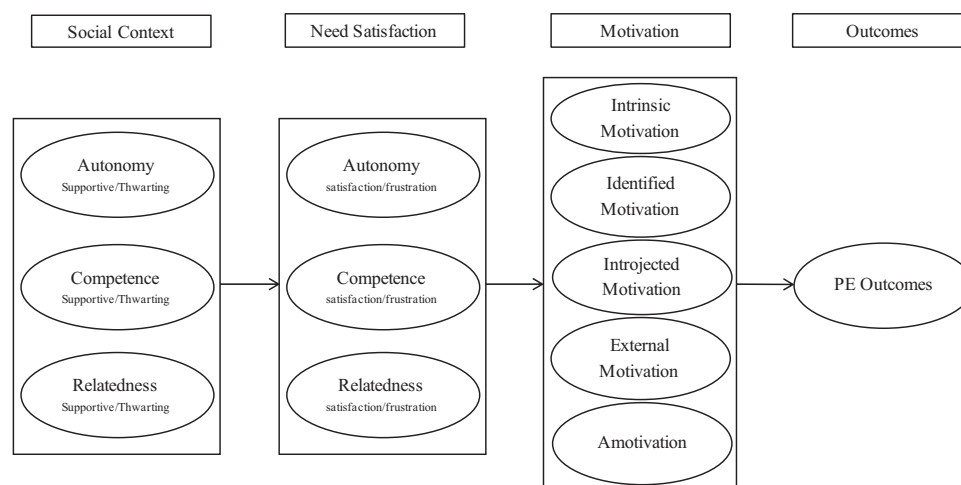


Figure 2. Model of motivational sequence in the context of school physical education.

joyment, confidence in their teacher's ability, and their estimation of their peers' confidence in their ability.

Teachers may also engage in controlling behavior, where they determine what students should do during the lesson without considering students' perspectives or input, rely on pressure-inducing language, and pressure students to think, feel, and behave in a specific ways (Reeve, 2009). In the school physical education context, research has found that perceptions of controlling teaching predicted undesirable outcomes, such as poor quality student motivation, fear of failure, and less engagement (Bartholomew et al., 2018; De Meyer et al., 2014, 2016; Haerens et al., 2015; Van den Berghe et al., 2016).

Previous Reviews

Researchers have reviewed some of the evidence involving SDT constructs and related consequences in the context of school physical education (e.g., Chatzisarantis, Hagger, Biddle, Smith, & Wang, 2003; Chen, Chen, & Zhu, 2012; Ntoumanis & Standage, 2009; Van den Berghe, Vansteenkiste, Cardon, Kirk, & Haerens, 2014). However, none of these reviews have applied a meta-analytic approach to examine tenets of the SDT-based motivational sequence model in physical education (Ryan & Deci, 2017; Vallerand, 1997). For example, Ntoumanis and Standage's (2009) review was narrative, rather than systematic, and Van den Berghe et al.'s (2014) systematic review did not include a meta-analysis. Other reviews included meta-analyses, but focused on a relatively narrow aspect of the model. For example, Chatzisarantis et al. (2003) examined the associations among perceived competence, self-determined motivation, and intentions toward physical activity in the exercise, sport, and physical education settings, while Chen et al. (2012) reviewed the association between motivation and competence-based outcomes. Our review includes a systematic approach designed to include all relevant literature and:

1. use meta-analysis to quantify the mean associations proposed in the motivational sequence model,
2. explore moderating factors associated with heterogeneity in effect sizes among existing studies,
3. test the motivational sequence model using path analysis, and
4. identify promising avenues for intervention to improve students' experiences in physical education.

Purpose and Hypotheses

The overarching purpose of this review was to examine the evidence regarding the tenets of SDT within the physical education context. To achieve this aim, we first explored the strength of each of the associations proposed in the SDT-based model summarized in Figure 2 – these meta-analytic findings are the critical components of this study. Then, we examined potential demographic moderators of these associations (i.e., age, sex, country, culture—to test the SDT tenet that such associations are expected to be universal). SDT claims that the need for autonomy is a universal need. As such it should be related to positive functioning in all countries. However, culture may play a moderating role in the way

in which basic needs are met (or not met) and the types of mechanisms by which they effect well-being. For example, Hofstede's (2001) classification of individualism and collectivism highlights that individual needs and goals are valued more in individualistic-oriented cultures, than it is in collectivistic-oriented societies. The differential influence of the relationship between social context and autonomy perceptions has yet not been tested in any synthesis of the SDT-physical education-based literature. Next, we conducted moderation analyses to examine the influence that methodological study characteristics (i.e., risk of bias) had on the effect sizes. We then examined an illustrative model outlined in Figure 2—which represents the SDT motivational sequence and provides the best overview complexity of the theory. In this model, teacher support is hypothesized to predict students' motivation and functioning (i.e., needs satisfaction, motivation, and outcomes).

Method

Reporting in this review aligns with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher, Liberati, Tetzlaff, & Altman, 2009).

Eligibility Criteria

Our review is limited to studies meeting the following criteria: (a) written in English and published in peer-reviewed journals before January 2017; (b) included a sample of children or adolescents; (c) conducted in the physical education lesson context; (d) included quantitative assessment and statistical analysis of the relationship between at least two of the following constructs outlined in SDT: needs support (e.g., teacher support, peer support), needs satisfaction (e.g., autonomy, competence, relatedness), motivation (at least one form of motivation outlined in SDT), or cognitive, affective, or behavioral outcome related to physical education (e.g., experiences during physical education lessons or physical education learning outcomes). Qualitative studies that were identified in the search were kept aside for a separate review that is not reported here.

Information Sources

Studies were identified through four electronic databases PsycINFO, PubMed, Scopus, and SPORTDiscus. Potential studies were searched by using different combinations of two groups of keywords.

Search

In January 2017, we conducted systematic searches of titles and abstracts to identify studies that related to at least one of the following three topics:

1. Social environment in physical education ("need* support" or "autonomy support" or "competence support" or "relatedness support" or "structure" or "involvement" or "control* teach*" or "motivational climate" or "motivational atmosphere" or "need* frustrat*" or "need* thwart*" or "hostil*" or "chaos" or "impersonal") AND "physical education";

2. Needs satisfaction in physical education (“need* satisf*” or “need* fulfil*” or “autonomy” or “competence” or “relatedness” or “belonging*”) AND “physical education”;
3. Motivation in physical education (“self-determin*” or “intrinsic motivation” or “intrinsic interest” or “extrinsic motivation” or “autonomous motivation” or “controlled motivation” or “amotivation” or “perceived locus of causality”) AND “physical education.”

Study Selection

The screening process began after the deletion of duplicate studies identified in the initial search. The titles and abstracts were independently screened for eligibility by three researchers, Diego Vasconcellos, Renata Cinelli, and Toni Hilland, with two researchers screening each record. Three researchers, Diego Vasconcellos, Katherine B. Owen, and Toni Hilland, carried out the full-text review of the potentially eligible studies. Once again, two researchers independently reviewed each article. We included a fourth researcher (Chris Lonsdale) to discuss any discrepancies regarding inclusion until consensus was reached (see Figure 3).

Data Collection Process

Diego Vasconcellos extracted all the data, which were independently checked by four researchers (Toni Hilland and GA each completed 70% of the checking process, and Jane Lee, and Devan Antczak verified the remaining 30%). Discrepancies between the

data extraction table and the original article were discussed and then resolved by further review by Diego Vasconcellos. Extracted data included descriptive study information (e.g., publication year, study design, sample size, school stage, age range, mean and standard deviation, and country of publication), measures of need support, measures of need satisfaction, measures of behavioral regulations, and measures of physical education outcomes, and the results of statistical analysis that examined the relations between two variables (as illustrated in Figure 2).

For our meta-analyses, we followed Cheung’s (2014) recommendation and extracted relationships among scores derived from measures at baseline. This strategy allowed us to extract results from different study designs, including cross-sectional, longitudinal, and experimental and then combine them in the meta-analyses (see e.g., Owen et al., 2016; Tod & Edwards, 2015; White et al., 2017). We also extracted coefficients from experimental studies so that we could compare these relationships with coefficients derived from cross-sectional studies.

Risk of Bias

Risk of bias was assessed using a tool that was based on items from two checklists: the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE; von Elm et al., 2014) guide and the CONSolidated Standards of Reporting Trials (CONSORT) statement. Items included: (a) description of eligibility criteria and/or sufficient description of the sample such that the population from which it was drawn can be determined; (b) sampling procedures adequately described and appropriate (i.e., likely to generate a

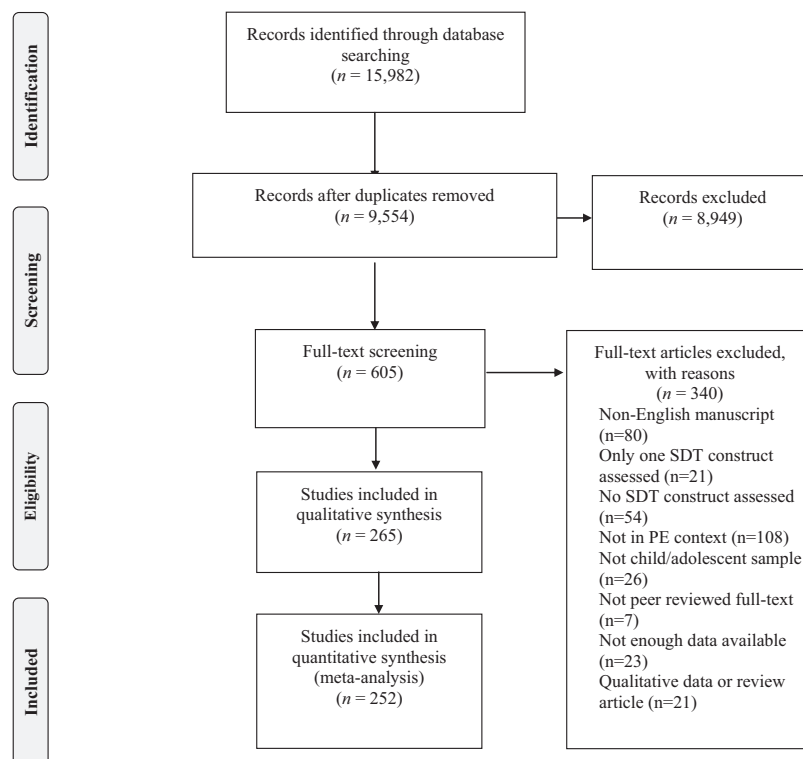


Figure 3. Flow diagram of literature search results. SDT = self determination theory.

representative sample of the population described in criterion a); (c) proportion (0 to 1) of variables that were measured using assessment tools with supportive reliability and validity evidence reported in the article; (d) power calculation reported and study adequately powered to detect hypothesized relationships; and (e) analyses adjusted for covariates. Kappa statistic (κ) was employed to test interrater reliability of percentage agreement (Cohen, 1968). Discrepancies were discussed until 100% consensus was reached. Studies were then classified with either low risk of bias ($>50\%$) or high risk of bias ($<50\%$).

Summary Measures and Synthesis of Results

Commonly used summary measures in the retrieved studies included the correlation coefficient (r), standardized regression analysis coefficient (β), and standardized mean difference (Cohen's d). All results were first converted into a correlation effect size (r). Rosenthal's (1994) formula was used to convert Cohen's d to r , while Peterson and Brown's (2005) formula allowed conversion from β to r . Although the combination of beta coefficients with different metrics (e.g., correlations) may be a limitation—as the number of covariates accounted for in multivariate analysis generally vary across studies—a beta coefficient can still be converted to r if it ranges from $-.50$ to $.50$ (Bowman, 2012; Hunter & Schmidt, 2004; Peterson & Brown, 2005). We requested from the authors the correlations where they were not reported in the original paper. We were successful in many cases, and only worked with beta coefficients when we did not receive a response from the authors. Less than 0.4% effect sizes fell outside the required range ($-.50$ to $.50$) and these correlations were, therefore, excluded from the main analyses. We conducted sensitivity analyses to test whether the inclusion of these extreme effect sizes (by rounding extreme values up to $-.50$ or down to $.50$) would affect the results, and no important differences were found (contact Diego Vasconcellos for details). We then corrected the effect sizes for attenuation (Charles, 2005) by using reported internal consistency for each measure (e.g., Cronbach's alpha). If not reported, .70 was used as an estimate of reliability measure. Next, given that the variance depends strongly on the correlation (Borenstein, 2009), we z -transformed the adjusted effect sizes for analysis and reversed them back into r for presentation. We defined effect sizes as >0.1 (weak), >0.3 (moderate), and >0.5 (strong; Cohen, 1988).

Statistical Analysis

Meta-analysis. We conducted main analyses and moderator analyses using a multilevel structural equation modeling (SEM) approach (Cheung, 2014; Viswesvaran & Ones, 1995). The multilevel SEM approach handles assumption of dependence among the effect sizes in cases where multiple effect sizes are reported within a single study. In this review, the number of effect sizes within each paper ranged from 1 to 273. Using the meta3 function of the MetaSEM package (Cheung, 2015) in R Version 3.3.2 (R Core Team, 2016), we employed three-level (effect size, within-study individual differences, and between-study individual differences) random-effects models to meta-analyze correlations in this study (see Table 1). This technique allowed us to explore heterogeneity at the within-study level (Level 2) and between-study level

(Level 3). We calculated heterogeneity in the effect sizes using the Q statistic, which represents the weighted sum of squared deviations. We also considered the I^2 statistic, which shows the proportion of the observed variance that reflects true difference in the effect sizes (Borenstein, 2009), to explore the proportion of variability in effect sizes attributable to true heterogeneity. For each effect size, we calculated 95% likelihood-based confidence intervals (CIs; Cheung, 2014). Based on Higgins, Thompson, Deeks, and Altman (2003) recommendations, when I^2 values were above .25, we considered effect sizes to be moderately (between .25 and .50) or highly (above .75) heterogeneous, and we investigated potential moderators that could influence these associations. We carried out moderation analysis on meta-analyzed correlations when there were at least two effect sizes in each subgroup (Borenstein & Higgins, 2013). We calculated the proportion of variance (R^2) in effect sizes that could be attributed to the inclusion of the moderator variable, as well the heterogeneity in effect sizes in each group (I^2). Potential moderators included demographic variables, such as age (children, mean age <10 ; preadolescents 10.1 to 14; adolescents, mean age >14), country (because of the large number of different countries we decided to moderate by only the most popular countries, United Kingdom and United States), culture (individualistic or collectivistic; Hofstede, 2001), and sex, as well as methodological variables, such as risk of bias within studies (see Table 3).

Path analysis. After completing the meta-analyses to determine the strength of relations between variables, we tested an illustrative structural model representing the motivational sequence outlined in SDT (i.e., Figure 2, need support $\rightarrow$ need satisfaction $\rightarrow$ motivation $\rightarrow$ outcomes). We created a correlation matrix using meta-analyzed correlations from the 3-level models described above. We used this correlation matrix input to fit the path model. As noted previously, these meta-analyzed correlations were based on data from cross-sectional studies or from the baseline correlations in longitudinal or experimental studies. We were not able to test the full hypothesized path model using longitudinal or experimental data because of the lack of matrix coverage in the data used to run the path analysis. For the data we extracted, five of the 66 correlations did not have data from longitudinal or experimental studies and a further four associations only had data from one longitudinal study.

For the path model, we estimated total, direct, and indirect effects via a structural equation modeling approach using the Lavaan package (Rosseel, 2012) in R (Cheung, 2014), with standard errors given via the delta method (Dowd, Greene, & Norton, 2014). Following Viswesvaran and Ones' (1995) recommendation for calculating uncertainty estimates, we used the harmonic mean of the sample sizes across the different cells in the meta-analyzed correlation matrix.

The illustrative model's exogenous variables were the different types of support the physical education teacher can provide. To meaningfully compare autonomy support with other aspects of needs support, we only examined those studies that included all three types of needs support, plus studies in which the autonomy support measure was specifically designed to measure autonomy support only and not competence or relatedness.

Because very few studies have looked at peer support, we decided not to include this construct in the model, even though it may be a source of support in physical education that is distinct

Table 1

Meta-Analyzed Correlations Involving Teacher Support, Peer Support, Needs Satisfaction, Motivation, and Student Outcomes in the Physical Education Context

Variable	Teacher autonomy support	Teacher competence support	Teacher relatedness support	Teacher controlling behavior	Teachers' relative need support	Peer support	Autonomy	Competence	Relatedness	Total needs satisfaction	Total needs frustration
Teacher competence support	.76 (12)										
Teacher relatedness support	.82 (14)	.79 (12)									
Teacher controlling behavior	-.19 (1)	(0)	(0)								
Teachers' relative need support	.76 (16)	.76 (12)	.80 (15)	-.40 (2)							
Peer support	.42 (2)	.45 (1)	.44 (2)	(0)	.41 (6)						
Autonomy	.70 (29)	.60 (7)	.65 (9)	.16 (2)	.61 (47)	.39 (4)					
Competence	.46 (30)	.62 (6)	.52 (9)	.45 (4)	.37 (52)	.27 (4)	.65 (54)				
Relatedness	.53 (27)	.61 (6)	.67 (12)	-.08 (2)	.49 (47)	.69 (5)	.60 (51)	.58 (50)			
Total needs satisfaction	.57 (36)	.61 (7)	.62 (14)	.37 (5)	.48 (63)	.51 (5)	(0)	(0)			
Total needs frustration	-.16 (2)	(0)	(0)	.80 (2)	-.55 (3)	(0)	(0)	(0)			
Intrinsic motivation	.52 (25)	.62 (6)	.53 (13)	.25 (3)	.46 (49)	.29 (1)	.61 (33)	.62 (53)	.55 (34)	.59 (55)	-.45 (1)
Integrated regulation	(0)	(0)	(0)	(0)	(0)	(0)	.66 (1)	.78 (2)	.30 (1)	.66 (2)	(0)
Identified regulation	.49 (18)	.61 (4)	.51 (10)	-.19 (1)	.48 (33)	.41 (1)	.54 (27)	.60 (38)	.52 (30)	.56 (40)	-.39 (1)
Introjected regulation	.20 (17)	.32 (4)	.24 (10)	.28 (1)	.19 (28)	.32 (1)	.35 (28)	.27 (39)	.27 (30)	.29 (41)	-.07 (1)
External regulation	-.11 (18)	-.08 (4)	-.15 (9)	.41 (1)	-.07 (34)	.25 (1)	-.13 (29)	-.10 (41)	-.07 (32)	-.10 (43)	-.13 (1)
Amotivation	-.25 (26)	-.35 (7)	-.28 (11)	.37 (2)	-.24 (39)	-.12 (1)	-.29 (26)	-.42 (32)	-.30 (28)	-.32 (39)	.32 (3)
Autonomous motivation	.50 (37)	.63 (6)	.53 (13)	.12 (4)	.47 (64)	.34 (2)	.57 (42)	.60 (66)	.51 (45)	.56 (73)	-.13 (3)
Controlled motivation	.04 (22)	.12 (4)	.07 (10)	.36 (2)	.05 (40)	.29 (1)	.08 (32)	.07 (46)	.09 (36)	.09 (52)	.08 (3)
Self-determination Index	.17 (45)	.13 (8)	.17 (18)	.17 (8)	.21 (90)	.23 (4)	.31 (55)	.32 (80)	.27 (59)	.33 (94)	-.10 (3)
Outcomes within PE	.36 (44)	.33 (8)	.29 (15)	.20 (9)	.33 (73)	.21 (2)	.48 (38)	.53 (83)	.45 (41)	.52 (96)	.48 (6)
Outcomes outside PE	.25 (20)	.34 (2)	.22 (5)	(0)	.25 (25)	.36 (3)	.34 (20)	.47 (38)	.35 (21)	.41 (40)	(0)
Affective outcomes	.45 (40)	.23 (5)	.27 (12)	.38 (5)	.34 (60)	.42 (3)	.48 (38)	.56 (70)	.47 (42)	.54 (78)	.48 (3)
Behavioral outcomes	.29 (44)	.43 (8)	.29 (13)	.04 (7)	.29 (70)	.26 (4)	.33 (34)	.48 (70)	.35 (34)	.45 (83)	.47 (4)
Cognitive outcomes	.28 (31)	.30 (6)	.26 (10)	(0)	.26 (36)	.55 (1)	.40 (19)	.50 (34)	.39 (19)	.46 (36)	.41 (1)
Adaptive outcomes	.37 (56)	.38 (9)	.38 (18)	-.27 (7)	.39 (89)	.33 (5)	.44 (50)	.52 (105)	.43 (53)	.51 (117)	-.37 (4)
Maladaptive outcomes	-.25 (13)	-.26 (3)	-.14 (9)	.45 (3)	-.26 (25)	-.35 (1)	-.26 (16)	-.27 (31)	-.32 (19)	-.26 (37)	.53 (5)
Outcomes (overall)	.33 (58)	.34 (9)	.33 (18)	.20 (9)	.31 (92)	.31 (5)	.43 (50)	.51 (107)	.41 (53)	.49 (120)	.48 (6)
Total studies (<i>k</i>)	68	13	26	13	121	5	85	152	87	167	6

Variable	Intrinsic motivation	Integrated regulation	Identified regulation	Introjected regulation	External regulation	Amotivation	Autonomous motivation	Controlled motivation	Self-determination index
Integrated regulation	.88 (4)								
Identified regulation	.88 (65)	.84 (4)							
Introjected regulation	.48 (57)	.65 (4)	.62 (57)						
External regulation	-.08 (69)	.19 (4)	-.02 (64)	.56 (56)					
Amotivation	-.47 (57)	-.02 (4)	-.38 (52)	.05 (44)	.58 (52)				
Autonomous motivation	.89 (49)	.84 (4)	.85 (22)	.56 (58)	-.03 (69)	-.43 (62)			
Controlled motivation	.30 (51)	.45 (4)	.67 (45)	.58 (37)	.52 (21)	.37 (59)	.25 (83)		
Outcomes in PE	.47 (69)	-.54 (1)	.42 (47)	.24 (39)	-.02 (52)	-.20 (58)	.44 (83)	.09 (62)	.47 (107)
Outcomes out of PE	.42 (31)	.48 (1)	.38 (22)	.25 (18)	-.03 (24)	-.26 (20)	.42 (43)	.10 (27)	.38 (54)
Affective outcomes	.43 (54)	-.25 (2)	.35 (38)	.22 (34)	.04 (44)	-.11 (43)	.40 (70)	.12 (49)	.48 (88)
Behavioral outcomes	.48 (52)	.59 (1)	.40 (40)	.21 (34)	-.08 (42)	-.27 (40)	.44 (68)	.05 (49)	.39 (93)
Cognitive outcomes	.49 (31)	.47 (1)	.52 (24)	.28 (22)	-.05 (23)	-.34 (25)	.50 (44)	.11 (28)	.43 (55)
Adaptive outcomes	.57 (84)	.48 (1)	.53 (60)	.26 (51)	-.07 (65)	-.37 (63)	.54 (105)	.06 (75)	.44 (139)
Maladaptive outcomes	-.26 (31)	-.54 (1)	-.23 (25)	.13 (22)	.25 (29)	.45 (30)	-.25 (38)	.20 (35)	.37 (45)
Outcomes (overall)	.54 (86)	.50 (2)	.50 (61)	.29 (52)	.27 (66)	.40 (67)	.51 (108)	.27 (77)	.43 (142)
Total studies (<i>k</i>)	145	4	103	92	118	112	108	77	108

Note. Each data point represents the meta-analyzed correlation, with the number of studies (*k*) listed in parentheses. A (0) shows an absence of studies examining that particular relationship. The last row shows the total number of studies per construct. Composite measures displayed in the table are: Teachers' relative need support (Autonomy Support, Competence Support, Relatedness Support, and Controlling Behavior [multiplied by -1]). Total needs satisfaction (Autonomy, Competence, and Relatedness). Autonomous motivation (Intrinsic Motivation, Integrated Regulation, and Identified Regulation). Controlled motivation (Introjected Regulation and External Regulation). Self-determination index (SDI) was calculated using the formula: $SDI = 2$ (Intrinsic Motivation) + 1 (average of Integrated Regulation and Identified Regulation) - 1 (average of Introjected Regulation and External Regulation) - 2 (Amotivation).

from teacher influences (González-Cutre, Ferriz, et al., 2014; González-Cutre, Sicilia, Beas-Jiménez, & Hagger, 2014; Koka, 2014). Next in the model, we analyzed the needs for autonomy, competence, and relatedness separately. Then, we combined intrinsic motivation, integrated and identified regulation into *autonomous motivation* for three reasons: (a) to have a parsimonious model that could be feasibly estimated; (b) 32 studies (12.1%) included in our review combined the autonomous motivation constructs—we would not have been able to include these studies'

data in our hypothesized model if we did not combine these motives across all studies, because these studies did not provide information that enabled us to test each regulation separately; and (c) because of the strong associations found among these motives (intrinsic motivation and integrated regulation $r = .88$, intrinsic motivation and identified regulation $r = .88$, integrated regulation and identified regulation $r = .84$; see Table 1). This decision was also supported by the findings from Howard, Gagné, and Bureau's (2017) meta-analysis, in which autonomous motivation constructs

were more strongly intercorrelated than controlled motives. We treated introjected regulation, external regulation, and amotivation as distinct constructs for analysis because their associations were not as strong ($r = .530$ to $r = .576$) as the associations among intrinsic motivation, integrated regulation, and identified regulation. We examined the type of outcome as adaptive and maladaptive rather than affective, behavioral, and cognitive. The reason for this was that the associations involving this latter group of constructs were relatively similar. Because of the large number of different adaptive and maladaptive outcomes found in this study and the complexity of the model tested in this meta-analysis, it was not feasible to present results associated with each outcome. Instead, we present meta-analyzed correlations for the nine most frequently examined outcome variables (three affective, three cognitive, and three behavioral). For greater detail on the meta-analyses involving each of the outcomes, please see the full dataset in [online supplemental materials](#). We focused our analysis of indirect effects on the influence teachers could have on other variables. We made this decision because this social agent represents a construct that could most directly be influenced in an intervention, as opposed to needs satisfaction and motivation which would be influenced indirectly.

Results

Study Selection

After duplicates were removed, 9,555 records remained for screening, of which 605 were retained for full-text review. Of these, 265 articles met the criteria to be included in the review (see Appendix). We tried to contact the authors of the 13 articles that did not provide sufficient information to be included in the meta-analyses, but received no response (see [Figure 3](#)).

Study Characteristics

A table with all the data extracted from each study is available through Open Science Framework (<https://tinyurl.com/y8vehmsr>). Most studies employed a cross-sectional design ($k = 159$), followed by experimental ($k = 62$) and longitudinal ($k = 44$) designs. Of these studies, 64.8% provided data from samples in Europe, 22.8% from North America, 8.2% from Asia, and 3.7% from Australia and Oceania. No studies from South America or Africa were identified. In total, data from 133,958 students aged 13.92 years ($SD = 1.64$ years) were included (see the [online supplemental materials](#) for detailed study characteristics), yielding 6,570 effect sizes.

Risk of Bias Within Studies

Regarding risk of bias within individual studies, the kappa coefficient ($\kappa = 0.81$) indicated strong initial agreement between the two raters (Cohen, 1968; McHugh, 2012). Nearly all studies (96.25%) exhibited low risk of bias. See the [online supplemental materials](#) for details.

Synthesis of Results

Most research within physical education has involved older children and adolescents, with less attention paid to young chil-

dren. As can be seen in [Table 1](#), behavioral and affective outcomes of student participation in physical education have been studied extensively; cognitive outcomes have been examined less frequently.

Most of the evidence regarding social context and SDT constructs examined teachers' provision of autonomy support. There were almost three times more effect sizes relating to teacher autonomy support than to competence support, relatedness support, or controlling behavior. Relatively few studies have looked at the association between peer support and constructs outlined in SDT (see [Table 1](#)).

In terms of the associations involving need satisfaction and motivation variables, competence has received substantially more empirical attention than autonomy or relatedness. Finally, the evidence involving the different forms of behavior regulations and outcomes in physical education shows that intrinsic motivation has been studied most extensively, followed by amotivation, external regulation, identified regulation and introjected regulation. The most autonomous form of extrinsic motivation, integrated regulation, has rarely been studied in this context (see [Table 1](#)).

Meta-analyses. [Table 1](#) shows the 319 meta-analytic correlations that emerged from the dataset, of which 57 were strong, 127 were moderate, 124 were weak, and 11 correlations were very weak ($<.1$). Associations involving teachers' need support were mostly in the expected direction. The meta-analyzed correlations between needs support factors were strong—all above .75. It is important to note that *autonomy support* has often been conceptualized and measured as an omnibus term for *needs support* (which could include competence and relatedness items). As a result, comparisons between *teacher autonomy support* and other aspects of needs support can be difficult to make. Teacher's relative need support (i.e., a combination of autonomy, competence and relatedness support, and controlling behavior) had a strong positive association with autonomy, and a moderate positive association with relatedness, and competence. Although the meta-analyzed correlation between teacher's relative need support and autonomous motivation was positive, teacher's relative need support correlated negatively with external regulation and amotivation.

Although the number of studies investigating peer support was small ($k = 5$), the associations involving peer support followed a largely similar pattern to the correlations involving teacher's relative need support. Peer support was negatively correlated with amotivation and maladaptive outcomes, and positively associated with all other variables. Notably, these positive meta-analyzed correlations included controlled forms of motivation—introjected regulation and external regulation.

The meta-analyzed correlations between social context factors and outcomes in physical education ranged from $-.35$ to $.39$. Both teacher's relative need support and peer support in physical education were positively associated with adaptive outcomes, and negatively associated with maladaptive outcomes.

Autonomy, competence, and relatedness were strongly correlated with autonomous motivation, and not so strongly, but still positively correlated with introjected regulation. Weak negative meta-analyzed correlations were found between autonomy, competence, and relatedness and external regulation. Amotivation had moderate negative correlations with needs satisfaction.

Autonomous motivation was positively correlated with adaptive outcomes, and negatively correlated with maladaptive outcomes. External regulation had a weak negative association with adaptive outcomes and a weak-to-moderate positive association with maladaptive outcomes. In contrast, amotivation had a moderate relationship with adaptive outcomes, and a strong positive relationship with maladaptive outcomes. Introjected regulation was positively correlated with both adaptive and maladaptive outcomes, a finding expectable given its place as a partial internalization, still entailing inner conflict.

Interfactor meta-analyzed correlations among motivation constructs supported the presence of the ordering of self-regulatory motives proposed by SDT. We found strong meta-analyzed correlations between intrinsic motivation and integrated regulation, intrinsic motivation and identified regulations, and between integrated regulation and identified regulation. In contrast, relatively weaker meta-analyzed correlations among introjected regulation, external regulation, and amotivation indicated these constructs were more distant from one another on a continuum of motivation.

Table 2 compares the results of three-level meta-analyses using data from cross-sectional and experimental studies that examined the relationship between teacher behavior and SDT variables and student outcomes. The pattern of associations from cross-sectional and experimental studies were similar.

Moderator analyses. Moderator analyses were conducted on the 66 associations in the path model (see Figure 4) to investigate whether study characteristics influenced these effects. Significant moderator effects at both within-study (Level 2) and between-study (Level 3) levels are presented in Table 3. Results of all moderator analyses are available in the [online supplemental materials](#). Significant moderation effects were found in seven of the 66 associations.

Sex. Sex accounted for a large portion of the within-study (Level 2) heterogeneity in studies that investigated the association between autonomy and competence ($R^2 = .57, p < .001$). Effect sizes were stronger in studies that reported combined results for boys and girls ($r = .67, 95\% \text{ CI } [.60, .73]$) than they were in studies reporting them separately for boys ($r = .28, 95\% \text{ CI } [-.03, .54]$) or girls ($r = .38, 95\% \text{ CI } [.26, .50]$). Sex also explained heterogeneity at the between-study level associations between introjected regulation and amotivation, and between introjected regulation and

adaptive outcomes. Stronger effect sizes were found in studies that reported combined results for boys and girls than separate sexes between introjected regulation and amotivation. In contrast, effect sizes were found to be stronger for boys in the association between introjected regulation and adaptive outcomes than they were in studies that reported combined results for boys and girls, or girls only.

Age. In studies that investigated the association between introjected regulation and maladaptive outcomes, age explained 71% ($p = .035$) of the heterogeneity in effect sizes at the between-study level (Level 3). The effect sizes were stronger for preadolescents ($r = .28, 95\% \text{ CI } [.11, .43]$) than they were for adolescents ($r = .04, 95\% \text{ CI } [-.09, .16]$).

Culture. Culture accounted for significant and large portions of the heterogeneity in effect sizes at the between-study level (Level 3) in six associations (see Table 3). Effect sizes were stronger for individualistic cultures regarding the negative relationships between: (a) autonomy and external regulation, and (b) relatedness and external regulation. Compared with individualistic-oriented countries, we found stronger positive effect sizes in collectivistic-oriented countries for the associations between: (a) peer support and adaptive outcomes, (b) autonomy and competence, (c) introjected regulation and external regulation, and (d) introjected regulation and maladaptive outcomes. The analysis pertaining to introjected regulation and maladaptive outcomes revealed that introjected regulation was not associated with maladaptive outcomes for students from individualistic countries, whereas there was a significant positive relationship between introjection and maladaptive outcomes ($r = .239$) in collectivistic countries.

Country. Country did not moderate any of the associations investigated.

Risk of Bias Across Studies

Egger's tests revealed nonsignificant results, which indicated low asymmetry and suggested low risk of publication bias across the studies. For example, studies that examined the association between perceived competence and external regulation had a nonsignificant Egger's test ($t = 0.8841, p = .381$; please contact authors for details on other test results).

Table 2

Comparison of Meta-Analyzed Relationships From Cross-Sectional and Experimental Studies

Cross-sectional				Experimental			
Relationship	Coef. (r)	Lower 95% CI	Upper 95% CI	Relationship	Coef. (r)	Lower 95% CI	Upper 95% CI
Need support–Need support	NA	NA	NA	Intervention–Need support	.53	.34	.68
Need support–Need satisfaction	NA	NA	NA	Intervention–Need satisfaction	.33	.16	.48
Need support–Autonomy	.61	.51	.69	Intervention–Autonomy	.51	.38	.61
Need support–Competence	.37	.28	.44	Intervention–competence	.31	–.07	.61
Need support–Relatedness	.49	.42	.56	Intervention–Relatedness	.21	.07	.26
Need support–Autonomous motivation	.47	.42	.51	Intervention–Autonomous motivation	.26	.16	.34
Need support–Introjected regulation	.19	.12	.26	Intervention–Introjected regulation	.20	.05	.34
Need support–External regulation	–.07	–.18	.05	Intervention–External regulation	.19	–.05	.21
Need support–Amotivation	–.24	–.29	–.18	Intervention–Amotivation	.08	–.01	.16
Need support–Adaptive outcomes	.39	.34	.43	Intervention–Adaptive outcomes	.33	.20	.45
Need support–Maladaptive outcomes	–.26	–.32	–.20	Intervention–Maladaptive outcomes	–.25	–.38	–.12

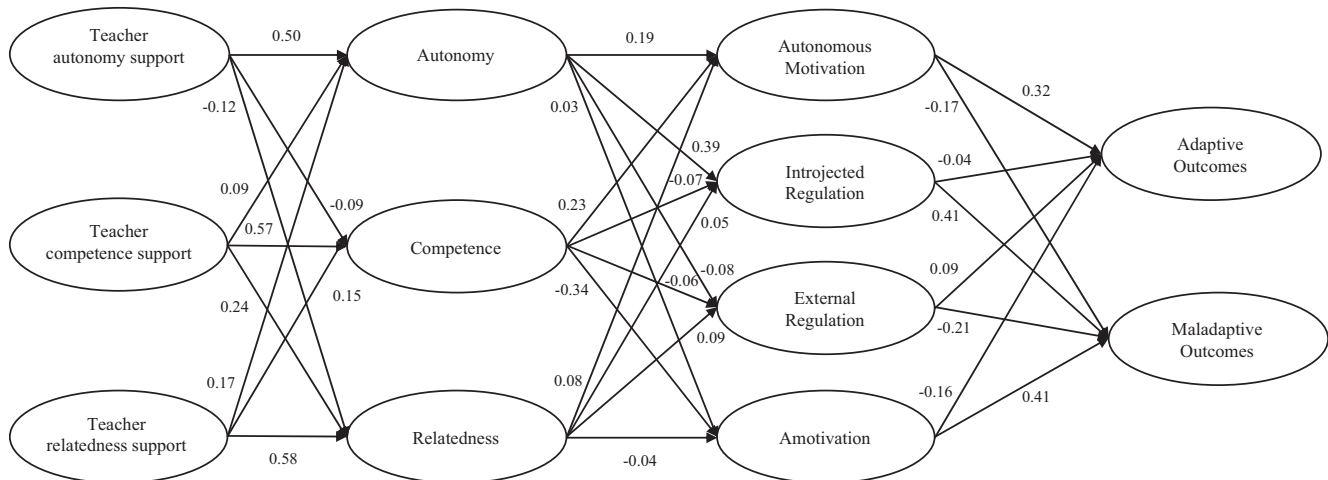


Figure 4. Motivational sequence as proposed by SDT applied to physical education (harmonic mean of the sample sizes, $N = 18,947$). All paths are significantly different from zero, $p < .001$.

Additional Analysis

We used 66 of the meta-analyzed correlations from Table 1 to create an input matrix (see Table 4) for path analyses. The illustrative model tested teacher's need support as predictors of students' outcomes in physical education, with students' needs satisfaction and motivation as mediators of this process. Given that moderators only influenced nine of 66 possible associations, and these effects were not consistent across associations, we decided to test a single path model (i.e., we did not test separate models divided according to levels of the moderators).

Among the different types of support from the physical education teacher, autonomy support was found to be a stronger predictor of autonomy ($\beta = .50$), whereas competence and relatedness were strongly predicted by competence support ($\beta = .57$) and relatedness support ($\beta = .58$), respectively.

Direct paths from needs satisfaction to motivation variables were all significant ($p < .001$). Among the needs satisfaction constructs, competence was the strongest predictor of both autonomous motivation ($\beta = .23$) and amotivation ($\beta = -.34$). Autonomy was the strongest predictor of introjected regulation ($\beta = .39$), and relatedness was the strongest predictor of external regulation ($\beta = -.09$).

There was evidence of an indirect effect of competence support on adaptive outcomes (indirect effect, $\beta = .41$), but little evidence of an indirect effect on maladaptive outcomes (indirect effect, $\beta = -.15$). As seen in Table 5, the proportion of the total effect that was indirect (i.e., indirect effect/total effect) in these associations through the hypothesized mediators (needs satisfaction and motivation) was very low. The indirect proportion of overall effect for the association between competence support and adaptive outcomes was 54%. For competence support and maladaptive outcomes this proportion was 49%. On the other hand, there were substantial indirect effects between teacher relatedness support and adaptive outcomes ($\beta = .10$, 87% of total effect) and maladaptive outcomes ($\beta = -.16$, 44% of total effect).

Discussion

Meta-Analyses and Path Analysis

This review presents a meta-analytic synthesis of the evidence regarding the application of SDT in physical education. Overall, the patterns of correlations align with theoretical postulates (Deci & Ryan, 1985; Ryan & Deci, 2017; Vallerand, 1997). SDT proposes that social environments can affect students' perceptions of psychological needs satisfaction. The evidence supported this postulate, yet also revealed that teachers and peers likely have differential impact on these needs. Indeed, meta-analyzed correlations indicated that, compared with peers, perceived teacher support appears more beneficial for autonomy and competence, whereas perceived peer and teacher support were similarly associated with relatedness. The very uneven number of studies involving teachers and peers (see Table 4) could partially explain this finding. Another possibility would be that the teacher is in control, so it is not surprising that autonomy for physical education activities is primarily influenced by teachers. Also, feedback comes from the teachers mainly, not peers, hence the effect from teachers on competence (e.g., Cheon & Reeve, 2013; Koka, 2014; Zhang, Solmon, Kosma, Carson, & Gu, 2011). Compared with autonomy and competence, relatedness is perhaps most influenced by peers because they interact with their peers throughout the day, not just during classroom time.

The findings in this study largely supported the existence of a continuum of self-regulation motives in physical education. Students appear, however, to have some difficulty in differentiating between autonomous forms of motivation in physical education (i.e., intrinsic motivation, integrated regulation, and identified regulation), as demonstrated by the strong interfactor correlations. With regard to the different forms of motivation proposed by SDT, one has to consider that intrinsic motivation and identified regulation can often not be empirically distinguished from each other. In addition, some adolescents may not differentiate intrinsic motivation (i.e., what they enjoy) and identified regulation (i.e., what

Table 3
Summary of Significant Moderation Effects

Measure	<i>k</i>	#ES	Sample size		Coefficient (<i>r</i>)	Lower 95% CI	Upper 95% CI	<i>R</i> ² ₂	<i>R</i> ² ₃	<i>I</i> ² ₂	<i>I</i> ² ₃	<i>Q</i> statistic
			Total	Harmonic <i>M</i>								
Autonomy–Competence Culture (<i>p</i> < .001)	54	66	32,833	271	.65	.58	.71			.08	.91	5854.978
Individualistic	32	39	17,894	281	.54	.44	.63	.00	.22	.04	.94	
Collectivistic	21	26	14,224	285	.78	.70	.84			.15	.84	
Sex (<i>p</i> < .001)								.57	.01			
Both	50	59	29,969	295	.67	.60	.73			.03	.96	
Male	4	4	1,482	191	.28	−.03	.54			.48	.48	
Female	3	3	1,382	275	.38	.26	.50			.40	.40	912.3109
Autonomy–External regulation Culture (<i>p</i> = .012)	29	36	14,082	220	−.13	−.23	−.03	.06	.21	.13	.84	
Individualistic	18	23	9,294	260	−.22	−.32	−.12			.19	.76	
Collectivistic	11	13	4,788	164	.03	−.13	.18			.09	.86	
Relatedness–External regulation Culture (<i>p</i> = .037)	32	39	15,192	223	−.07	−.14	.00	.01	.11	.00	.94	
Individualistic	19	24	8,928	250	−.14	−.22	−.05			.14	.79	
Collectivistic	13	15	6,264	190	.02	−.11	.14			.00	.94	592.9022
Introjected regulation–External regulation Culture (<i>p</i> = .035)	56	66	26,196	228	.56	.48	.63	.00	.51	.84	.14	
Individualistic	35	43	15,788	224	.49	.38	.59			.93	.06	
Collectivistic	21	23	10,408	235	.66	.55	.74			.71	.27	
Introjected regulation–Amotivation Sex (<i>p</i> < .001)	44	65	26,437	255	.05	−.03	.14	.00	.08	.40	.58	
Both	43	64	26,337	247	.06	−.02	.15			.41	.56	1817.888
Male	1	1	100	100	−.39	.54	−.21			.50	.50	
Female	0	0	—	—	—	—	—			—	—	
Introjected regulation–Adaptive outcomes Sex (<i>p</i> = .017)	51	125	49,964	253	.26	.18	.31	.00	.24	.37	.59	
Both	49	121	49,321	262	.25	.19	.31			.43	.53	
Male	1	3	300	100	.66	.58	.72			.16	.00	
Female	1	1	343	343	−.21	−.31	−.10			.50	.50	1033.303
Introjected regulation–Maladaptive outcomes Culture (<i>p</i> = .049)	22	31	11,837	212	.13	.01	.24	.00	.62	.69	.28	
Individualistic	14	19	6,853	273	.05	−.06	.17			.96	.00	
Collectivistic	8	12	4,984	156	.24	.02	.44			.20	.78	
Age (<i>p</i> = .035)								.00	.71			
Children	0	0	—	—	—	—	—			—	—	
Preadolescents	8	13	6,663	215	.28	.11	.43			.98	.00	
Adolescents	14	18	5,174	210	.04	−.09	.16			.32	.62	

Note. *k* = number of studies; #ES = number of effect sizes; *r* = population effect size; *R*²₂ and *R*²₃ = proportion of variance explained by the moderator variable at Level 2 (within study) and Level 3 (between study), respectively. *I*²₂ and *I*²₃ = proportion of variability in effect sizes at Level 2 and 3, respectively.

they value; Lonsdale, Sabiston, Taylor, & Ntoumanis, 2011). However, introjected regulation and external regulation, which are often combined into controlled motivation (Aelterman, Vansteenkiste, Soenens, & Haerens, 2016; De Meester et al., 2016; De Meyer et al., 2016; Gairns et al., 2015), and amotivation, were all found to be distinct constructs. The simplex structure of different self-regulations has been tested in a recent meta-analysis by Howard et al. (2017), which showed results similar to ours across different domains, such as work, sport, exercise, education, and physical education. The proximity of autonomous forms of regulation, as well as the distance among introjected regulation, external regulation, and amotivation, has also been confirmed in a meta-analysis in the health domain (Ng et al., 2012), and in other areas of education such mathematics (e.g., Brandenberger, Hagenauer, & Hascher, 2018; Lohbeck, 2018), science (e.g., Lavigne, Vallerand, & Miquelon, 2007; Salmi & Thuneberg, 2018), and physics (e.g., Byman, Lavonen, Juuti, & Meisalo, 2012).

Introjected regulation, a self-regulatory way of engaging in behaviors by feelings of internal pressure and obligation, corre-

lated with other variables in ways predicted by the theory, in that its effects lay somewhere between the relatively positive effects of intrinsic motivation and identification, and the largely null or negative effects of external regulation and amotivation. Within SDT, introjection represents a “partial or incomplete” internalization that, on the positive side can foster behavioral compliance, as well as “certain forms of self-esteem, satisfaction, and feelings of pride about oneself” (Ryan & Deci, 2017, p. 185). Yet, because of its controlling elements it can also foster anxieties and self-criticism that negatively affect motivation, persistence, and well-being. In this review, introjected regulation was associated with both adaptive and maladaptive outcomes in physical education. In particular, introjection was positively associated with need satisfaction, suggesting that this partial internalization is facilitated by support. Interesting too was that introjection was positively correlated with both teacher autonomy support and teacher control, suggesting that both elements may contribute to this type of motivation.

Table 4
Correlation Matrix for the Path Analysis

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Autonomy support	—	12	14	29	30	27	37	17	18	26	56	13
2. Competence support	.76	—	12	7	6	6	6	4	4	7	8	3
3. Relatedness support	.82	.79	—	9	9	12	13	10	9	11	18	9
4. Autonomy	.70	.60	.65	—	54	51	42	28	29	26	50	16
5. Competence	.46	.62	.52	.65	—	50	66	39	41	32	105	31
6. Relatedness	.53	.61	.67	.60	.58	—	45	30	32	28	53	19
7. Autonomous motivations	.50	.63	.53	.57	.60	.51	—	58	69	62	105	38
8. Introjected regulation	.20	.32	.24	.35	.27	.27	.56	—	56	44	51	22
9. External regulation	-.11	-.08	-.15	-.13	-.10	-.07	-.03	.56	—	52	65	29
10. Amotivation	-.25	-.35	-.28	-.29	-.43	-.30	-.43	.05	.58	—	63	30
11. Adaptive outcomes	.37	.40	.38	.44	.52	.43	.54	.26	-.07	-.37	—	53
12. Maladaptive outcomes	-.25	-.26	-.14	-.26	-.27	-.32	-.25	.13	.25	.45	-.21	—

Note. Lower diagonal = meta-analyzed correlations. Upper diagonal = corresponding number of studies.

Positive and negative correlations have been found between introjected regulation and SDT constructs, as well as different types of outcomes. These variable patterns of relationships have been found in the exercise (Gillison, Osborn, Standage, & Skevington, 2009), education (Can, 2015), public health (Verloigne et al., 2011), work (Slemp, Kern, Patrick, & Ryan, 2018), and sport (Pelletier, Fortier, Vallerand, & Brière, 2001) settings. Some research has found introjected regulation to be associated with both adaptive and maladaptive outcomes in other academic domains, such as mathematics (Brandenberger et al., 2018; Lohbeck, 2018) and science (Lavigne et al., 2007; Salmi & Thuneberg, 2018), for example. Introjected regulation can enhance behavioral outcomes, especially in the short term (e.g., promoting effort on a task). Yet, as a partial internalization, introjection may not sustain behavior over time. For instance, Pelletier et al. (2001) found positive correlations of introjection with sport persistence at baseline, but these effects disappeared over time, whereas the effects of autonomous motives on persistence remained positive over time. Because our review is based on cross-sectional data, it does not address the potential for such maladaptive long-term outcomes.

Moderator analysis revealed substantial heterogeneity in some of the associations investigated; some of this heterogeneity could be explained by study characteristics. Sex, for example, moderated three of 66 associations in this study—autonomy and competence, introjected regulation and amotivation, and introjected regulation and adaptive outcomes. Unfortunately, there were a small number of studies in which data were analyzed separately for boys and girls (e.g., only four studies broke down by sex the relationship between autonomy and competence) precludes further exploration of this finding. Future physical education-based research should consider providing separate data on boys and girls for sex differences to be investigated.

Age was found to be a moderator of the association between introjected regulation and maladaptive outcomes in one of 66 associations. Results suggested that introjected reasons, such as to avoid punishment from the teacher or to avoid a sense of guilt, lead to undesired outcomes in students aged 10–14, but not for older adolescents. Indeed, this correlation was seven times stronger for preadolescents ($r = .28$) than it was for adolescents ($r = .04$). These results suggest that preadolescents and adolescents may not experience guilt/shame the same way. Research in the educational

context examining academic motivation has shown a decrease in students' introjected regulation as a function of age (Gillet, Vallerand, & Lafrenière, 2012; Otis, Grouzet, & Pelletier, 2005). Ryan and Deci (2000b) pointed out that externally motivated behaviors (e.g., introjected regulated) are often performed in order to satisfy significant others (parents, teacher). Our finding could, therefore, support previous research indicating that preadolescents are more affected by significant other's influence (parents, teacher) than adolescents (Chan, Lonsdale, & Fung, 2012; Horn & Weiss, 1991; McKiddie & Maynard, 1997).

Lastly, the inclusion of Hofstede's classification of individualistic and collectivistic cultures provided insights to the SDT tenet of cross-cultural invariance. In individualistic cultures, individuals' needs are seen as more important than a group's needs. In the education context, it could therefore be argued that students from individualistic or collectivist countries could experience needs support from the teacher differently (Awang-Hashim, Thaliah, & Kaur, 2017). Yet in our review, culture was not found to moderate any relationship involving perceptions of teacher support. Thus, it appears that students from across cultures experience similar benefits from need supportive teaching. Also, filial piety feelings (e.g., endorsing parents' values) found in collectivistic-oriented countries could also explain why introjected regulation might be different for different cultures, as in collectivistic-oriented cultures individuals are likely to engage in behaviors because they think they should, and not because they want to (Hui, Sun, Chow, & Chu, 2011; Tam, 2016). In our review, the significant positive relationship found between introjected regulation and maladaptive outcomes indicated that introjected regulation likely has negative consequences for collectivistic students, but perhaps less so for individualistic cultures. Sources of these different effects warrant further study.

Overall Implications

With only a few exceptions discussed previously, the results of our meta-analysis align with the motivational processes proposed by SDT in the school physical education setting. Most of the effect sizes were moderate and in the expected direction. Autonomous motivation and amotivation are the types of motivation that have the strongest associations with students' outcomes in physical

Table 5
Path Analysis Direct and Indirect Effects

Variable	Direct effect			Indirect effect		
	Estimate	SE	p value	Estimate	SE	p value
Adaptive outcomes						
Autonomous motivation	.32	.011	.000			
Introjected regulation	-.04	.011	.000			
External regulation	.09	.010	.000			
Amotivation	-.16	.009	.000			
Autonomy	.01	.012	.324			
Competence	.26	.010	.000			
Relatedness	.10	.009	.000			
Teacher autonomy support	.14	.014	.000	.13	.014	.000
Teacher competence support	-.19	.012	.000	.41	.013	.000
Teacher relatedness support	.02	.14	.267	.10	.013	.000
Maladaptive outcomes						
Autonomous motivation	-.17	.011	.000			
Introjected regulation	.41	.012	.000			
External regulation	-.21	.011	.000			
Amotivation	.41	.010	.000			
Autonomy	-.17	.012	.000			
Competence	.10	.010	.000			
Relatedness	-.32	.009	.000			
Teacher autonomy support	-.23	.014	.000	-.08	.014	.000
Teacher competence support	-.16	.013	.000	-.15	.013	.000
Teacher relatedness support	.53	.014	.000	.16	.015	.000
Autonomous motivation						
Autonomy	.19	.010	.000			
Competence	.23	.009	.000			
Relatedness	.08	.009	.000			
Teacher autonomy support	-.04	.012	.002			
Teacher competence support	.39	.011	.000			
Teacher relatedness support	-.05	.012	.000			
Introjected regulation						
Autonomy	.39	.012	.000			
Competence	-.07	.011	.000			
Relatedness	.05	.011	.000			
Teacher autonomy support	-.31	.015	.000			
Teacher competence support	.36	.014	.000			
Teacher relatedness support	-.04	.015	.015			
External regulation						
Autonomy	-.08	.013	.000			
Competence	-.06	.012	.000			
Relatedness	.09	.012	.000			
Teacher autonomy support	.06	.016	.000			
Teacher competence support	.13	.015	.000			
Teacher relatedness support	-.28	.017	.000			
Amotivation						
Autonomy	.03	.012	.009			
Competence	-.34	.011	.000			
Relatedness	-.04	.011	.000			
Teacher autonomy support	.02	.015	.295			
Teacher competence support	-.16	.014	.000			
Teacher relatedness support	.02	.015	.209			
Autonomy						
Teacher autonomy support	.50	.010	.000			
Teacher competence support	.09	.010	.000			
Teacher relatedness support	.17	.011	.000			
Competence						
Teacher autonomy support	-.09	.011	.000			
Teacher competence support	.57	.011	.000			
Teacher relatedness support	.15	.012	.000			
Relatedness						
Teacher autonomy support	-.12	.011	.000			
Teacher competence support	.24	.010	.000			
Teacher relatedness support	.58	.011	.000			

education. Autonomously motivated students are more likely to have more positive experiences in physical education, whereas amotivated students are more likely to report negative experiences. Teachers appeared to have greater influence on students' perceptions of autonomy and competence, whereas peers appear to have more impact on feelings of relatedness. Among the basic need satisfactions, competence satisfaction was most strongly associated with students' self-determined motivation, suggesting that a sense of efficacy in physical education is particularly associated with more willing participation. In sum, support from a physical education teacher appears to motivate students to experience adaptive outcomes through perceptions of autonomy and competence, whereas feelings of relatedness are more strongly associated with peer support.

In terms of applied implications, this review could guide educators in their selection of classroom strategies to employ to effectively motivate students and enhance student outcomes. We sought to identify what teacher and peer focused interventions should focus on to foster an environment where students' needs are supported. The effect of supportive teaching on autonomy and competence highlights that these two needs can be influenced by certain strategies adopted by the teacher. According to Reeve (2009), students will experience autonomy when they perceive an environment where they can perform tasks without feeling pressured, where the teacher welcomes students' thoughts, feelings and actions, rely on noncontrolling language, and where exploratory rationale is given so the content is seen as meaningful to their lives (How, Whipp, Dimmock, & Jackson, 2013; Lonsdale et al., 2013; Perlman, 2011b; Taylor & Ntoumanis, 2007). In addition, a number of strategies can be implemented in order to support student's need for competence, such as planning and organizing activities according to the students' physical skills level, making it clear what is expected, and praising and encouraging individual effort, instead of collective efforts (Almolda-Tomás et al., 2014; Taylor & Ntoumanis, 2007; Tessier et al., 2010).

We found good support for the process model suggested by Ryan and Deci (2000a). The question is, thus, whether the variables at the beginning of this process model (i.e., teacher behaviors) are amenable to intervention. Su and Reeve's (2011) meta-analysis indicated that teachers' needs support increased following intervention ($d = .63$). To examine intervention effectiveness in studies from our review, we extracted 23 effect sizes from 16 intervention studies that attempted to modify teacher support. We found interventions to be effective at increasing teacher needs support ($d = .63$; $p < .001$) This is a moderate to large effect size and suggests training interventions can enhance teacher behaviors.

Peers likely influence each other's sense of relatedness in physical education. Although the literature on how students can support each other's needs in physical education is limited—see Wallhead and Ntoumanis (2004) for an exception—there has been an increase in implementing peer-focused methods in other areas of education (e.g., Lee & Lim, 2012; Nathan et al., 2017; Slavin, 1996; Thalluri, Flaherty, & Shepherd, 2014; Topping & Ehly, 2001). Some of the strategies proposed by the different methods involve both same level and higher-level students tutoring (Thalluri et al., 2014; Topping & Bryce, 2004; Topping, Peter, Stephen, & Whale, 2004), one-to-one (i.e., mentoring) and group situations (e.g., Nixon & Topping, 2001), and cooperative learning (Slavin, 1990, 1996). Teachers can also influence peer relatedness by

organizing activities in small groups, to make peer support more prominent. Indeed, simple strategies that are easy to be applied, such as modified and small-sided games are features of two pedagogical models—Teaching Games for Understanding (TGfU; Bunker & Thorpe, 1982; Leary, 2014), and Sport Education (Siedentop, 1998)—that have been shown to have positive impact on students' motivation. The main idea behind such strategies is the promotion of a supportive learning environment through social interactions among students. Perhaps having peer support as a formalized intervention component would also lead to the satisfaction of other students' needs in physical education, other than relatedness alone, in part by directing peer interactions toward activities consistent with physical education goals.

Strengths and Limitations

The key strength of this review is that it is first to meta-analyze the large body of SDT research within the physical education context. Apart from examining the strength and direction of the associations proposed by the theory in physical education, we used path analysis to test a full model of the motivational sequence (see Figure 2). The number of studies included, the number of effect sizes analyzed, and the total sample size are strengths of this review. This study, however, also presents the following limitations: The review is limited to peer-reviewed studies written in English, which could omit some important contributions published in other languages. Most of the studies in this review employed self-report measures, which can be a limitation because such instruments measure self-attributions and not objective needs or motivation. Recent advancements have been made in this area by measuring implicit motives (Lang, 2014; Sheldon & Schuler, 2011) that are less subject to perceptions of social desirability (Boyle, 2015; Edwards, 1957; Miller et al., 2015). Also, we did not complete moderator analysis for all 319 relationships presented in Table 1. Instead, we investigated potential moderators on the 66 associations included in the path model we tested. Finally, we did not have matrix coverage to test our path model using longitudinal or experimental data.

Future Directions

This systematic review raises a number of opportunities for future research. Although there are many elements involved in supporting students' psychological needs, much of the existing evidence comes from the provision of autonomy support from the teacher (see Table 1). Relatively few SDT-based studies have investigated the impact of competence (i.e., structure) and relatedness (i.e., involvement; Sparks et al., 2017) support from the teacher in physical education settings, and more research is needed to understand how these teacher behaviors influence these student experiences. Our review also found a relative lack of objective measures of social support in the literature, and thus more research is needed to understand how observable teacher and peer behaviors influence motivational processes and outcomes. Also, we found that peer support has been rarely studied in physical education, and thus represents another promising area for future interventions.

Most research has focused on older children and adolescents. Additional research is needed with young children (<10 years of age) to better understand how the SDT model applies to physical education involving young children.

There is also a dearth of research on integrated regulation. Although this form of regulation may not be relevant in younger students, older adolescents whose sense of self is more developed are more likely to be able to express the extent to which their behavior is a good representation of their own personal values and beliefs (Deci et al., 1991). In these students, it may be important to investigate determinants and outcomes of integrated regulation in school physical education in order to understand how this form of motivation influences students' experiences.

Give the wide scope of our review and the large number of meta-analyzed correlations, we did not test for the moderating role that different operationalizations of SDT may play. Future researchers could investigate the influence of the different SDT measures when examining specific relationships outlined in the theory.

Finally, we found that behavioral and affective outcomes have been extensively studied in physical education, but little attention has been paid to cognitive outcomes. Future research should also focus on how self-determined behaviors influence cognitive variables, such as the use of learning strategies, metacognitive processes (i.e., knowledge about and regulation of one's cognition), and in-class concentration.

Conclusion

The overarching aim of this study was to synthesize results from studies underpinned by self-determination theory conducted in the school physical education context. Results of this meta-analytic review support SDT's theoretical postulates, suggesting that it provides a useful theoretical framework to understand motivational process in physical education, and a basis for effective interventions designed to improve in-class experiences as well as physical education learning outcomes.

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References marked with an asterisk indicate studies included in the systematic review.

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