



The efficacy of Self Determination Theory-based interventions in increasing students' physical activity: A systematic review

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Abstract

Recent studies suggest that students fail to meet the international guidelines for physical activity. Therefore, an increased number of physical activity interventions attempt to change this trend. The current paper reviews the intervention studies which were based on the Self-Determination Theory (SDT). Three databases (PsycINFO, Medline, and SPORTDiscus) were scrutinized in the current review, which yielded 437 potential articles. Employing the recommended selection based on the population, intervention, comparators, and outcome (PICO), 14 articles could be included in the narrative analysis. The results showed that interventions based on the SDT were very heterogeneously operationalized in these studies. Despite different interventions, the results suggest that SDT-based interventions have the potential to increase students' physical activity through both, autonomy and supportive environment. Teachers' professional development in implementing SDT-based physical activity interventions for students is highly recommended.

Keywords: active living; exercise; health; learning; school

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INTRODUCTION

We live in an increasingly sedentary world [1-3]. The Statistical data from World Health Organization (WHO) revealed that nearly 30% of the adult population is physically inactive [3]. This segment of the population could be at higher risk for mortality rates related to diabetes, cardiovascular diseases, and other non-infectious diseases.

Education can play a role in increasing physical activity. Through physical education (PE) courses, extracurricular activities, and sports events at primary, secondary, or tertiary level, schooling can help students to regulate their physical activity so that they can be intrinsically motivated to also exercise in adulthood. However, recent studies showed that students at different levels are also showing signs of insufficient physical activity [1-3]. It is estimated that around 80% of the adolescents (11-17 years old) are not meeting the WHO's recommendation of 60 minutes of moderate-to-vigorous physical activity (MVPA) per day [1-2].

With a growing concern on how to increase students' physical activity several intervention studies were carried out. Studies examining university students were summarised in two systematic reviews [4-5], which concluded that not all intervention are effective in increasing physical activity level. However, these reviews were limited to university students' and none of them focused on a theoretically driven intervention.

Physical activity interventions developed from theoretical frameworks are often considered to be more effective in changing the behaviour [6-7]. One of theoretical frameworks that has been used to explain exercise and other health behaviours is the Self-Determination Theory (SDT).

The SDT is a macro theory about motivation [8-10]. According to the theory, human behaviour is either intrinsically or externally motivated. Intrinsic motivation is the impetus for doing a behaviour for the internal reasons [11]. According to SDT the intrinsic motivation is related to three basic needs: autonomy (the need to have the feeling of owning the behaviour), competence (the need to have a sense of mastery in the behaviour), and relatedness (the need to be connected with those who have similar interest). These needs can either be facilitated or thwarted by the environment. People can move within the intrinsic-extrinsic motivation continuum, depending on the environment. Individuals can show more intrinsic motivation in an autonomy supportive environment, whereas a more controlling environment would result in a more extrinsic motivation. In this regard, SDT can be described as a motivation theory having a dynamic organismic nature that integrates both intrapersonal factors (i.e. personal goals, basic needs) and interpersonal and environmental factors [11].

In the context of health behaviours, there were studies that used SDT approach to increase physical activity and found that SDT-based interventions are effective in changing behaviour in health settings [12]. Two systematic reviews by Ng and colleagues [9] Teixeira and colleagues [10] revealed that SDT is a viable framework for interventions aimed at increasing physical activity. The SDT is said to perform better in understanding why some individuals were responsive to interventions (and as a result easier to change the negative behaviours) than others [9-10, 13]. However, to the authors' best knowledge, no systematic review exists on SDT-based intervention aimed at increasing students' physical activity. Previous intervention studies were either not theory-driven or were based on other theories (i.e. social-cognitive theory, transtheoretical theory), and/or were limited to university student populations.

Physical Education (PE) in primary and secondary schools are mandatory for most schools [11]. The PE course offers a unique chance where PE teachers can help students to internalize their motivation for exercise. Hence once they reach university level (or graduate from university), where physical education is no longer mandatory, they might be motivated to stay active. The PE teachers who instructed their class in an autonomy supportive way could affect students' basic needs satisfaction which later affect their physical activity level [11]. Despite the fact that an increasing number of studies implement SDT-based intervention to increase students physical activity, the effectiveness of these interventions was not evaluated to date.

The aim of the current paper is to systematically review intervention studies based on the SDT aimed at increasing students' physical activity. The current work complements the earlier systematic reviews which were limited to a university student population. Schools, through PE and

extracurricular activities offer chance for researchers and practitioners to influence student's motivation for exercise. Therefore, studies performed in this milieu should also be evaluated with special focus on the factors that promote intrinsic motivation.

METHODS

The current review follows Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines [14-16]. The search is delimited to articles published in English.

Eligibility Criteria

Studies inclusion criteria were:

1. Original academic articles published in peer reviewed journals.
2. The studies employ SDT-based intervention(s).
3. Selection of the studies is based on Population Intervention, Comparison, and Outcome (PICO) standard [14]:
 - a. P (population): students of any level education (primary, secondary, and university) of any socioeconomic status.
 - b. I (intervention): the intervention aimed at promoting physical activity must be based on the SDT.
 - c. C (comparison): the study must involve an intervention and a control group.
 - d. O (Output): the studies need to report physical activity level. The physical activity can be objectively measured (e.g. accelerometer or pedometer data) or subjectively measured or graded performance by assessors. If no physical activity reported, the study will be excluded. Articles that report only protocols of intervention will be excluded.

Since the aim of current systematic review is to summarize efficacy of SDT-based interventions to increase students' physical activity, only intervention studies that report physical activity level of students are included here. Protocol report, reviews, or correlational studies will be excluded from the result.

Search Strategy

The search was done by examining research articles from three electronic databases (SPORTDiscus, PubMed/Medline, and PsycINFO). A combination of keywords related to the theory (SDT), population of interest (student) and context (physical activity) were utilized under a Boolean logic-commands. The results were sorted by relevance. Other than searching through the databases, the authors also looked at the references in previous systematic reviews and articles from a website (www.selfdeterminationtheory.org). The search strategy is outlined in the Table 1.

Table 1. Search strategies used in current review.

Search Strategy Items	Details
Used keywords	Combination of two from the following: <ul style="list-style-type: none"> - Self-determination theory OR related constructs (e.g. autonomous motivation or intrinsic motivation) - Physical activit* OR exercise* OR Sport - Student*
Searched databases	PubMed/MEDLINE, Sportdiscus, and PsycINFO
Time filter	<i>none</i>
Language filter	English only
Document type filter	Articles in peer-reviewed journals
Inclusion criteria	Original article complying to the established PICO
Exclusion criteria	Reviews, Dissertation, Technical papers

Data Extraction and Analysis

The resulting selected studies are summarized and describe the authors, countries where the study took place, study design, characteristics of participants (education level, sex, age), and PA measure. Characteristics of the interventions employed is also summarized: duration of intervention, type of intervention, and target of population.

Data from the articles is analysed by the type of interventions. Each type of intervention is described in more detail. Potential impact of the intervention is reported on the analysis. Narrative analysis and synthesis is used to summarize the findings.

Risk of Bias Assessment

The studies included here were evaluated with Risk of Bias (RoB) 2.0. The RoB 2.0 is a tool for evaluating the bias from selected studies in a systematic review. The RoB 2.0 assesses five potential domains of bias source: (1) bias due to randomization process, (2) bias due to deviations from intended intervention, (3) missing outcome data, (4) bias in measurement of outcome, and (5) bias of selective reporting in results [17-19]. It can be used for randomized parallel-group trials, cluster-randomized parallel-group trials, and randomized cross-over trials and other matched designs. The five domains used different signalling questions that can be answered "Yes", "Probably Yes", "Probably No", "No", and "No Information." Based on answers to the signalling questions, the bias will be rated "low concern", "some concern" or "high risk of bias".

Since three studies included here are not randomized controlled trials, the authors used different bias evaluation tool for the three studies. The Risk of Bias in Non-Randomized Studies of Intervention (ROBINS-I) is similar to the RoB 2.0. However, the ROBINS-I is specifically used for non-randomized intervention studies. ROBINS-I evaluates studies in 7 domains: (1) confounding variables, (2) selection of participation bias, (3) classification of intervention bias, (4) deviations from intended intervention bias, (5) missing data, (6) measurement outcome bias, and (7) selective reporting bias [20]. These domains were evaluated by answering signalling questions. Depending on the answers to the signalling questions, the overall risk of bias was categorized into "low risk", "moderate risk", "serious risk", "critical risk", or "no information."

RESULTS

Through the search of the three databases, 371 potential articles were identified for the current systematic review. Additional search from Google Scholar, references of previous systematic review, and self-determination theory website (www.selfdeterminationtheory.org) found 66 more articles as potentially includable in the review, resulting in a total of 437 articles. Of this total, 88 duplicates were removed.

The remaining 349 articles' were screened by their titles and abstracts. Ensuing, 261 articles were removed because they were not in accord to the inclusion criteria (i.e. not focusing on physical activity, not intervention studies). The remaining 88 potential studies needed further assessment. Of the 88 articles, 64 were removed because they were either not intervention studies ($n = 20$), or not using the SDT as framework for the adopted intervention ($n = 44$), or no physical activity measurement was reported ($n = 10$). Consequently, 14 articles could be included for the qualitative synthesis in the current review. The search result is depicted in Figure 1.

Characteristics of the Included Studies

The included studies are presented in numerical order in Table 2 and cited according to their number in the subsequent text. Of the 14 articles, two articles reported the same intervention study from two different perspectives [21-22]. Therefore, these two articles are treated as one study.

Three of the studies were RCT studies (study 1, 7, 9), seven were cluster RCT studies (study 3, 4, 6, 10, 11, 12, 13), and three were quasi-experimental design (study 2, 5, 8). The studies had large variation in terms of the sample size, ranging from 43 in one study to 1806 participants in another study.

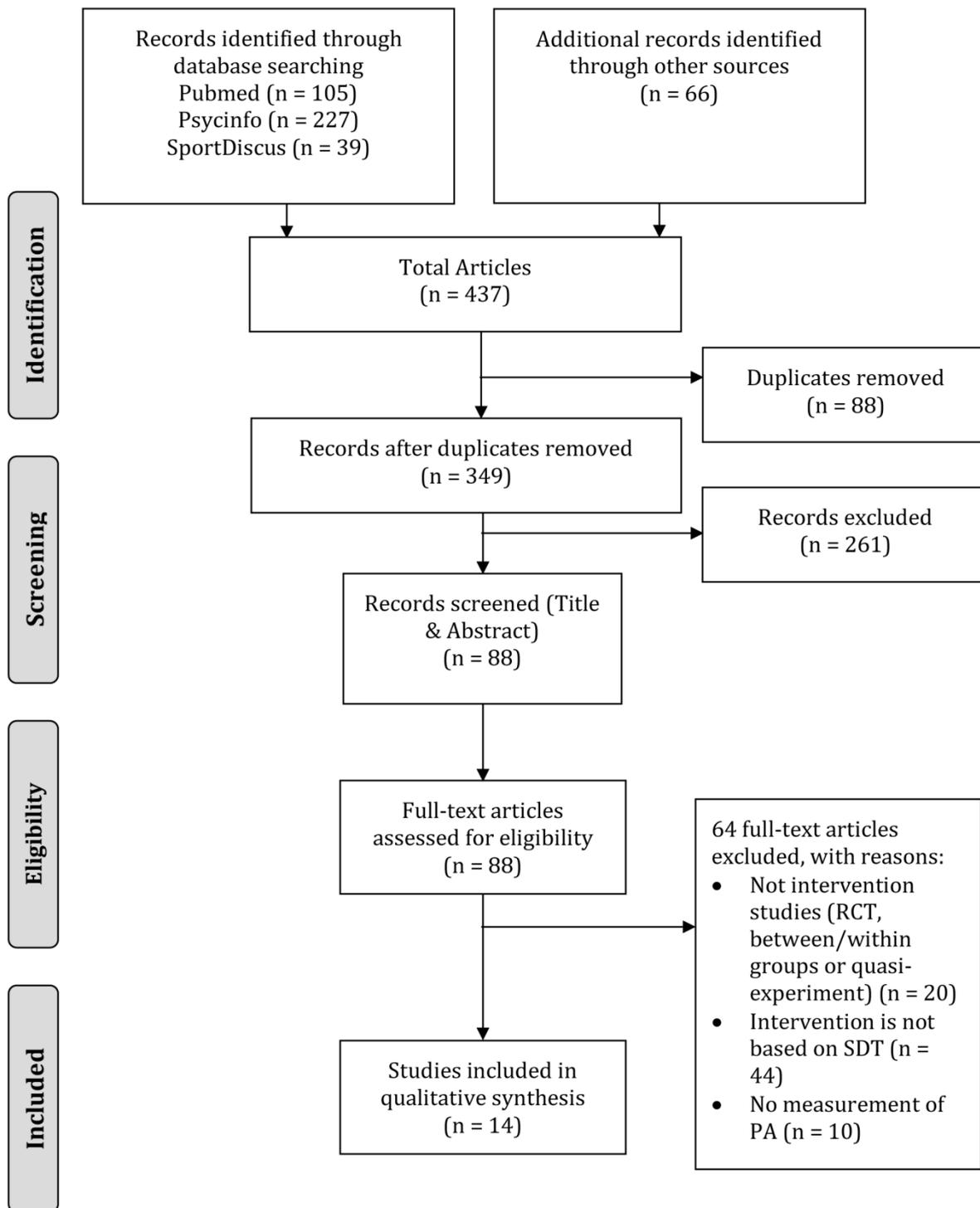


Figure 1. Article selection process for the current review. Based on Liberati et al. (2009)

Table 2. Summary of included articles.

No	Authors	Country	Study design	Context	Number of participants (students)	Total Attrition	Sex of Participants	Groupings	Mean Age of Participants (SD)	PA Outcome Measure
1	Vansteenkiste, et al (2004)	Belgium	RCT	S-Sch	224	NR	MF	4 (EG ₁₋₄)	NR	GP FC-B
2	Wilson, et al (2005)	US	Quasi-experiment	P-Sch	48	NR	MF	2 (EG-CG)	EG = 11 (0.6) CG = 11 (0.7)	Obj-PA
3	Chatzisarantis, et al (2009)	UK	Cluster RCT	S-Sch	235	20	MF	2 (EG-CG)	TS = 14.84 (0.48)	SR-PA
4	Lonsdale, et al (2013)	Australia	Cluster RCT	P-Sch	288	43	MF	4 (EG ₁₋₃ , CG)	TS = 13.6 (SD not reported)	Obj-PA
5	Pardo, et al (2014)	Spain	Quasi experiment	S-Sch	682	NR	MF	2 (EG, CG)	NR	Obj-PA
6	Smith, et al (2014)	Australia	Cluster RCT	S-Sch	361	68	M	2 (EG-CG)	TS = 12.7 (0.5)	Obj-PA
7	Peng, et al (2015)	US	RCT	Uv	127	6	MF	4 (EG ₁₋₃ , CG)	EG ₁ = 20.32 (1.19) EG ₂ = 20.26 (1.44) EG ₃ = 20.00 (1.73) CG = 20.13 (1.48)	Obj-PA
8	Wang, et al (2015)	Singapore	Quasi experiment	Uv	62	NR	MF	4 (EG ₁₋₃ , CG)	22.3 (1.51)	SR-PA
9	Sylvester, et al (2016)	UK	RCT	Uv	144	23	MF	2 (EG-CG)	F = 20.87 (3.09) M = 21.88 (3.57)	SR-PA
10	Ha, et al (2017)	Hongkong	Cluster RCT	S-Sch	767	36	MF	2 (EG-CG)	TS = 14.38 (1.07)	Obj-PA
11	Hankonen, et al (2017)	Finland	Cluster RCT	S-Sch	43	28	MF	2 (EG-CG)	NR	Obj-PA
12	Lonsdale, et al (2017)	Australia	Cluster RCT	S-Sch	1806	385	MF	2 (EG-CG)	EG = 12.96 (0.56) CG = 12.90 (0.52)	Obj-PA
13	Escriva-Boulley, et al (2018)	French	Cluster RCT	P-Sch	293	0	MF	2 (EG-CG)	TS = 8.31 (1.13)	Obj-PA

RCT - randomized controlled trial; Cluster RCT - cluster randomized controlled trial; S-Sch - secondary school; P-Sch - primary school; Uv - University; NR - not reported; MF - male & female; M - male; F - female; EG - experimental group(s); CG - control group; TS - total sample; GP - graded performance; FC-B - free choice behavior; Obj-PA - objectively measured physical activity; SR-PA - self-report physical activity

The studies also targeted students' physical activity at different education levels. Three studies targeted physical activity level in primary school (2, 4, 13), six studies focused on secondary school students (1, 3, 5, 6, 10, 11, 12), and three studies focused on university students (7, 8, 9). The studies also employed different physical activity measurements. Nine studies used objective measurement (i.e. using accelerometer) (2, 4, 5, 6, 7, 10, 11, 12, 13). Another three studies collected self-reported data to measure physical activity (3, 8, 9) and one study used physical education teachers' grade of performance in physical activity (1).

Table 3. Summary of intervention used in the current review.

No.	Authors	Target Intervention				Intervention			Intervention Provider			Duration
		Stu	Teac	Sch Adm	Sch Comm	Tra	Pra	EP	Res	Teac	Pro	
1	Vansteenkiste, et al (2004)	✓				✓			✓			1 wk
2	Wilson, et al (2005)	✓				✓			✓			4 wk
3	Chatzisarantis, et al (2009)	✓	✓			✓				✓		10 wk
4	Lonsdale, et al (2013)	✓	✓			✓	✓			✓		8 wk
5	Pardo, et al (2014)	✓	✓	✓		✓	✓		✓	✓	✓	3 yr
6	Smith, et al (2014)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	8 mo
7	Peng, et al (2015)	✓					✓		✓			4 wk
8	Wang, et al (2015)	✓					✓				✓	12 wk
9	Sylvester, et al (2016)	✓					✓				✓	6 wk
10	Ha, et al (2017)	✓	✓				✓			✓	✓	3 mo
11	Hankonen, et al (2017)	✓	✓			✓	✓		✓			6 mo
12	Lonsdale, et al (2017)	✓	✓			✓	✓		✓			15 mo
13	Escriba-Boulley, et al (2018)	✓	✓			✓	✓		✓			10 mo

St - students; Teac - teachers; Sch-Adm - school administrators; Sch comm - school community; Tra - training; Pra - practice; EP - equipment provision; Res - researchers

The reviewed studies differ in the intervention targets, form of intervention, and duration of the intervention. The duration of the interventions varied from one-week (1) to three years (5). All studies examined students' physical activity, but six studies also looked at teachers', school administrators', and parents' behaviour which encourage students' physical activity (3, 4, 5, 6, 10, 11). To increase students' physical activity, three studies provided training for the students directly (1, 2, 3) while the other 10 studies arranged training and practice for the students or teachers (4, 5, 6, 7, 8, 9, 10, 11, 12, 13). One study also provided exercise equipment for the school to help increasing students' activity level (6). Summary of the different intervention for the studies is presented in Table 3.

Risks of Bias

Assessment of bias from the randomized control trials included here showed that eight studies showed low overall risk of bias. These studies appropriately randomized participants into different treatments, ensured intervention fidelity, overcame potential bias from missing outcome data, used unbiased measures toward a specific group, and reported the findings in a holistic manner. Two studies had some concern of bias. These two studies had little information on how the randomization was performed, resulting in some concern whether the randomization was appropriate. Summary of the RoB 2.0 for the 10 randomized trials are presented in Table 4.

The remaining quasi experimental studies included in the review showed higher potential risk of bias compared to the randomized trials. These studies might potentially suffer from bias related to confounding variables. They do not consider the possible confound in data analysis. Unlike the randomized trials, these studies do not try to estimate the participants' missing data impact on the overall outcome. In general, these quasi experimental studies seemed to have more potential biases. Hence, the interpretation of their result should be cautious. The result of ROBINS-I of the quasi experiment studies is summarized in Table 5.

Efficacy of Different SDT-based Interventions

While the included studies were based on the SDT, they adopted different intervention techniques described in some detail below.

Effect of Written Text Material Bounded in Self-determination Framework

Vansteenkiste and colleagues conducted research that focused on whether PE class material that is framed in accord with the self-determination approach would impact physical activity behaviour of the students [23]. The researchers manipulated the written description of planned

physical activity. In one condition they read the benefits which reflect intrinsic (autonomous) goals, while in the other they read benefits associated with extrinsic (heteronomous) goals. The study also manipulated teachers' instruction to reflect autonomy in supportive or controlling manner.

Result of the study revealed that participants exposed to intrinsically motivating information showed better physical exercise performance as graded by a blinded assessor [23]. Further analysis revealed that the teachers' instruction (autonomy supportive or controlling) had larger effect on the graded performance and free choice behaviour compared to the written course material.

Effects of Student Training

Two studies used training for students as intervention [24-25]. Wilson and colleagues used an afterschool program for inactive students [24]. The intervention focused on improving snacking behaviour as well as increasing physical activity. Students were asked to come up with physical activities they would like to do themselves. The study revealed that compared to control group (who were given standard physical activity curriculum), participants in the experimental groups showed greater increase in the moderate physical activity (MPA), moderate-to-vigorous physical activity (MVPA), and Vigorous Physical Activity (VPA) levels. However, this pattern only occurred in program days. On other days, there were no differences between the groups.

Similar to the above study, Sylvester and colleagues conducted a study where the participants were allowed to make their own choices of the exercise they would like to do [25]. In this study, university students were randomly assigned to a condition where they performed fitness training in a variety situations (did similar exercises but with different techniques in different sessions) and low variety situation (similar technique for each session). The analysis showed that there were differences in exercise adherence and exercise behaviour between groups. The participants in the high variety exercise condition reported significantly higher exercise behaviour and adherence to exercise schedule.

Table 4. Risk of bias evaluation of randomized controlled trials in the current review.

Authors	Domain 1: Randomization Process	Domain 2: Deviation of intended intervention	Domain 3: Missing outcomes	Domain 4: Measurement of the outcome	Domain 5: Selective reporting	Overall Bias
Vansteenkiste, et al (2004)	High	Low	Low	Low	Low	Some concern
Peng, et al (2015)	Low	Low	Low	Low	Low	Low concern
Sylvester, et al (2016)	Low	Low	Low	Low	Low	Low concern
Chatzisarantis, et al (2009)	Low	Low	Low	Low	Low	Low concern
Lonsdale, et al (2013)	Low	Low	Low	Low	Low	Low concern
Smith, et al (2014)	Low	Low	Low	Low	Low	Low concern
Ha, et al (2017)	Low	Low	Low	Low	Low	Low concern
Hankonen, et al (2017)	Low	Low	Low	Low	Low	Low concern
Lonsdale, et al (2017)	Some concern	Low	Low	Low	Low	Some concern
Escriva, et al (2018)	Low	Low	Low	Low	Low	Low concern

Table 5. Risk of bias evaluation of quasi-experimental studies in the current review.

Authors	Bias due to confounding	Bias in Selection of Participants	Bias in Classification of Intervention	Bias due to deviation of intended intervention	Bias due to missing data	Bias in Measurement outcome	Bias in the selective reporting	Overall Bias
Wilson, et al (2005)	Moderate	Low	Low	Low	Moderate	Moderate	Low	Moderate
Pardo, et al (2014)	Moderate	Low	Moderate	No information	No Information	Moderate	Low	Moderate
Wang, et al (2015)	Serious	No Information	No information	Low	Low	Moderate	Low	Moderate

Effects of Teacher Training

Chatzisarantis and Hagger examined how teacher interpersonal behaviours impact students' physical activity [26]. Ten teachers were randomly assigned to treatment and control conditions. In the treatment condition the teachers were taught how to provide rationale for physical activity, positive feedback, and how to acknowledge students' difficulties in physical activity with the aim to boost autonomy support in students. These behaviours were the SDT concepts' application in real life situation. In control condition, the teachers were simply asked to provide rationale for engaging in physical activity. The results showed that students who were taught in an autonomy-supportive manner reported more leisure time physical activity than those in the control group.

In another research, teachers were randomly assigned to four training conditions: 1) rationale condition, 2) fixed choices condition, 3) free choices condition, and 4) practice as usual condition [27]. The first three groups reflected the SDT. In the rationale condition, the teachers were asked to explain students the activity they are going to do in the beginning of physical education session. In the fixed choice condition, the teachers were asked to provide students with options they can choose from. The free choice condition required teachers to let the students decide on their own the exercise they want to do. The results showed that only the free choice condition increased leisure time physical activity and reduced sedentary behaviour. Providing a rationale and options from which students can choose did not impact leisure time physical activity.

Similar results, to the previous study, were found in another research [28]. In this study 101 physical education (PE) teachers were randomly assigned to treatment condition or control condition. In treatment condition, teachers were given a professional development program prior to an academic year so that they can meet students' basic psychological needs that later influence their exercise behaviour. Analysis of difference between students in the experimental and control groups favoured the former. At the end of the intervention, measures based on accelerometer data revealed that the intervention group had 5% higher leisure time physical activity level than the control group. There was a decrease in the difference between the groups in the follow up sessions, but the intervention group still outperformed the control group.

Another study that focused on teacher training impact on students' physical activity was conducted by Escriva-Boulley and colleagues [29]. The researchers provided training for PE teachers before and during an academic year. The teachers in the training group were given materials on how to motivate students in their PE classes in an autonomy-supportive way. An evaluation at the end of the academic year has revealed that students in the teachers in intervention condition improved their MVPA level, whereas students in the control condition showed decreased MVPA compared to baseline.

Another study incorporated rope skipping for PE classes [30]. In this study, the researchers provided PE teachers with training to integrate rope skipping for their PE classes to increase students' physical activity. The training mimics the suggested practice for their PE classes. The results showed that that the integration of rope skipping did not influence the physical activity level. Further analysis indicated that the impact of rope skipping was moderated by the gender of the students. Rope skipping did improve girls' physical activity, but had no impact on boys' physical activity level.

The Effect of Whole School Approach

Two studies reported whole school approach that used multiple intervention strategies to increase students' physical activity [22, 31]. In a study conducted in Spain, an integrated intervention that used curricular and extracurricular activities was evaluated [31]. The curricular activities include training the PE teachers and a weekly tutorial on the implementation plans. The extracurricular activities included information dissemination for the broader schools' community (parents and other teachers), as well as arranging events and programs to increase students' physical activity. An evaluation of the approach performed three years later, revealed that the schools in treatment condition showed significantly higher MVPA level.

A similar study was conducted by Smith and colleagues [22]. The study used a wide array of interventions: from teacher development program, dissemination of information to parents, seminars for students, arranging sport sessions within the participating schools, mentoring, the utilization of pedometer, and development of internet-based application to increase physical activity in obese boys coming from lower socioeconomic status. The study reported mixed results. Analysis of the pedometer data showed that the intervention had no impact on the overall level of physical activity. However, the participants showed improved fitness skills (i.e. upper body muscular strength and resistance training skills).

The Impact of Technology Assisted Intervention

With the growing use of internet and social media, two studies integrated the use of social media or internet-based application in their intervention for physical activity [32-33]. A study conducted by Peng and colleagues focused on the impact of features of gaming that has features resembling application of SDT [32]. The game itself was an active video game (AVG) which required players to move their controller to advance in the game. When comparing participants who played the game with SDT-based features turned on and off, it was found that participants playing with the SDT-based features had greater attendance at playing games and, subsequently, had greater MVPA because of their higher frequency in moving while playing the AVG.

Another study tried to integrate the use of social media in the intervention [33]. This study compared participants in: (a) 3 hours physical activity intervention group, (b) 3 hours physical activity intervention group who were connected through a Facebook group, (c) 1-hour physical activity intervention group who were connected through a Facebook group, and (d) a control group. The results showed that the two 3-hours physical activity intervention groups, whether connected or not on the Facebook, had higher physical activity compared to the other two groups. This finding suggests that the 3-hours physical activity intervention was responsible for the increment of physical activity level, and the connection through the Facebook group did not have any additional effect.

DISCUSSION

The objective of the current review was to synthesize the published articles SDT based intervention to physical education for students. The current review found 14 articles reporting 13 intervention approaches delivered to primary, secondary, and university students. Of the 13 studies, 11 reported that the SDT-based interventions had a positive effect on physical activity. This finding agrees with previous systematic review on SDT-based intervention [9-10] that were carried out on mixed samples. It appears that the SDT-based interventions are effective in improving physical activity level in students of different age.

Despite differences in the operationalization of the SDT intervention, the studies seemed to indicate that perception of teachers' interpersonal style impact subsequent students' exercise behaviour [23-24, 26, 29, 35-36]. Simply explaining the rationale and the importance of physical activity is not enough in inducing changes in the level of physical activity [27, 30, 33]. Teachers' who provide rationale of the exercise as well as provide positive feedback, and acknowledge students' difficulty to remain active will be perceived as more autonomy supportive and facilitate the basic need satisfaction. The result of this perception can influence students' activity level.

Such findings support the previous claims that autonomy support would influence students' basic psychological needs satisfaction, which will lead to more autonomous motivation in doing

exercise regularly [11, 37]. However, this issue should be investigated more thoroughly, because some questions remain open. For example, how long the effects of teachers' autonomy support could last? As one study included here, indicated that after the intervention stopped, there were reduction in students' physical activity, though it was still significantly higher than at baseline. Longitudinal studies that follow students' exercise behaviour while transitioning into adulthood are necessary.

Another question begging for elucidation is how the teachers should interact with students during the PE classes so that they could provide support for autonomy? It seems that merely implementing one strategy (providing rationale only or choices only) is not enough to induce changes in students' physical activity. The SDT application should be used concurrently. It is recommended that teachers provide rationale, give students opportunities to generate their own options, and provide feedback as well as acknowledge students' difficulty during the process [24-25]. These joint actions could facilitate the internalization of physical activity.

Further, educating teachers on the concept of motivation in the SDT framework is important. Providing teachers with trainings and workshops, as well as monitoring their progress while giving feedback in an academic year should be endorsed. Such an intervention should not be limited to PE teachers only, but also to teachers and administrators, which would lead to an overall better learning climate in the school as a whole, not just in PE classes.

This review followed the suggestions of a previous review which proposed that theoretical based intervention evaluation should concentrate on which interventions are effective, for whom are they effective, and under what circumstances are they effective [34]. Specifically, this systematic review revealed SDT-based interventions that are effective in increasing students' physical activity level.

Despite the reviews contribution to supporting the SDT-based interventions' efficacy in increasing physical activity in students, the work has some limitations too. One is related to the inclusion of a few studies which used multi-interventions (e.g. providing physical activity equipment for school at low socio-economic neighbourhood) [24, 29, 31, 35]. The integration of multifaceted intervention creates difficulty in drawing *specific* conclusions concerning the SDT-based intervention's effectiveness. A second limitation (out of the authors' control) is that the studies included here were conducted in economically developed countries (i.e. US, UK, Australia, Singapore, Hongkong). These countries may have more policies and infrastructures that facilitate physical activity. Hence, more research are needed in this area, especially in developing countries.

CONCLUSION

There is strong support for SDT-based interventions' positive impact of the physical activity level of students at different levels of education. Providing teachers and administrators with training on SDT and its implementation might be beneficial in increasing students' physical activity as well as overall learning climate.

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