Preventive Medicine 101 (2017) 188–194

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

A school-based rope skipping program for adolescents: Results of a randomized trial

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ARTICLE INFO

Article history:
Received 11 October 2016
Received in revised form 31 May 2017
Accepted 5 June 2017
Available online 7 June 2017

Keywords:
Intervention
Moderate-to-vigorous physical activity
Self-determination theory
Autonomous motivation

ABSTRACT

Despite physical education's health enhancing potential, students' activity levels in lessons are low. We evaluated a school-based intervention that involved rope skipping on students' moderate-to-vigorous physical activity (MVPA) in physical education. The intervention was evaluated using a clustered randomized controlled trial in 24 classes ($N = 731$ students; $M = 14.38$ years; all from Secondary 2) from 12 Hong Kong schools during September to December 2013. The primary outcome was percentage of lesson time spent in MVPA. Secondary outcomes included students' vigorous activity, counts per minute, perceived autonomy support and motivation for physical education. Accelerometer-based activity measures were taken from a sub-sample of 168 students during lessons 1 to 3 (baseline) and lessons 5 to 7 (treatment phase). Participants self-reported motivation variables at lessons 4 and 8. Teachers allocated to the experimental group included an intervention during treatment phase; those in the control group continued usual practices. The intervention involved a 15-minute rope skipping activity where students completed intervals of skipping with rests in between. Using multilevel modeling, we examined the intervention effects on measured outcomes, and whether effects differed for boys and girls. Overall intervention effects were not found. However, girls in the intervention group spent more time in MVPA ($\beta = 0.25$) and had higher counts per minute ($\beta = 0.32$) than control group counterparts at treatment phase. Perceived autonomy support and motivation variables were similar across groups. The intervention increased activity levels of girls, but not boys. Implementation of the intervention may reduce differences between boys' and girls' physical education activity levels. Trial registration: ANZCTR: ACTRN12613000968774.

1. Introduction

Participation in moderate-to-vigorous physical activity (MVPA) is associated with a variety of physical and psychological health benefits, such as higher bone density or lower depressive symptoms (Janssen and LeBlanc, 2010). Physical education (PE) represents an important opportunity for students to acquire skills and knowledge that facilitate participation in physical activity within and beyond the school setting (Sallis et al., 2012). PE also provides students with an opportunity to accumulate MVPA during class, which can positively influence students' health (Lonsdale et al., 2013a). Specifically, it was recommended that students should spend at least 50% of PE lesson time in MVPA (Institute of Medicine, 2013). However, results of a meta-analysis by Hollis et al. (2017) suggested that the recommended level was not met in many classes.

Interventions can effectively counteract the problem of low activity levels in school PE (Lonsdale et al., 2013a). Previously employed methods can be broadly categorized into two types, namely i) teaching strategies and ii) fitness infusion (Lonsdale et al., 2013a). The former represents interventions where teachers aim to increase students' MVPA by selecting appropriate activities, improving organization and enhancing instruction. By contrast, fitness infusion includes methods that add vigorous fitness activities to supplement normal classes. For example, teachers would insert jumping or stationary runs within PE classes to increase students' activity levels. In their review, Lonsdale et al. (2013a) found that fitness infusion approaches, compared to teaching strategies, led to greater increases in students' MVPA (+16% versus +6%, respectively). However, the risk of bias is high in evaluative trials of fitness infusion interventions (Lonsdale et al., 2013a). Implementing vigorous forms of activity could also cause displeasure and become demotivating (Ekkekakis et al., 2011). Hence the viability of this type of strategy as a long-term solution is debatable.

In Hong Kong, many students, especially girls, do not enjoy PE or physical activity in general (Ha et al., 2009). Specifically, many students do not value PE, and find it monotonous and boring (Ha et al., 2010).

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http://dx.doi.org/10.1016/j.ypmed.2017.06.001
0091-7435/

Thus, we aimed to design an intervention which students, especially girls, would find interesting as well as increase activity levels. As rope skipping is a form of vigorous activity (Ridley and Olds, 2008) and was previously found to be an activity girls would find interest in (Ha et al., 2014b), it was deemed an appropriate activity for such an intervention. Therefore, we designed a rope skipping intervention to be implemented in school PE classes (Ha et al., 2014a). The intervention involved bouts of rope skipping (i.e., high intensity exercise) with short rest periods in between, and thus could be considered a form of high-intensity interval training (HIIT). Our goal was to increase students' MVPA during school PE. Moreover, we also examined whether students' motivation towards school PE might change after the intervention was implemented. Based on the tenets of self-determination theory (SDT) (Ryan and Deci, 2002), students are likely to be more physically active if they have higher levels of autonomous motivation (e.g., enjoyment in PE, the motive to gain positive outcomes of PE). In contrast, students will likely be less active if they have higher levels of controlled motivation (e.g., being active to gain self-worth or avoid punishment) over the course of a school year (Owen et al., 2014). Results from previous PE intervention studies based on SDT suggest that by enhancing autonomous motivation, students' activity levels could be increased both during PE (Lonsdale et al., 2013b) and in their leisure time (Chatzisarantis and Hagger, 2009). Therefore, in this trial we aimed to increase students' enjoyment, and hence autonomous motivation through the implementation of the intervention.

A detailed description of the intervention has been previously published (Ha et al., 2014a). In the current paper, we present the results of the clustered randomized controlled trial (trial registration: ACTRN12613000968774) designed to examine the effectiveness of the intervention. We hypothesized that students in the experimental group, who received the intervention, would spend a larger proportion of time in MVPA during their PE lessons at treatment phase, compared to those in the control group. We also hypothesized that students in the experimental group, compared to those in the control group, would show higher levels of autonomous motivation at treatment phase. Group differences, at treatment phase, in secondary outcomes of vigorous physical activity and volume of activity completed were also examined.

2. Method

2.1. Participants and procedures

We conducted a sample size calculation to estimate the number of classes to be recruited to detect a group difference of 1.0 standardized difference (in our sample this constitutes a 8.6% difference in lesson time spent in MVPA) (Ha et al., 2014a) in our primary outcome, which was a conservative estimate based on findings from Lonsdale et al.'s (2013a) meta-analysis, where an effect of 1.4 was expected for fitness infusion interventions. This analysis indicated that a minimum of 24 classes should be recruited. Therefore, students and their teachers (all classes were taught by different teachers) of 24 Secondary 2 (equivalent of Grade 8) classes from 12 schools (one school with one class, ten schools with two classes, and one school with three classes) were recruited to take part in the randomized controlled trial. Each class had one PE period per week or school cycle; classes ranged from 45 to 90 min long. Recruitment took place from June to August 2013. We included only single-sex PE classes, as these are common in Hong Kong. Accelerometer-based outcome measures were taken from seven students per class. This number was chosen because we felt there was sufficient representativeness as it constitutes over 20% of typical class sizes. Also, administering seven devices would cause minimal disruption to classes. These students were randomly chosen from the class list before baseline measures were taken. Therefore, accelerometer measures from a subsample of 168 students ($n_{experimental} = 84$, $n_{control} = 84$; age = 14.34 years, $SD = 0.82$; 54.2% female) were taken. Self-report questionnaires were collected from 731 students ($n_{experimental} = 381$, $n_{control} = 350$; age = 14.38 years, $SD = 1.07$; 51.8% female) from the same classes. Written informed consent was provided by students and their parents. The timing of baseline (September to October 2013) and treatment phase (October to December 2013) measures are summarized in a flow diagram in Fig. 1.

A parallel experimental design was used in the trial. The randomization procedure was conducted after baseline measures were taken. First, based on our primary outcome of students' percentage time spent in MVPA, classes were stratified into high or low activity groups (12 classes each), split at the median. Then classes were coded and a blinded researcher randomized half the classes in each stratum into the experimental group using a computer-generated algorithm. The remaining classes were allocated to the control group. The ethical review board of the lead author's university approved all procedures.

2.2. Intervention content and fidelity

Teachers in the experimental group were invited to take part in a four-hour workshop after the completion of all baseline measurements, and before the first lesson of the treatment phase. The workshop was led by the lead author and a professional rope skipping coach. This coach has over 10 years of experience in teaching or coaching rope skipping for students ranging from beginners to elite athletes. The workshop included a role playing exercise that mimicked the structure of the rope-skipping activities that constituted the intervention to be delivered during lessons. Before the workshop was held, we piloted the intervention activity with 13 students with varying rope skipping experiences. The pilot session was led by the coach who also instructed teachers during the workshop. We found that during the pilot study, students spent an average of 45.6% ($SD = 5.0\%$) of time in MVPA. The results did not suggest any relation between rope skipping experiences and measured MVPA. Based on our observation, students with little rope skipping experience were also able to complete the intervention activity. A suggested rundown provided to teachers is shown in Table 1. A discussion session was then held with teachers to discuss potential barriers (e.g., variations in student initial rope skipping levels) they might face and methods to overcome them (e.g., provide tasks or goals of varying difficulties). After the workshop, teachers in the experimental group were asked to teach the rope skipping intervention, which we suggested to be approximately 15 min long, at the start of their lessons. Rope skipping ambassadors (i.e., certified rope skipping coaches) were assigned to attend the first two activity sessions (i.e., during lesson 5 and 6) in each school. These ambassadors provided demonstrations and helped teachers provide feedback to students. By contrast, teachers in the control group were asked to teach using usual practices during the treatment phase.

To ensure intervention fidelity, randomly selected lessons (one per class) in both experimental and control groups were video-recorded. Based on the recordings, all classes in the experimental group included the intervention activity, while none in the control group did. Additionally, class activities of lessons during treatment phase were recorded using a modified SOFIT protocol (McKenzie et al., 1991) by trained research assistants, who were blinded to the research hypotheses. Specifically, research assistants recorded the activity levels of students fitted with accelerometers and the lesson context (management, knowledge, etc.) at 20-second intervals. In addition to the original SOFIT protocol, research assistants recorded whether the selected student was engaging in rope skipping activities. Specifically, research assistants were asked to code time as rope skipping activities if students were skipping, or if teachers designated that period of time to teach rope skipping-related activities, such as the intervention activity. Since these assistants were not told of any intervention activities, we were unable to ask them to record whether teachers were applying the intervention activities per se. Nonetheless, this allowed us to estimate if, and for how long,

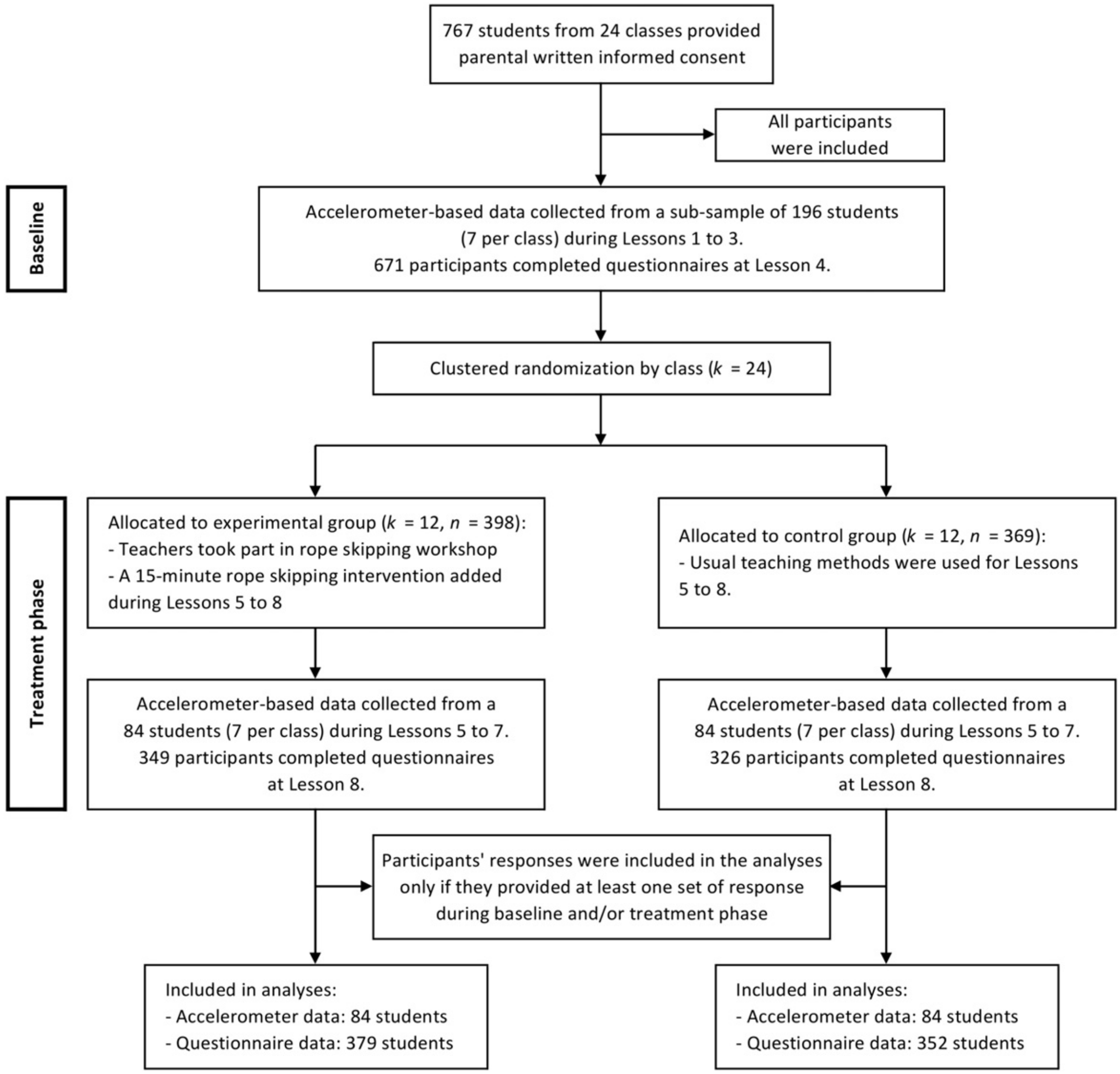

Fig. 1. Flow diagram summarizing recruitment and data collection procedures.

the intervention was conducted in experimental classes, and to check if classes in the control group included any rope skipping activities.

2.3. Measures

2.3.1. Physical activity

Students' physical activity levels were measured using ActiGraph GT3X+ accelerometers worn at the hip. Sample rate of devices were set at 30 Hz. Research assistants administered the accelerometers to participating students at the start of each PE lesson, and collected the devices at the end of each period. Using the cutoff points proposed by Evenson et al. (2006) and epoch lengths of 1 s, accelerometer-measured activity data were classified as sedentary, light, moderate and vigorous. The primary outcome of the trial was the percentage of time students spent in MVPA during their PE lessons. Secondary outcomes included the percentages of time spent in vigorous physical activity and counts per minute (CPM), which was used as a measure of total volume of physical activity.

2.3.2. Perceived teacher autonomy support

Students' perceptions of teachers' autonomy support were measured at baseline and treatment phase, as a secondary outcome of the trial. A Chinese version of the 6-item Learning Climate Questionnaire (e.g., "I feel understood by my teacher"; Niemiec and Ryan, 2009) was used; responses were provided using a 7-point scale. The Cronbach alphas of scores were 0.89 at baseline and 0.92 at treatment phase. Questionnaires data were obtained from all students in the classes (i.e., including students who did not wear accelerometers).

2.3.3. Motivation variables

Students' autonomous motivation and controlled motivation towards school PE were measured using the Chinese version of the Internal Perceived Locus of Causality Questionnaire (Lonsdale et al., 2011). The scale consisted of items tapping students' autonomous motivation (8 items; e.g., "Because PE is fun"; $\alpha = 0.90$ at baseline and 0.91 at treatment phase) and controlled motivation (8 items; e.g., "because that's the rule"; $\alpha = 0.63$ at baseline and 0.67 at treatment phase). Subscale means were used as a measure for the constructs.

2.3.4. SOFIT

As described previously, a modified SOFIT protocol (McKenzie et al., 1991) was used at treatment phase as manipulation check. Four students were selected at the start of each lesson, and were given accelerometers with different colored straps to identify them. Only one of the four students was rated at each time; the student being observed rotated every five minutes.

Table 1
A suggested rundown to teachers for the intervention activity.

Step	Content	Notes
1	Tricks practice (without ropes) - e.g., skier, bell, straddle, scissors (one skill per lesson)	- Place ropes on floor - Start from low speed/frequency - Increase speed/frequency gradually
2	Tricks practice (with ropes) - Same skill as in Step 1	- Try tricks with ropes - Start from low speed/frequency - Increase speed/frequency gradually - Set different goals for students with varying skill levels
3	Cooperative game - Forward or backward normal skipping	- Pair students, each of them will take turns to jump continuous (e.g., 30 s), while the other rests - Award marks for completed jumps within given time (e.g., 1 mark for 30 jumps, 2 for 50 jumps, etc.) - Sum marks from all students in class after each round, stop game when total reaches a certain number (e.g., 50)
4	Introduce new trick - e.g., push up jump, forward 180, double side swing and jump, crossover (one skill per lesson)	- Teacher demonstration - Highlight key learning points for each skill
5	Practice tricks taught in Step 4	- Start from low speed/frequency - Increase frequency gradually - Set different goals for students with varying skill levels

2.4. Data analysis

Multilevel modeling (random intercepts and slopes) techniques were employed for the main analyses of the trial. Analyses were conducted using MLwiN. Specifically, 3-level (time within student within class) multiple regression analyses were conducted for all measured outcomes. In this model, we evaluated the effects for the independent variables of Sex (males coded as "0", females as "1"), Group (control group coded as "0", experimental group as "1"), Time (baseline coded as "0", treatment phase as "1"). Our pre-specified analyses also included Time × Group and Time × Group × Sex interaction terms to examine the effects of the intervention, and whether the hypothesized intervention effects differed for boys and girls, respectively. When required, follow-up analyses were conducted to examine if there were between-group differences at each time point. Finally, we also examined whether the intervention had an effect on students' motivation variables (i.e., perceived autonomy support, autonomous and controlled motivation), using two-level regression equations with the same set of independent variables as above. A researcher blinded to the coding of the variables conducted the main analyses. Follow-up analyses, when required, were conducted by an author of this paper, and were verified by the researcher who completed the initial analyses.

3. Results

3.1. Manipulation check

SOFIT data suggested that teachers in the experimental group included a rope skipping activity in all their lessons during treatment phase. In these classes, the mean time students spent on rope skipping-related activities was 26.5 min (range = 14 to 36 min; or 41.1 ± 16.5% of total lesson time); the suggested duration for this activity was 15 min. With the exception of one lesson from one class, rope skipping was not included in any lessons of the control group classes during treatment phase.

SOFIT data also showed that experimental group classes spent more time in management ($B = 3.90$, $SE = 1.94$, $\beta = 0.24$, $p = 0.04$) and less time in game play ($B = -7.60$, $SE = 2.70$, $\beta = -0.33$, $p < 0.01$), compared to control group classes. The groups did not differ in terms of percentage time spent in knowledge, fitness, or skill practice.

3.2. Intervention effect on the primary outcome

Descriptive statistics of the measured variables are presented in Table 2, while regression coefficients of the multilevel models examined are presented in Table 3. Specifically, the effects of Time and Time × Group for MVPA were not significant. However, the Time × Group × Sex interaction was significant ($B = 5.24$, $SE = 2.38$, $\beta = 0.21$, $p = 0.03$), suggesting that the intervention effect was different for boys and girls. To further investigate these differences, the analyses were repeated separately for boys and girls. For boys, we did not find any Time × Group interaction effects or group differences at either baseline or treatment phase. For girls, we also did not find any interaction effects. However, at treatment phase participants in the experimental group had higher levels of MVPA compared to those in the control group ($B = 3.62$, $SE = 0.89$, $\beta = 0.25$, $p < 0.01$), while no such differences were found at baseline ($B = 2.74$, $SE = 3.71$, $\beta = 0.19$, $p = 0.46$).

3.3. Intervention effect on secondary outcomes

Using the same analytical procedures, we explored the effect of the intervention on accelerometer-measured secondary outcomes, namely the percentage of time spent in vigorous physical activity and CPM. For all analyses involving these outcomes, we found evidence that boys were more active than girls (see Table 2). For vigorous activity and CPM, although the Time × Group term was not significant, the Time × Group × Sex terms in these analyses were significant, suggesting that the intervention effects may have been moderated by students' sex. Similar to our analyses for the primary outcome, we ran separate analyses for boys and girls.

In boys, we did not find any significant Time × Group effects for either vigorous activity or CPM. In contrast, despite there being no Time × Group differences in girls ($B = 1.76$, $SE = 2.84$, $\beta = 0.13$, $p = 0.54$), those in the experimental group, compared to those in the control group, spent more time in vigorous activity at treatment phase ($B = 3.85$, $SE = 0.71$, $\beta = 0.32$, $p < 0.01$), but not at baseline ($B = 2.08$, $SE = 2.80$, $\beta = 0.17$, $p = 0.46$). For CPM, the Time × Group term was significant ($B = 500.46$, $SE = 245.09$, $\beta = 0.38$, $p = 0.04$). We found that girls in the experimental had higher CPM than those in the control group at treatment phase ($B = 629.21$, $SE = 72.88$, $\beta = 0.53$, $p < 0.01$), but not at baseline ($B = 127.65$, $SE = 239.49$, $\beta = 0.11$, $p = 0.59$).

3.4. Intervention effects on motivation and perceived autonomy support

Two-level models (time within class) were evaluated to examine whether the intervention might have effects on students' perceived autonomy support, autonomous and controlled motivation within PE. No Group or Time × Group differences were found for these three variables. However, we found that students reported higher levels of perceived autonomy support at treatment phase ($B = 0.24$, $SE = 0.10$, $\beta = 0.11$, $p = 0.02$), compared to baseline. At baseline, girls reported lower levels of controlled motivation compared to boys ($B = -0.10$, $SE = 0.05$, $\beta = -0.09$, $p = 0.04$), but the same was not found at treatment phase.

4. Discussion

Our main objective in this cluster RCT was to evaluate whether inserting a 15-minute rope skipping activity in PE lessons would lead to increases in students' physical activity across the entire lesson. In terms of our primary outcome, despite a lack of overall

Table 2
Descriptive statistics of accelerometer-based and motivational outcomes at baseline and treatment phase.

Outcome	Baseline		Treatment phase		Cohen's *d* (in favor of experimental group)
	Control group	Experimental group	Control group	Experimental group	
	M ± *SD*	*M* ± *SD*	*M* ± *SD*	*M* ± *SD*	
Accelerometer-based outcomes					
Girls only ($n = 91$)					
MVPA (%)	15.8 ± 5.2	18.8 ± 7.7	14.5 ± 3.0	18.6 ± 4.3	0.55
VPA (%)	10.2 ± 4.0	12.6 ± 6.2	9.0 ± 2.2	13.1 ± 3.4	0.68
CPM (counts)	1120.0 ± 352.7	1287.3 ± 491.9	1048.7 ± 205.8	1713.1 ± 431.4	1.00
Boys only ($n = 77$)					
MVPA (%)	23.9 ± 9.0	23.3 ± 5.0	22.8 ± 6.9	21.2 ± 5.4	−0.20
VPA (%)	17.0 ± 7.5	16.0 ± 3.7	15.2 ± 5.0	14.5 ± 4.0	−0.12
CPM (counts)	1763.7 ± 654.0	1752.3 ± 405.4	1643.9 ± 487.5	1912.1 ± 492.2	0.40
Motivational outcomes					
All students					
Perceived autonomy support	4.31 ± 1.14	4.46 ± 1.09	4.57 ± 1.11	4.69 ± 1.10	0.10
Autonomous motivation	3.41 ± 0.87	3.47 ± 0.81	3.36 ± 0.93	3.45 ± 0.95	0.16
Controlled motivation	2.80 ± 0.64	2.81 ± 0.60	2.81 ± 0.73	2.75 ± 0.76	−0.07

Note. MVPA = percentage of time spent in moderate-to-vigorous physical activity; VPA = percentage of time spent in vigorous physical activity; CPM = counts per minute.

intervention effect, we found evidence suggesting that the intervention was somewhat effective for girls' MVPA, but not for boys. Further, the results suggest that this was mainly contributed by differences of time spent in vigorous forms of PA. This meant that girls in the experimental group spent an extra 2.9 min in vigorous PA compared to their counterparts in the control group. Although this result is promising for adolescent girls, who are typically less active than boys, the infrequency of PE lessons in Hong Kong means the effect may have limited clinical significance.

Contrary to our hypotheses, the intervention had no effective on boys' MVPA. There might be a few possible explanations for such unexpected results. First, previous researchers (Gomersall et al., 2013; Goodman et al., 2011) have suggested that compensation effects might be present in terms of physical activity participation. That is, after students were exposed to higher levels of activity during the rope skipping intervention, they may consciously or subconsciously reduce their activity intensity or effort during the remaining time within the lesson. One counterargument is that if compensation effects were present, it should equally affect both boys and girls. Also, compensation effects, if they existed, may be more cross-contextual (e.g., in-school versus after school). Hence, this effect may not be applicable to activities within the same PE class.

Another potential explanation has to do with teachers' management during the lesson while implementing the intervention. Teachers of classes in the experimental group, compared to those in the control group, spent a larger proportion of time on class management (i.e., attending to issues unrelated to class activities), and less time on game play (i.e., application of skills in game or competitive settings). One possible interpretation of this finding is that teachers had to spend more time to manage students while implementing rope skipping activities because they were initially not familiar with teaching this activity. Although we were unable to quantify this, observers of the classes reported that boys seemingly behaved worse during the rope skipping activity. This might explain why teachers spent increased amounts of time managing students, especially boys, which therefore reduced the effect on students' physical activity. As this was not the main objective of the current study, there is insufficient evidence to support or reject this suggestion. Nonetheless, this provides insight for researchers interested in the design and implementation of school-based interventions, who may need to consider strategies to minimize the increased management time when introducing new activities.

Results of our analyses regarding the secondary outcomes suggested that girls' increase in MVPA was largely due to changes in vigorous physical activity. This is not surprising as rope skipping

Table 3
Coefficients from multilevel regression analyses.

Dependent variable	Independent variables									
	Time		Exp		Female		Time × Exp		Time × Exp × Female	
	B (SE)	β	B (SE)	β	B (SE)	β	B (SE)	β	B (SE)	β
Percentage of time spent in moderate-to-vigorous physical activity	−2.05 (2.15)	−0.12	−0.28 (2.74)	−0.02	−6.75 (1.54)	−0.39*	−1.46 (3.26)	−0.08	5.24 (2.38)	0.21*
- Girls only[a]	−0.88 (2.82)	−0.06	3.62 (0.89)	0.25*	–		0.99 (3.82)	0.06	–	
- Boys only	−1.33 (2.60)	−0.16	−2.96 (3.81)	−0.10	–		−0.46 (4.26)	0.05	–	
Percentage of time spent in vigorous physical activity	−2.37 (1.65)	−0.17	−0.45 (2.17)	−0.03	−5.07 (1.08)	−0.37*	−0.30 (2.47)	−0.02	4.55 (1.61)	0.23*
- Girls only[a]	−1.15 (2.13)	−0.10	3.85 (0.71)	0.32*	–		1.77 (2.88)	0.13	–	
- Boys only	−3.01 (2.41)	−0.23	−2.65 (3.10)	−0.06	–		1.62 (3.53)	0.12	–	
Counts per minute	−196.29 (145.30)	−0.15	−35.90 (185.58)	−0.03	−512.25 (104.00)	−0.38*	320.30 (220.56)	0.21	355.90 (159.92)	0.18*
- Girls only[a]	−73.84 (184.69)	−0.06	629.21 (72.88)	0.53*	–		501.57 (250.33)	0.38*	–	
- Boys only	−273.48 (217.03)	−0.22	−171.87 (269.34)	0.22	–		450.13 (318.06)	0.30	–	

Note. B = unstandardized coefficients. β = standardized coefficients. Exp = being in experimental group; Female = being female.
[a] For subgroup analyses, a significant Exp term denotes group differences at treatment phase.
* $p < 0.05$.

would likely be measured as vigorous activity (Ha et al., 2014a; Ridley and Olds, 2008). Research has suggested that vigorous forms of physical activity might lead to increased health benefits when compared to moderate forms of activities (Costigan et al., 2015; Swain and Franklin, 2006), therefore, the increase in vigorous activity found, albeit only in girls, is encouraging. Given that girls are generally less active than boys, increasing girls' activity levels should probably be of higher urgency. This finding is consistent with previous school-based interventions (e.g., Lubans et al., 2012; Neumark-Sztainer et al., 2010), which have often observed stronger effects among females (Yildirim et al., 2011).

When examining the effects of the intervention on motivational variables, no differences were found. In fact, other researchers have also attempted to change motivational variables of students during PE in previous studies, but were not successful (e.g., Lonsdale et al., 2013b). Researchers suggested that this lack of differences may be attributed to the short time between measurement time points, as motivational constructs in students may require longer periods to change (Lonsdale et al., 2013b). Situational measures of motivation may be included to examine students' specific responses towards the intervention activity in the future. Regardless, enhancing motivational constructs will remain a challenge for researchers, with autonomous motivation being an important factor researchers should take into account while designing and evaluating similar interventions. Additional intervention components to increase students' autonomous motivation, such as helping teachers become more need supportive (e.g., Gillison et al., 2013; Lonsdale et al., 2013b), should also be applied in future studies.

To the authors' knowledge, this is the first school-based intervention using rope skipping that could be applied to large class sizes (e.g., >30) and with limited space (half a basketball court). Thus, this intervention could be applied to most PE classes. Nonetheless, research is still needed to explore whether the intervention would be applicable and effective within other cultural contexts that may differ in terms of PE curriculum, school environment, students' cultural backgrounds and activity preferences. Further, based on our current findings, researchers may design studies in the future to address some of the limitations of this study. For example, the 15-minute suggested duration of the intervention was set to ensure a meaningful amount of time would be spent on rope skipping, while minimizing potential disruptions caused to teachers. Researchers could examine the dose-response relation to determine the optimal duration of rope skipping interventions. The intensity of the rope skipping activities could also be adjusted to meet HIIT principles (Costigan et al., 2015), thereby potentially reducing the length of the intervention. Secondly, although we found evidence that the intervention increased girls' activities levels during PE lessons, the majority of students' physical activity is usually accumulated outside these school periods (Institute of Medicine, 2013). Researchers may combine this intervention with other strategies and examine whether students' leisure time physical activity might be increased as well. Further, in this study, we did not examine the effects of the intervention on students' physical fitness (e.g., body composition, cardiovascular fitness) or well-being. These are beneficial outcomes associated with physical activity (Janssen and LeBlanc, 2010; Lubans et al., 2016), thus researchers may investigate whether similar interventions might positively impact students' fitness and well-being. As rope skipping is a form of high-intensity, weight-bearing activity, students with low cardiovascular fitness or a high body mass index may find the activity to be more difficult and tiring, compared to other students. Such factors may alter students' motives and behaviors towards rope skipping-related activities. Therefore, researchers may investigate in future studies whether students' fitness and weight status moderate the effects of rope skipping-related interventions.

In conclusion, the class-based rope skipping intervention was found to enhance students', particularly girls', physical activity during school PE. Rope skipping is a high-intensity activity that could be incorporated to school PE. With appropriate out-of-class support, this intervention may be expanded into a broader program that might increase students' activity levels outside school PE, and potentially affect other indicators of health and well-being.

Funding

This work was supported by the Coca-Cola Foundation.

Conflict of interest statement

The authors declare no conflict of interest associated with this study.

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