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Review

Self-determined motivation and physical activity in children and adolescents: A systematic review and meta-analysis

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ABSTRACT

Objective: Self-determination theory is used as a framework for examining the relation between motivation and physical activity. The purpose of this review was to systematically review studies that assessed the association between self-determined motivation and physical activity levels in children and adolescents.

Method: We searched electronic databases in April 2013. Included studies assessed the relation between motivation (as outlined in self-determination theory) and physical activity in children and adolescents.

Results: Forty-six studies ($n = 15{,}984$ participants) met the inclusion criteria. Meta-analysis indicated that overall levels of self-determined motivation had a weak to moderate, positive associations with physical activity ($\rho = .21$ to $.31$). Autonomous forms of motivation (i.e., intrinsic motivation and identified regulation) had moderate, positive associations with physical activity ($\rho = .27$ to $.38$), whereas controlled forms of motivation (i.e., introjection and external regulation) had weak, negative associations with physical activity ($\rho = -.03$ to $-.17$). Amotivation had a weak, negative association with physical activity ($\rho = -.11$ to $-.21$).

Conclusions: Evidence provides some support for self-determination theory tenets. However, there was substantial heterogeneity in most associations and many studies had methodological shortcomings.

Contents

Introduction . . . 271
Method . . . 271
Eligibility criteria . . . 271
Information sources . . . 271
Data extraction . . . 271
Summary measures and synthesis of results . . . 271
Risk of bias in individual studies . . . 272
Results . . . 272
Study selection . . . 272
Study characteristics . . . 272
Risk of bias . . . 272
Main analyses . . . 272
Homogeneity tests and moderator analyses . . . 272
Discussion . . . 273
Physical education . . . 273
Leisure-time . . . 275
Moderators . . . 275
Strengths and limitations . . . 275

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Conclusions . . . 275
Funding . . . 278
Conflict of interest statement . . . 278
Acknowledgments . . . 278
References . . . 278

Introduction

Physical activity (PA) is associated with numerous health benefits in children and adolescents. For example, PA has positive effects on cholesterol and blood lipids, blood pressure, metabolic syndrome, overweight and obesity, bone mineral density, and depression (Janssen and LeBlanc, 2010). In addition, PA has positive relations with children and adolescents' academic performance and mental health (Biddle and Asare, 2011; Singh et al., 2012). Many children and adolescents, however, do not currently participate in sufficient levels of PA to acquire these benefits (Department of Health and Ageing, 2008; Troiano et al., 2008). As a result, PA promotion among young people has been identified as a global health priority (World Health Organisation, 2010).

Motivation is an important correlate and potential determinant of PA (Ng et al., 2012). The importance of different types of motivation (known as behavioral regulations) underpinning PA behavior, has become a prominent area of research over the past decade (Ng et al., 2012). Self-determination theory (SDT; Deci and Ryan, 1985) has emerged as popular framework for examining the relation between motivation and PA. The theory differentiates between controlled and autonomous forms of motivation. Five motivation regulations exist over these two categories and fall onto a systematically varying continuum, depending of the degree of self-determination present.

Autonomous forms of motivation include intrinsic motivation, integrated regulation, and identified regulation. Intrinsic motivation exists when the behavior is viewed as interesting or enjoyable. Integrated regulation, defined as acting because the behavior aligns with personal values and one's sense of self, is the most autonomous form of extrinsic motivation. Identified regulation exists when the outcomes of a behavior are viewed as personally beneficial and important; this regulation is also considered an autonomous form of extrinsic motivation (Deci and Ryan, 1985).

Controlled forms of motivation include external regulation and introjection. External regulation involves acting to obtain a reward or avoid punishment, whereas introjection occurs when feelings of guilt or contingent self-worth drive behavior. A final category, amotivation, refers to an absence of motivation (Ryan and Deci, 2000).

According to SDT, autonomous forms of motivation will be positively related to sustained health-promoting behaviors, such as PA, whereas controlled forms of motivation will not promote these behaviors over the long term. A recent meta-analysis examined this association in adults (Teixeira et al., 2012). However, no previous review has examined the relation between self-determined motivation and PA in children and adolescents. Due to the current low levels of PA in children and adolescents, it is critical that we determine whether interventions targeting autonomous motivation are likely to be effective in promoting PA in children and adolescents. Therefore, the aim of this study was to calculate effect sizes pertaining to relations between SDT-based motivation regulations and PA behavior of children and adolescents. In line with SDT tenets, we hypothesized that more autonomous forms of motivation would have stronger positive relations with PA behavior, whereas, more controlled forms of motivation would show stronger negative relations with PA behavior. We also identified and tested potential moderators of these effect sizes, such as measurement tools, study design, type of PA measure used, risk of bias within studies, and publication status.

Method

Eligibility criteria

To be included in this review, studies were required to include: a) participants with a mean age between 5 and 18 or were enrolled in either primary or secondary schools, b) quantitative assessment of at least one form of motivation outlined in SDT (e.g., intrinsic motivation), an overall score of self-determination (i.e., Relative Autonomy Index; RAI; Ryan and Connell, 1989), a composite measure of autonomous motivation (e.g., mean of the intrinsic motivation and identified regulation subscales; McDavid et al., 2012), or a composite measure of controlled motivation (e.g., mean of introjection and external regulation subscales; Bagoien and Halvari, 2005), c) quantitative assessment of PA (e.g. observation, self-report, accelerometer, pedometer, heart rate), d) quantitative assessment of the relation between scores derived from measures of motivation and PA, and e) a cross-sectional, cohort, or experimental/quasi-experimental study design. Studies involving special populations (e.g., children and adolescents with autism) were excluded from the review. All full-text articles meeting these criteria published in the English language between 1980 and April 2013 were included.

Information sources

Searches were conducted within PubMed, Psych Info, Scopus, and Sport Discus up to April 18th, 2013. Systematic combinations of two groups of keywords were used to identify eligible studies: a) self-determination OR self-determination theory OR self-determined motivation OR autonomous motivation OR controlled motivation OR intrinsic motivation OR extrinsic motivation; AND b) physical activity OR exercise OR fitness OR movement.

Search results were exported into Endnote reference manager software and duplicates removed. The titles and abstracts of these studies were independently screened by two researchers for eligibility. Any discrepancies regarding criteria fulfillment were resolved by discussion between the two researchers and a third investigator until consensus was reached. Next, reference lists of the eligible studies were reviewed to identify additional studies. Full-text articles of these studies were retrieved; when they were unobtainable, we contacted authors of the paper to request a copy of the paper or the information required for the analyses. Further, to include studies that may not be included in these databases (e.g., theses, unpublished datasets, in-press publications), the authors posted a message on the Self-Determination Theory and SPORTPSY electronic mailing lists, requesting that researchers provide such information to be included in the meta-analysis.

Data extraction

The relations between SDT-based motivation variables and PA were extracted. These motivation variables included: (1) overall level of self-determined motivation (measured with the RAI); (2) intrinsic motivation; (3) integrated regulation; (4) identified regulation; (5) introjection; (6) external regulation; (7) amotivation; (8) composite autonomous motivation; and (9) composite controlled motivation. Many studies assessed the relation between motivation and activity in more than one life context. For example, multiple studies examined the association between motivation towards physical education (PE) and PA behavior during leisure time, as well as the relation between motivation towards leisure time PA and PA behavior within the same context. In these instances, both results were extracted.

Summary measures and synthesis of results

Zero order correlations were extracted and guidelines for interpreting the strength of the correlations (r) were .1 (weak), .3 (moderate), and .5 (strong) (Cohen, 1988). The meta-analytic procedures suggested by Hunter and Schmidt

(2004) were used to calculate the pooled effect sizes (ρ). This method is based on a random effects model. When calculating effect sizes, measurement errors were also corrected for using Cronbach alphas. A 95% confidence interval (CI) was drawn for each meta-analyzed effect size. When a 95% CI did not include zero, a real effect between the variables was said to exist. To account for possible publication bias, the fail-safe N (FSN) was also calculated for each effect size exceeding .10, or a weak effect. Essentially, the FSN is a number presenting the number of unpublished studies with a null effect that, if included in the existing analyses, would bring the effect size to a weak effect. When the FSN is small, relative to the number of studies (k) included, the real effect found would be unlikely to be overturned by unpublished studies that were not identified in the review.

The I^2 statistic was then used to assess the heterogeneity in effect sizes from primary studies (Higgins et al., 2003). When I^2 exceeded 25%, moderator analyses were conducted. Essentially, subgroup meta-analyses based on different levels of potential moderators were conducted. For each heterogeneous effect size, the effects of measurement tools (objective vs. subjective), study design (cross-sectional vs. prospective vs. longitudinal vs. experimental), type of PA measure used (objective measure vs. self-report), age (children under age 13 vs. adolescents, age 13 or above), risk of bias within studies, and publication status (published vs. unpublished) were tested. For effect sizes involving the RAI, the formulae used to derive the index was also examined as a potential moderator (2 * intrinsic motivation + identified regulation − introjection – 2 * external regulation vs. 3 * intrinsic motivation + 2 * identified-regulation − introjection – 2 * external regulation − 3 * amotivation). When the 95% CIs corresponding to two or more levels of effect sizes did not overlap, the variable was considered to moderate the effect size.

Risk of bias in individual studies

Risk of bias was assessed using a tool based on the guidelines for reporting observational studies: Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guide and the CONsolidated Standards of Reporting Trials (CONSORT) statement. Six criteria from these guidelines were adapted in order to assess studies employing cross-sectional, longitudinal, and experimental designs. Specifically, two researchers independently assigned a 1 (present and explicitly described) or 0 (absent or inadequately described) based on the following criteria: a) description of participant eligibility criteria, b) random selection of schools and/or participants (sampling procedures appropriate and adequately described), c) valid assessment of participant motivation (reliability and validity evidence was reported in the article), d) valid assessment of participant PA and/or activity level of physical education (reliability and validity evidence was reported in the article), e) power calculation reported and study adequately powered to detect hypothesized relations, and f) covariates adjusted for in analyses (e.g. gender, age, weight status). For each criterion, we conducted moderator analyses (six for each effect size) by separating studies coded as 1 or 0, thereby examining whether potential risks of bias were indeed moderators of the pooled effect sizes.

Results

Study selection

As shown in Fig. 1, we identified 1928 studies after duplicate records were removed ($n = 686$). An additional five unpublished studies were identified through responses to our request on electronic mailing lists. We screened all titles and abstracts and removed those that did not meet the inclusion criteria. Next, we obtained full-text articles of 139 papers and two researchers independently screened the papers for eligibility. Forty-six full-text articles met the inclusion criteria and were included.

Study characteristics

See Table 1 for complete study characteristics. Twenty-six studies employed a cross-sectional design, 13 employed a prospective design, and five employed a longitudinal design. Other studies included a randomized controlled trial with randomization occurring at school level (Chatzisarantis and Hagger, 2009), and a quasi-experimental design (Lonsdale et al., 2009).

A total of 16,723 participants were included across the 46 studies. Study sample sizes ranged from $n = 61$ (Owen et al., 2013) to $n = 1071$ (Hwang and Kim, 2011), with a median of $n = 237$. Participant mean ages ranged from 10.03 (Sebire et al., 2013) to 17.43 (Gerber et al., 2011), with a median of $n = 14.04$.

Risk of bias

See Table 2 for complete risk of bias assessments. The majority of studies met less than three of the six risk of bias criterion, ($M = 2.5$). The criteria most often not addressed included the statistical power calculation ($k = 44$), sampling procedure description ($k = 44$), participant eligibility description criteria ($k = 34$), and covariate adjustment in the analyses ($k = 32$).

Main analyses

Full results of the meta-analyses and moderator analyses are presented in Table 3. Some analyses involved only one study; therefore, the CI using meta-analytical techniques could not be generated. In these cases, the CIs for point estimates were presented instead. However, these effect sizes or results of related moderator analyses will not be interpreted.

Regarding the effect sizes between motivation to PE and PA levels during PE, we found that autonomous forms of motivation (RAI, intrinsic motivation, identified regulation, composite autonomous motivation) had weak to moderate, positive associations with PA ($\rho = .25$ to .34). A weak positive effect size was also found between introjection and PA ($\rho = .22$, 95% CI [.08, .35]). However, the 95% CI of the association size between external regulation and PA encompassed zero ($\rho = .06$, 95% CI [−.15, .28]), suggesting that a real effect did not exist. As hypothesized, we also found a negative association between amotivation and PA ($\rho = -.11$, 95% CI [−.20, −.02]).

In terms of the relation between motivation towards general PA and leisure time PA, we again found that autonomous forms of motivation had weak to moderate positive associations with PA ($\rho = .26$ to .38). Within this context, the association between introjection and PA encompassed zero ($\rho = .06$, 95% CI [−.01, .12]). A negative, but very weak association was found between external regulation and PA ($\rho = -.08$, 95% CI [−.16, −.01]). A weak negative association was found between amotivation and PA ($\rho = -.14$, 95% CI [−.24, −.04].

Some researchers also examined whether motivation towards PE may be related to students' PA behaviors in their leisure time. Similar to associations in the other contexts, we found weak to moderate positive associations between autonomous forms of motivation and PA ($\rho = .21$ to .33). Introjection had a weak positive relation with PA ($\rho = .12$, 95% CI [.02, .22]), and a null effect was found for external regulation ($\rho = -.08$, 95% CI [−.16, .003]). Amotivation towards PE was negatively associated with PA during leisure time ($\rho = -.21$, 95% CI [−.28, −.13]).

Homogeneity tests and moderator analyses

The I^2 value of all main analyses exceeded 25%, and, therefore, moderator analyses were conducted for all effect sizes. Only those effects for which a significant moderator was found are described below and listed in Table 3.

For the effect sizes relating motivation towards general PA and PA during leisure time, we found the association between identified regulation and PA was moderated by the type of PA measure used. Specifically, an effect did not exist in studies using objective measures for PA ($\rho = .08$, 95% CI [−.004, .16]), while a moderate effect was found when self-reported measures were used ($\rho = .30$, 95% CI [.22, .37]).

Publication status was found to moderate the association between external regulation and PA. Published studies that examined this

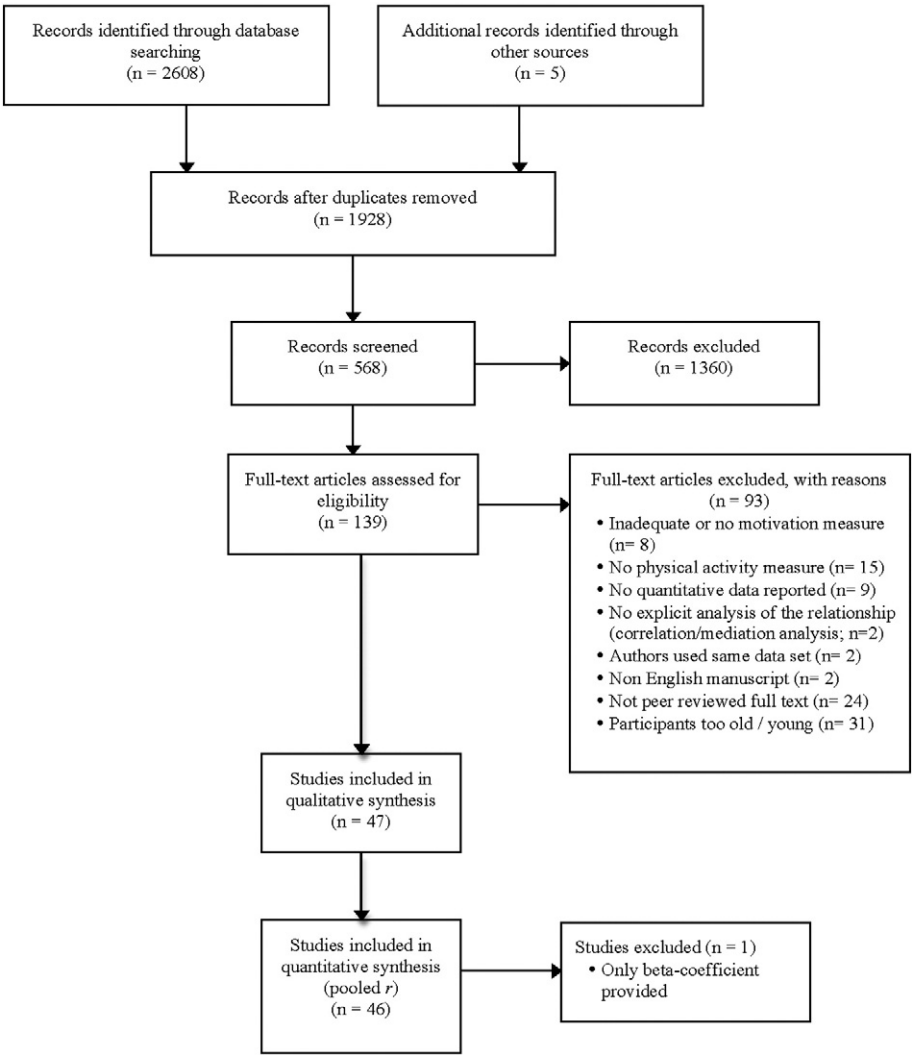

Fig. 1. Flow diagram of search results.

association reported a weak positive effect ($\rho = .09$, 95% CI [−.09, .27]); whereas, unpublished studies that examined the association reported a moderate negative effect ($\rho = -.48$, 95% CI [−.80, −.15]). Moderator effects were also found for age. Specifically, the effect size of the relationship between identified regulation towards leisure time PA and PA during leisure time was larger in studies conducted with adolescents (mean age ≥ 13; $\rho = .30$, CI [.22, .38]), compared to studies with children (mean age < 13; $\rho = .07$, CI [−.02, .17]). A criterion of risk of bias was also found to moderate an effect; the association between external regulation and PA was stronger when studies controlled for participants' age and sex in their analyses ($\rho = -.26$, 95% CI [−.33, −.19]) than when these variables were not included in the analyses, and null effects were found ($\rho = -.01$, 95% CI [−.07, .06]).

Discussion

The aim of this study was to systematically review studies framed by SDT that examined the association between motivation and PA in children and adolescents. Overall, the findings provide some support for SDT tenets, as autonomous forms of motivation were more strongly and positively associated with PA than controlled motivations. However, it should be noted that even the strongest effects observed were only weak to moderate in size, suggesting that factors other than motivation are important correlates of PA behavior (Martin et al., 2012). That said, motivation was found to be a significant predictor of PA in both PE and leisure-time contexts.

Physical education

Autonomous forms of motivation towards PE had weak to moderate associations with PA during PE. It is important to acknowledge that PA levels in PE may be largely determined by teachers' lesson planning, and some weak effects may be partly explained by teacher practices that fail to maximize opportunities to be active (Lonsdale et al., 2013). It is, therefore, possible for students to be highly motivated to participate in PE, but spend a large portion of the lesson listening to instructions, waiting for their turn, and transitioning between activities. Indeed, evidence suggests that students are typically engaged in moderate-to-vigorous physical activity (MVPA) for one third of PE lesson time (Fairclough and Stratton, 2005; Lonsdale et al., 2013; Marmeleira et al., 2012; Sallis et al., 2012). While students need opportunities to be active in PE lessons, motivation appears to also be an important correlate of PA during PE. For example, Jaakkola et al. (2008) found that students' autonomous motivation was a significant predictor of accelerometer measured PA during PE. As a result, interventions designed to increase PA during PE, may be maximally effective if they not only create greater opportunities for PA (Lonsdale et al., 2013), but also enhance autonomous forms of motivation (Chatzisarantis and Hagger, 2009).

Table 1
Study characteristics.

Author	Study design	Sample size (n)	Age (y)	Male/ female	Country	Measures			
						Motivation in PE	Physical activity in PE	Motivation in LT	PA in LT
Aelterman et al., 2012	Cross-sectional	739	14.36	342/397	Belgium	BRPEQ	Accelerometer		
Bagoien et al., 2010	Cross-sectional	329	16.5		Norway	SRQ		SRQ	11-item self-report
Bagoien and Halvari, 2005	Cross-sectional	231	16.6	121/110	Norway			SRQ	1-item self-report
Barkoukis and Hagger, 2009	Prospective	183	13.93	92/91	Greece	PLOC		BREQ	LTEQ
Barkoukis et al., 2010	Prospective	274	16.89	132/137	Greece	PLOC		BREQ	LTEQ
Biddle and Armstrong, 1992	Prospective	72	12.2	37/35	England	MOSS	Heart rate monitor		
Chatzisarantis et al., 1997	Prospective	100	13.5	21/79	England	PLOC			LTEQ
Chatzisarantis and Hagger, 2009	Cluster randomised control	215	14.84	106/109	England	PLOC			LTEQ
Chatzisarantis et al., 2002	Prospective	140	13.53	78/62				PLOC	LTEQ
Cox et al., 2008	Longitudinal	344	12.4	152/192	United States	SRQ	PAQ-C		PAQ-C
Cox and Ullrich, 2010	Cross-sectional	249	12.75	115/134	United States	SRQ	PAQ-C		
Cox et al., 2013	Cross-sectional	298	15.72	119/179	United States	PLOC	PAQ-A		PAQ-A
Fenton et al., under review	Cross-sectional	108	12.81	108	England			BRSQ	Accelerometer
Gerber et al., 2011	Longitudinal	210	17.43	60/150	Switzerland			12-item Seelig, 2006	LTEQ
Gillison et al., 2006	Cross-sectional	580	14.06	300/280	England			BREQ	LTEQ
Gillison et al., 2011	Prospective cohort	310	14.93	157/153	England			BREQ-2	LTEQ
Gourlan et al., 2013	Cross-sectional	125	14.82	54/71	France			BREQ-2	PAQ-A
Hagger et al., 2003	Prospective	295	14.5	132/163		PLOC		PLOC	LTEQ
Hagger et al., 2009	Prospective	210	13.19	94/116	Brittain	PLOC		BREQ	LTEQ
		268	15.04	117/151	Estonia	PLOC		BREQ	LTEQ
		127	14.3	55/72	Finland	PLOC		BREQ	LTEQ
		235	14.02	114/121	Hungary	PLOC		BREQ	LTEQ
Hagger et al., 2005	Prospective	222	14.68	104/118	Britain	PLOC		BERQ	LTEQ
		93	13.99	36/57	Greece	PLOC		BERQ	LTEQ
		103	16.28	47/56	Poland	PLOC		BREQ	LTEQ
		133	13.32	66/67	Singapore	PLOC		BREQ	LTEQ
Hashim et al., 2011	Cross-sectional	300	13.4	197/103	Malaysia			BREQ-2	IPAQ:S-F
Hwang and Kim, 2011	Cross-sectional	1071	14.91	662/409	South Korea			BREQ-2	LTEQ
Jaakkola et al., 2008	Cross-sectional	139		87/52	Finland	SMS, SIMS	Polar Team System heart rate moitor		
Kalaja et al., 2010	Cross-sectional	316	13	154/162	Finland	SMS			2-item self-report
Lonsdale et al., 2009	Quasi-experimental	528	15.78	232/296	Hong Kong	SIMS	Pedometer		
Markland and Ingledew, 2007	Cross-sectional	98	16.89	50/48	Brittain			BREQ-2	LTEQ
Mcdavid et al., 2012	Cross-sectional	161	12.77	64/97	United States			BREQ	PAQ-C
Ng et al., conference paper	Cross-sectional	115	11.6	51/64	Hong Kong			PLOC	Accelerometer
Ommundsen and Kvalø, 2007	Cross-sectional	194	16	100/94	Norway	PLOC			1-item self-report
Owen et al., 2013	Cross-sectional	61	14.36	61/0	Australian	PLOC	Accelerometer	PLOC	Accelerometer
Pan et al., 2011	Prospective	75	14.08	75/0	Taiwan	MPES	Accelerometer		
Papaioannou et al., 2006	Longitudinal	882		329/553	Greece	IMI			2-item self-report
Pihu et al., 2008	Prospective	399	14.7	123/276	Estonia	PLOC		BREQ	LTEQ
Sebire et al., 2013	Cross-sectional	462	10.03	199/263	England			Adapted BREQ	Accelerometer
Shen et al., 2008	Cross-sectional	837	12.9	410/427	United States	PLOC			LTEQ
Slingerland et al., unpublished	Cross-sectional	73	15.7	37/36	The Netherlands	BRPEQ	Heart rate monitor, accelerometer, activity diary	BREQ-2	Heart rate monitor, accelerometer, activity diary
Standage et al., 2012	Prospective	494	12.58	201/291	England	PLOC		BREQ-2	Pedometer-Yamax Digiwalker SW-351
Taylor et al., 2010	Longitudinal	178	13.82	123/55	England	PLOC			PAQ-C
Ullrich-French and Cox, 2009	Prospective	386	12.78		United States	SRQ			PAQ-C
Verloigne et al., 2011	Cross-sectional	177	15.1	67/110	Belgium			BREQ-2	FPAQ
Vierling et al., 2007	Cross-sectional	239	12.11	120/119	United States			SRQ	Pedometer-Walk4Life
Wang et al., 2002	Cross-sectional	824	12.71	427/391	England	PLOC AMS			3-item self-report
Wang et al., 2010	Cross-sectional	984	14.12	342/642	China	PLOC			2-item self-report
Yli-Piipari et al., 2009	Cross-sectional	429	13.04	213/216	Finland	SMS			HBSC
Yli-Piipari et al., 2012	Longitudinal	822	12.31	430/392	Finland	SMS			HBSC
Zhang, 2009	Cross-sectional	286	13.4	143/143	United States	PLOC			PAQ-C

Note. PE = physical education; LT = leisure-time; AMS = Academic Motivation Scale; BREQ = Behavioural Regulation Exercise Questionnaire; BRPEQ = Behavioral Regulations in Physical Education Questionnaire; BRSQ = Behavioural Regulation in Sport Questionnaire; HBSC = Health Behaviour in School-aged Children; IMI = Intrinsic Motivation Inventory; LTEQ = Leisure-time Exercise Questionnaire; MOSS = Motivational Orientation in Sport Scale; MPES = Motivation in Physical Education Scale; PAQ-A = Physical Activity Questionnaire for Adolescents; PAQ-C = Physical Activity Questionnaire for Children; PLOC = Perceived Locus of Causality; SIMS = Situational Motivation Scale; SMS = Sport Motivation Scale; SRQ = Self-Regulation Questionnaire; blank cells indicated that study variable was not measured.

Leisure-time

As hypothesized, autonomous forms of motivation towards PE had weak to moderate positive associations with leisure-time PA. This finding supports previous research that suggests that PE may help to shape young people's PA beliefs and behaviors outside school hours (Hagger et al., 2003). However, caution is warranted as most studies in our review employed a cross-sectional design, making causal inferences premature. Schools, and more specifically PE lessons, are well placed to promote PA among young people (Centers for Disease Control & Prevention, 2011). Indeed, the trans-contextual model proposes a motivational sequence in which autonomy supportive teacher practices in PE predict autonomous motivation, intentions and leisure-time PA behavior (Hagger et al., 2005). Alternatively, poorly planned and delivered PE lessons that fail to engage students, along with teachers that use controlling teaching practices (e.g., 'exercise as punishment') may negatively influence long-term PA participation (Biddle, 2001). There is some evidence that interventions designed to enhance PE teachers' autonomy support can increase students' self-determined motivation towards PE, as well as their PA intentions and self-reported PA behavior (Chatzisarantis and Hagger, 2008; Cheon et al., 2012). Further research is needed to determine if these interventions can increase objectively measured PA during leisure-time.

Regarding the relationship between autonomous forms of leisure-time PA motivation and PA accumulated during leisure-time, weak to moderate positive associations were found. Leisure-time is an important context for children and especially adolescents to be physically active, as opportunities for PA during PE lessons and other school contexts will cease upon the completion of school. Further, leisure-time PA habits tends to track from childhood and adolescence into adulthood (Janz et al., 2000; Telama et al., 2005). Future interventions aiming to promote life-long PA habits may be effective in targeting leisure-time motivation alongside other factors that influence motivation (Martin et al., 2012).

Moderators

Moderator analyses indicated that studies adopting self-report measures of PA found stronger correlations than studies adopting objective measures in the leisure-time context. Common method artifact (Dishman, 1994), social desirability bias, and young people's inability to accurately recall their PA behavior may explain these findings (Troiano et al., 2012). Further research that minimizes the potential for respondent bias is needed. For example, studies that employ objective measures of PA, such as accelerometers, may provide a more accurate estimate of young people's PA levels (Troiano et al., 2008), compared to self-report measures.

Age was found to moderate the association between identified regulation towards leisure time PA and PA during leisure time. Studies that mostly examined adolescents (i.e., mean age ≥ 13; Esposito et al., 2009) reported stronger associations between identified regulation towards leisure time PA and PA during leisure time, compared to studies that mostly assessed children (i.e., mean age <13; Esposito et al., 2009). This finding may be due to different forms of motivation being more salient at different stages of life. Children's PA tends to be underpinned by intrinsic motivation (e.g., enjoyment; Pellegrini and Smith, 1998); whereas, adolescents' PA is driven more by identified regulation (e.g., self-identified benefits; Ingledew and Sullivan, 2002). However, the PA evidence base regarding SDT studies is limited, as little research has focused on children; only three studies specifically recruited and assessed children (Biddle and Armstrong, 1992; Ha et al., 2013; Sebire et al., 2013). Therefore, future research that examines the relation between children's motivation and PA is needed. Understanding children's patterns of PA is particularly important, given the evidence suggesting that children's PA habits tend to track into adulthood (Janz et al., 2000; Telama et al., 2005).

Moderator analyses were conducted to compare results from studies that had, or did not have, potential risk of bias to effect sizes. Although some subgroup analyses for a specific level of risk of bias only had a single study, and therefore the corresponding moderator analyses should be interpreted with caution. Generally, studies that met a specific risk of bias criterion reported slightly stronger correlations between motivation and PA, compared to the studies that did not. The majority of studies met less than three of the six risk of bias criterion ($M = 2.5$). Therefore, future research with low risk of bias is needed in this area (Concato et al., 2000). In particular, studies are needed that are adequately powered, describe participant eligibility criteria, conduct random allocation procedures (where appropriate), and adjust for appropriate covariates in analyses. Future research is also needed that examines the differences in the predictive utility different RAI formulas.

Strengths and limitations

To the authors' knowledge, this is the first systematic review and meta-analysis of the relation between motivation (as framed by SDT) and PA in children and adolescents. Although other researchers (Ng et al., 2012; Teixeira et al., 2012) have conducted meta-analysis examining the relation between behavioral regulations and exercise behaviors, these studies did not include effect sizes of children's and adolescents' PE motivation or PA behaviors during PE, or leisure time. It is important to examine children and adolescents' exercise behaviors, as current levels of PA are particularly low. This review indicates that targeting autonomous forms of motivation in interventions may indeed be an effective way to promote PA in children and adolescents; however, there are some limitations that should be noted.

The meta-analyses are limited as there was substantial heterogeneity observed in the majority of analyses and therefore, results should be interpreted with caution. This high level of heterogeneity could be attributed to the wide variety of PA measurement tools and the different contexts in which the original data were collected (i.e., PE and leisure time). Additionally, when we examined age as a moderator, studies were divided into two categories: studies with a mean age of 13 and above (adolescents) and studies with a mean age less than 13 (children). This method of separating studies is limited in that studies with a mean age of less than 13 most likely included some participants who are older than 13 and these participants were misclassified as children, and vice versa. Therefore, caution is warranted when interpreting these results.

This review has a number of other limitations. For example, most studies included in the review employed a cross-sectional design, thus further testing of SDT tenets in longitudinal and experimental studies is warranted. Another limiting factor is that this review did not explore the inter-relations between basic psychological needs satisfaction, motivation, and PA. The satisfaction of three basic psychological needs (competence, relatedness, and autonomy) predicts self-determined motivation (Ryan and Deci, 2000) and further study into the influence of needs satisfaction on PA is clearly warranted. Investigations that examine the social factors (e.g., teachers, parents, peers) that influence needs satisfaction, motivation, and PA are also needed. However, these relations were considered to be beyond the scope of this review.

Conclusions

Promoting PA in children and reducing the decline in activity typically observed during adolescence are global health priorities. Self-determination theory provides a useful framework for understanding children and adolescents' motivation for PA. This review supports an important tenet of SDT that self-determined motivation is associated with sustained health promoting behavior.

Table 2
Risk of bias within studies.

Author	Description of participant eligibility criteria	Random selection of schools and/or participants (sampling procedures appropriate and adequately described)[a]	Valid assessment of participant motivation (reliability and validity evidence was reported in the article)	Valid assessment of participant physical activity and/or activity level of physical education (reliability and validity evidence was reported in the article)	Power calculation reported and study adequately powered to detect hypothesized relationships	Covariates adjusted for in analyses (e.g. gender, age, weight status)	Risk of bias/6
Aelterman et al., 2012	0	0	1	1	0	1	3
Bagoien et al., 2010	0	0	1	0	0	0	1
Bagoien and Halvari, 2005	0	0	1	1	0	0	2
Barkoukis and Hagger, 2009	0	0	1	1	0	0	2
Barkoukis et al., 2010	0	0	1	1	0	0	2
Biddle and Armstrong, 1992	1	0	1	1	0	1	4
Chatzisarantis et al., 1997	0	0	1	1	0	0	2
Chatzisarantis and Hagger, 2009	1	0	1	1	0	0	3
Chatzisarantis et al., 2002	0	0	1	1	0	0	2
Cox et al., 2008	1	0	1	1	0	0	3
Cox and Ullrich, 2010	1	0	1	1	0	0	3
Cox et al., 2013	1	0	1	1	0	1	4
Gerber et al., 2011	0	0	1	1	0	0	2
Gillison et al., 2006	1	0	1	1	0	1	4
Gillison et al., 2011	0	0	1	1	0	0	2
Gourlan et al., 2013	1	0	1	1	0	1	4
Hagger et al., 2003	0	0	1	1	0	0	2
Hagger et al., 2009	0	0	1	1	0	1	3
Hagger et al., 2005	0	0	1	1	0	1	3
Hashim et al., 2011	0	0	1	1	0	0	2
Hwang and Kim, 2011	0	0	1	1	0	1	3
Jaakkola et al., 2008	0	0	1	1	0	1	3
Kalaja et al., 2010	0	0	1	1	0	0	2
Markland and Ingledew, 2007	0	0	1	1	0	1	3
Mcdavid et al., 2012	1	0	1	1	0	0	3
Ommundsen and Kvalø, 2007	0	0	1	0	0	0	1
Owen et al., 2013	1	0	1	1	0	0	3
Pan et al., 2011	0	0	1	1	0	0	2
Papaioannou et al., 2006	0	0	1	0	0	0	1
Pihu et al., 2008	0	0	1	1	0	0	2
Shen et al., 2008	0	0	1	1	0	1	3
Standage et al., 2012	0	0	1	1	0	0	2
Taylor et al., 2010	0	0	1	1	0	1	3
Ullrich-French and Cox, 2009	0	0	1	1	0	0	2
Verloigne et al., 2011	1	0	1	1	0	0	3
Vierling et al., 2007	0	0	1	1	0	0	2
Wang et al., 2002	0	0	1	0	0	0	1
Wang et al., 2010	0	0	1	0	0	0	1
Yli-Piipari et al., 2009	0	0	1	1	0	1	3
Yli-Piipari et al., 2012	1	0	1	1	0	1	4
Zhang, 2009	0	0	1	1	0	0	2

[a] For intervention studies the criterion was as follows: were participants randomly allocated and was the process of randomization clearly described and adequately carried out (envelope or algorithm)?

Table 3
Results of meta-analyses and moderator analyses.

	k	*n*	ρ/95% CI	I^2	FSN
Motivation towards physical education (PE)–physical activity (PA) during PE					
Relative autonomy index and PA					
All studies	6	1220	.25 [.19, .31]	35.9%	9
By moderator: study design					
Cross-sectional	3	273	.33 [.27, .38]	0.0%	
Prospective	1	75	.01 [−.22, .24]	n/a	
Intrinsic motivation and PA					
All studies	5	1035	.34 [.25, .43]	64.5%	12
By moderator: study design					
Cross-sectional	3	432	.39 [.32, .46]	15.5%	
Prospective	1	75	.01 [−.23, .25]	n/a	
Experimental	1	528	.35 [.25, .44]	n/a	
By moderator: risk of bias					
Bias 1 = Yes	4	960	.37 [.32, .42]	14.6%	
Bias 1 = No	1	75	.01 [−.23, .25]	n/a	
Identified regulation and PA					
All studies	5	1035	.27 [.15, .39]	81.0%	9
By moderator: PA measure type/risk of bias					
Objectively measured PA/Bias 6 = No	4	737	.19 [.13, .25]	0.0%	
Self-reported PA/Bias 6 = Yes	1	298	.46 [.33, .58]	n/a	
Introjected regulation and PA					
All studies	3	446	.22 [.08, .35]	60.8%	4
By moderator: PA measure type/risk of bias					
Objectively measured PA/Bias 6 = No	2	148	.05 [−.03, .14]	0.0%	
Self-reported PA/Bias 6 = Yes	1	298	.30 [.17, .43]	n/a	
External regulation and PA					
All studies	5	1035	.06 [−.15, .28]	92.2%	n/a
By moderator: publication status					
Published	4	962	.09 [−.09, .27]	91.5%	
Unpublished	1	73	−.48 [−.80, −.15]	n/a	
By moderator: risk of bias					
Bias 1 = Yes	4	960	.02 [−.20, .24]	86.9%	
Bias 1 = No	1	75	.53 [.28, .78]	n/a	
Bias 2 = Yes/Bias 5 = Yes	1	73	−.48 [−.80, −.15]	n/a	
Bias 2 = No/Bias 5 = No	4	962	.09 [−.09, .27]	91.5%	
Amotivation and PA					
All studies	4	737	−.11 [−.20, −.02]	50.1%	1
Composite autonomous motivation and PA					
All studies	3	1110	.27 [.16, .38]	84.0%	6
By moderator: PA measure type					
Objectively measured PA	2	812	.22 [.19, .25]	0.0%	
Self-reported PA	1	298	.43 [.31, .54]	n/a	
By moderator: risk of bias					
Bias 1 = Yes	2	371	.40 [.32, .48]	27.8%	
Bias 1 = No	1	739	.21 [.13, .29]	n/a	
Composite controlled motivation and PA					
All studies	1	73	−.17 [−.45, .11]	n/a	1
Motivation towards general PA and PA during leisure time					
Relative autonomy index and PA					
All studies	15	3000	.31 [.25, .38]	81.2%	32
Intrinsic motivation and PA					
All studies	16	4625	.29 [.21, .37]	89.4%	31
Integrated regulation and PA					
All studies	1	125	.47 [.28, .67]	n/a	4
Identified regulation and PA					
All studies	14	4118	.26 [.16, .35]	93.2%	22
By moderator: PA measure type					
Objectively measured PA	5	1371	.08 [−.004, .16]	64.6%	
Self-reported PA	9	2747	.30 [.22, .39]	92.4%	
By moderator: risk of bias					
Bias 5 = Yes	1	462	.04 [−.07, .15]	n/a	
Bias 5 = No	13	3656	.28 [.19, .37]	92.6%	
By moderator: age					
≥13 years old	10	2808	.30 [.22, .38]	91.7%	
<13 years old	4	1310	.07 [−.02, .17]	73.2%	
Introjected regulation and PA					
All studies	14	4118	.06 [−.01, .12]	76.1%	n/a
External regulation and PA					
All studies	14	4118	−.08 [−.16, −.01]	82.4%	n/a
By moderator: risk of bias					
Bias 6 = Yes	3	1294	−.26 [−.33, −.19]	44.6%	
Bias 6 = No	11	2824	−.01 [−.07, .06]	56.9%	
Amotivation and PA					

(continued on next page)

Table 3 *(continued)*

	k	*n*	ρ/95% CI	I^2	FSN
All studies	9	2751	−.14 [−.24, −.04]	94.6%	4
Composite autonomous motivation and PA					
All studies	4	995	.38 [.14, .61]	96.2%	12
By moderator: study design					
Cross sectional	3	721	.51 [.38, .64]	87.0%	
Prospective	1	274	.02 [−.10, .15]	n/a	
Composite controlled motivation and PA					
All studies	1	231	−.03 [−.17, .11]	n/a	n/a
Motivation towards PE–PA during leisure time					
Relative autonomy index and PA					
All studies	16	3817	.21 [.14, .27]	82.3%	18
By moderator: study design					
Cross sectional	4	820	.24 [.19, .29]	0.0%	
Prospective	10	1960	.20 [.11, .29]	81.0%	
Longitudinal	1	822	.13 [.06, .20]	n/a	
Experimental	1	215	.49 [.36, .62]	n/a	
Intrinsic motivation and PA					
All studies	15	5882	.28 [.23, .34]	78.1%	28
Identified regulation and PA					
All studies	11	4335	.26 [.18, .34]	88.4%	18
Introjected regulation and PA					
All studies	10	4274	.12 [.02, .22]	89.3%	2
External regulation and PA					
All studies	11	4335	−.08 [−.16, .003]	86.9%	n/a
Amotivation and PA					
All studies	8	2566	−.21 [−.28, −.13]	71.1%	9
Composite autonomous motivation and PA					
All studies	4	1245	.33 [.23, .42]	79.8%	10

Note. Bias 1 = description of participant eligibility criteria; Bias 2 = random selection of schools and/or participants (sampling procedures appropriate and adequately described). For intervention studies the criteria were as follows: were participants randomly allocated and was the process of randomization clearly described and adequately carried out (envelope or algorithm)? Bias 3 = valid assessment of participant motivation (reliability and validity evidence was reported in the article); Bias 4 = valid assessment of participant physical activity and/or activity level of physical education (reliability and validity evidence was reported in the article); Bias 5 = power calculation reported and study adequately powered to detect hypothesized relationships; Bias 6 = covariates adjusted for in analyses (e.g. gender, age, weight status); FSN = fail-safe number; PA = physical activity.

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Conflict of interest statement

The authors declare that there are no conflicts of interest.

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