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Author(s)	Ming Li Carol Seah and Koon Teck Koh
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The efficacy of using mobile applications in changing adolescent girls' physical activity behaviour during weekends

Ming Li Carol SEAH and Koon Teck KOH

Physical Education & Sports Science, National Institute of Education, Nanyang Technological University, Singapore

Corresponding Author:

Koon Teck KOH, Nanyang Technological University, NIE5-03-12, 1 Nanyang Walk, 637616 Singapore
Email: koonteck.koh@nie.edu.sg
Tel: (65) 6790-3690 GMT+8h Fax: (65) 6896-9260

Abstract

Smartphones are omnipresent and offer real-time information on the go. Predominantly, adolescent girls have been found to be engaged in levels of physical activity (PA) below the daily recommended guideline of at least 60 minutes of moderate-to-vigorous intensity, and especially during weekends. Lack of sufficient PA can lead to a risk of contracting non-communicable diseases. The purpose of this exploratory study was to investigate the efficacy of using mobile applications (i.e. MapMyFitness) in changing adolescent girls' PA behaviour during weekends. It also examined the perceived benefits, challenges and recommendations for using mobile applications. Thirty-six participants aged 15 years (M_{age} = 14.9; SD = 0.30) from a convenience sample volunteered and took part in the present study that spanned four weekends. Quantitative results showed a significant difference in the mean step count between experimental and control groups during week two, probably due to the novelty effect when the participants were introduced to the new MapMyFitness (MMF) mobile app. Overall, the use of the MMF app seems to be able to attenuate the decline of adolescent girls' PA level during weekends. Qualitative results revealed benefits of using mobile apps to promote PA such as a sense of autonomy in selecting PA, the ability to view friends' postings of PA, and self-monitoring of PA. The study revealed specific challenges to using such PA mobile applications, in particular, factors such as the cumbersome and confusing functions in the app that discouraged users from performing PA. Recommendations included allowing users to customise their accounts, simplifying the application's functions, and including rewards and videos as motivators to enhance users' PA experience. Although mobile applications may have the potential to encourage participation in PA, a careful selection of mobile application functions is required to engage adolescent girls to continue to use it for PA.

Keywords

Adolescent girls, mobile applications, weekends, physical activity, mixed methods

Introduction

Globally, eighty-one percent of school-aged adolescents are not active enough despite the benefits that regular physical activity (PA) brings about, such as a lower risk of developing health-related issues, and enhancing quality of life (World Health Organization [WHO], 2018a). The WHO found that 84% of school-aged adolescent girls were not meeting the PA guidelines of a minimum of 60 minutes of moderate-to-vigorous intensity physical activity (MVPA) daily (WHO, 2018b). This trend was evident across different cultural contexts when the duration of PA decreased in adolescents, with the decrease more noticeable in females than in males (Aibar et al., 2014; Lam and McHale, 2015; Lye et al., 2015).

A lack of PA puts people at risk of non-communicable diseases (NCDs) such as diabetes, stroke and cancer (WHO, 2018c). It is one of the top 10 risk factors for global mortality (WHO, 2018a). In addition, a lack of PA could also lead to an increased risk of mental health problems. For example, it was estimated that 24% of British girls and 9% of British adolescent boys experienced depressive symptoms (Patelay and Gage, 2019), and suicide is one of the major causes of mortality in adolescence (WHO, 2018c). On the other hand, participation in PA could strengthen the psychosocial aspects of adolescents such as relationship-building and increase self-esteem that may help protect against the development of mental health problems (Kirsten et al., 2020). Therefore, it is important for adolescents to adopt the habit of performing PA regularly so that this can be internalised from young and be sustained through adulthood (WHO, 2018c) to minimise the risk of contracting NCDs in the future.

Adolescent girls have a relatively low level of PA compared to boys. Research found that poor perceived competence in physical abilities, lack of support and relatedness to others, poor self-image, lack of choice autonomy in PA, and increased workload in school were the reasons for adolescent girls' low level of PA (Coleman et al., 2008; Mitchell et al., 2015). These reasons

echoed with the three basic needs in self-determination theory (SDT) (Ryan and Deci, 2000), namely autonomy, competence and relatedness. Specifically, these reasons cited reflected a sense of choice deprivation for PA, the poor personal perception of perceived competence and a poor sense of support from significant others respectively. Based on SDT, when these basic needs are met, intrinsic motivation can be developed in an individual (Ryan and Deci, 2007). Teixeira et al. (2012) concluded that having more intrinsic participation motives or goals was associated with higher levels of PA participation. Thus, intrinsic motivation is important for longer-term PA participation, and is essential in producing a sustained change in PA patterns in an individual (Ryan and Deci, 2000).

Past studies also showed that weekends provided unstructured time for adolescents to be autonomous in performing PA that they feel competent in and with people whom they feel a sense of relatedness to such as friends and family (Aibar et al., 2014; Nilsson et al., 2009). Despite these favourable conditions, the level of PA on weekends was still found to be very low for young adolescents compared to weekdays across all geographical locations, environment, seasons and cultures (Aibar et al., 2014; Wang et al., 2014). Hence, there is a need to seek effective interventions to promote PA during weekends.

There are many reasons contributing to the sedentary lifestyle of young adolescents. Longer screen time due to the usage of digital platforms such as applications (apps), tweeting, blogging and social networking sites are changing adolescents' priorities or preference for PA on a daily basis (Greenhow and Lewin, 2016; Kemp et al., 2020). Indeed, the use of digital devices such as smartphones is ubiquitous worldwide. It was estimated that there were 2.5 billion smartphone users worldwide as of 2019 (Wang et al., 2020). In Singapore, students as young as nine years old were reported to have already owned one (Singapore Press Holdings, 2017). Given that smartphones not only bring convenience to daily life but also easy accessibility to

information and connectivity among young people (Casey et al., 2017; Greenhow and Lewin, 2016), its influence in the lives of most adolescents cannot be underestimated (Kemp et al., 2020).

Past studies showed that a myriad of mobile health-related applications are being developed at a tremendous rate (Wang et al., 2020). Some of these apps (e.g. mHealth and digital behavioural change interventions) could be used to improve lifestyles and health management (Brannon and Cushing, 2015), and exert gradational effect on the PA of young men (Harries et al., 2016). A range of PA behaviours such as walking, running, and climbing stairs can be measured accurately with smartphone technology (Bort-Roig et al., 2014). Researchers found that intervention compliance using mobile apps was especially high when the level of PA measured was connected to behaviour change techniques such as real-time feedback, goal-setting and expert consultation (Wang et al., 2020). Some of these features correspond to SDT (e.g. relatedness and competence respectively). In addition, some mobile apps provide users with a choice to select the type of PA that they want to participate in, fulfilling the basic need for choice autonomy. Using the SDT as a framework to guide the selection of appropriate mobile apps to promote and increase the level of PA in adolescent girls during weekends may help encourage them to start a new PA habit and sustain existing PA habits (Sas-Nowosielski et al., 2016), or change their behaviour (Ferrara et al., 2018). In addition, the decrease in PA is most discernible from 15 years old onwards (Coleman et al., 2008; Gibbons and Humbert, 2008; Mitchell et al., 2015; Langlois et al., 2012) and limited studies have examined how mobile apps with PA functions could potentially be used to change adolescent girls' PA behaviours. Therefore, the purpose of the present study was to address the current research gaps by investigating the efficacy of using mobile apps in changing adolescent girls' PA behaviour during weekends. This study was guided by three research questions: (1) to what extent would the use of mobile apps promote and increase PA level in adolescent girls during weekends, (2) what are the perceived

benefits and challenges of using mobile apps outside of the classroom settings, and (3) what are the recommendations on the use of the mobile apps to increase PA levels?

Method

Participants

A total of 36 high school students (69.4% Chinese, 16.7% Malay, 11.1% Indian and 2.8% Others)[1], all 15 years old, and from a government girls' school participated in this study. Thirteen girls (*Mage*=14.9, *SD*=.30) and 23 girls (*Mage*=14.8, *SD*=.32) were randomly assigned to an experimental group and a control group respectively. The sampling method was guided by Thomas, Nelson and Silverman (2015), especially on the estimated number of participants needed for the present study. Randomisation was conducted at the group level by drawing lots. The mismatch in number was due to participants dropping out or not adhering to the study protocol. The inclusion criteria were: 1) participants must be non-users of PA apps, and 2) they must own a smartphone with data access. Participants who were advised against performing PA by medical professionals and did not have access to mobile data were excluded from the present study.

Procedures

Ethics approval was obtained from first author's Institution Review Board to conduct the study. Permission to collect data from schools was also sought and obtained from the Ministry of Education (MOE) Data Administration Centre. Convenience sampling, which was very common in participant-based research (Patton, 2002), was employed to recruit potential participants. Consent to carry out the study in the school was sought from the school principal. Upon

[1] Singapore is a multi-cultural and multi-religious country. The ratio of race distribution in the present study represents most of those found in public schools.

approval, a letter of invitation to participate, consisting of a participant information sheet and a parental consent form was issued to the students via their physical education (PE) teacher. Before the commencement of the study, participants were informed of the purpose of the study. They were informed that participation in the study was voluntary and they had the right to withdraw from the study at any time. Their confidentiality and anonymity were also assured.

A 45-minute training workshop on the operating functions of the MapMyFitness (MMF) app (Figure 1) was conducted for the experimental group in school. The MMF app is a commercially available fitness tracking app developed by Under Armour. At present, there are about 20 million registered active users using the MMF app. The MMF app enables users to use the built-in GPS of their smartphones to track aspects of their PA such as duration, distance, pace, speed, elevation, calories burned, and route travelled. It has features that were found to be strongly associated with successful *behaviour change techniques*, such as feedback, self-monitoring, goal setting and social support (Lyons et al., 2014), and thus was chosen over a host of many other mobile apps. In addition, it is cost-free (basic version) and able to track a wide variety of PA. During the workshop, the participants downloaded and set up their account on the MMF app, and were given time to familiarise themselves with it. The participants were informed that they should use the app to track their PA, and note their step count during the weekends using a separate pedometer mobile app (e.g. Health/Samsung Health/Pacer Step Counter/Pedometer and Weight Loss Coach) on their smartphone. For the control group, the participants were informed to continue with their normal lifestyle on weekends. They were reminded to note down their step count during the weekends using the same pedometer app options used by the experimental group. The purpose was to track their level of PA for ease of comparison with the experimental group. The step count data supplemented the information on the level of PA provided by the MMF app and gave a more holistic overview of participants'

level of PA.

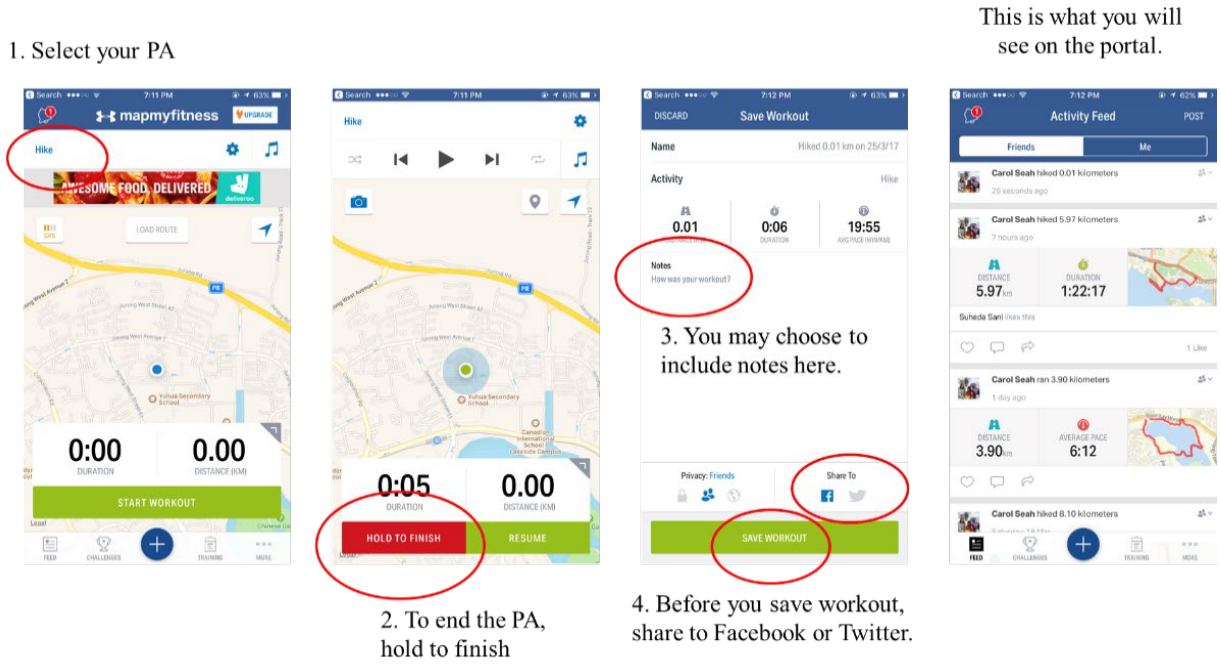

Figure 1. The various features and functions of the MapMyFitness application.

All participants completed the three-day physical activity recall (3DPAR) survey after each weekend and submitted the hardcopy to their PE teacher by the following Tuesday. This minimised the effort to recall and reduced errors as findings from Lee and Trost (2005) found that the 3DPAR's validity dropped when the recall period was lengthened. On average, the participants took 30 minutes to complete the survey. Data collection for all the participants spanned four weekends at three time points (Baseline: Week 0, Time 1: Week 1-2, Time 2: Week 3-4) to provide an overview of their level of PA.

Two focus group interviews from the experimental group were conducted to complement the quantitative results, with the aim of having an in-depth understanding of the efficacy of using mobile apps in changing adolescent girls' PA behaviour during weekends. Participants were assigned to the focus group interview based on the results of the 3DPAR survey. Five and three participants were assigned to the High and Low metabolic equivalent (METs) focus groups

respectively. Initially, the study intended to have 10 participants (five for high MET and five for low MET). However, two participants from the low MET group were absent during the focus group discussion. Thus, only three students were in the low MET focus group discussion. Although the number of participants for the focus group interviews were small, it allowed more interactions to take place and enabled researchers to elicit different perspectives from the participants (Sparkes and Smith, 2014).The selection of participants was based on the difference between their baseline PA level and total average PA level (based on 3DPAR results) accrued after using the MMF app.

Measures

Three-day physical activity recall (3DPAR). The 3DPAR survey is a self-reported tool to measure the PA habits of adolescents. It has been validated in a study by Lee and Trost (2005) on Singaporean youths. Participants were instructed to write down the main activity that they had participated in for each block and rate the relative intensity of the activity as light, moderate, hard, or very hard. The MET value for each PA was then determined. MET is described as the ratio of the working metabolic rate to the resting metabolic rate of a person. One MET is defined as the energy cost of sitting quietly and is equivalent to a caloric consumption of one kcal/kg per hour (WHO, 2018b). An appropriate MET value was assigned to the block if the activity description was found to be incompatible with its intensity rating. The level of PA in adolescent girls was measured by adding up the total METs for each 30-minute time block per weekend. The average MET per day can be calculated by averaging them over the two days. Similarly, the MVPA and VPA were measured by adding the daily number of 30-minute blocks in which the main activity was rated at three METs or greater, and six METs or greater, averaged over the two days, respectively. The 3DPAR survey is valid and reliable for use, with its validity coefficients among girls ranging from .26 to .41 ($p < 0.1$), and the test-retest reliability value at .87 (Lee and

Trost, 2005) respectively. The present study also adopted the guidelines on the recommended levels of PA of at least 60 minutes of MVPA daily for children aged five to 17 years (WHO, 2018b) as a reference. This accounts for two or more 30-minute blocks of MVPA and/or one or more 30-minute blocks of VPA in the 3DPAR survey.

Pedometer. The pedometer was found to be popular, low cost and easy to use (Andrew et al., 2014). The step count data captured by the pedometer app supplemented the 3DPAR survey findings to increase its validity, as a single measure of reported PA would be insufficient (Andrew et al., 2014).

Focus groups. Two focus group interviews with the High MET and Low MET groups were conducted to understand participants' perspectives of their current level of PA, their experience in using the mobile apps to improve their level of PA, as well as recommendations on improving the use of such apps in the future. To prevent domination of the discussion by a few participants, the first author, who was the interviewer and carried out all the interviews, monitored the dynamics of the groups and the interactions. She occasionally intervened during discussions to prompt opinions from the less active participants (Sparkes and Smith, 2014). The interviews were conducted in an enclosed room at the school's premises and took about 60 minutes/group.

In developing the interview guide, reference was made to the study by Kirwan et al. (2013) and Koh et al. (2017) due to the similar nature of the study. The interview questions were grouped around similar themes and structured from general to detailed questions. To understand participants' PA patterns during the weekends, key questions such as 'How regularly are you involved in PA on weekends?' and 'How does your current level of PA on weekends compare with your past level during the weekends?' were asked. To understand the perceived benefits and challenges of using the mobile app, key questions such as 'What do you like/dislike about the app?', 'How does it compare with your experience of doing PA without the app?' and 'What are

some of the challenges you faced when using the app?' were asked. Probing questions were also used to gain additional information from the participants (Sparkes and Smith, 2014).

Data analysis

The descriptive statistics of key variables were computed using SPSS software version 24. The 3 X 2 mixed ANOVA (Thomas et al., 2015) was used to determine any differences in the level of PA between the control and the experimental groups (i.e. between subject factor) as well as within the groups (i.e. within subject factor) over three time points (i.e. Week 0/baseline, Week 2, and Week 4) over a duration of four weeks. The independent variable was the use of the MMF app and the dependent variable was the level of PA accrued by the participants during the weekends. The control variables were gender, age, and the duration of the study. Statistical significant level was set at $p < .05$. The PA data analysed were mean METs, MVPA, VPA and step count.

Interview transcripts were transcribed verbatim. Thematic analysis (Braun and Clarke, 2013) was employed and data were coded inductively. This is a flexible approach but requires the researchers to be reflective and thoughtful in terms of engagement with their data, and make well-reasoned decisions during the data analysis process (Braun & Clarke, 2019). The stages include: (1) Immersion – by reading the transcripts repeatedly, the first author familiarised herself with and improved understanding of the data; (2) Generate initial codes – the entire data set were coded in an orderly manner. The first author then gathered and collated relevant data to each code; (3) Search and identify themes – different codes were sorted and grouped into overarching themes; (4) Review the codes – the themes were checked again to determine if they formed a coherent pattern; (5) Define and name themes – the first author identified the focus of each theme and determined what each theme represented, with reference to the research questions.

To establish the credibility of the qualitative data, the first author summed up the discussion points at the end of each interview to the participants. This is to ensure that the information provided was captured accurately. The rigour of the data analysis was enhanced with the critical dialogue between the first and second authors. The second author who was not involved in the data analysis acted as a 'critical friend' to randomly check the coded data sets. This encouraged reflection on the data by challenging one another's knowledge. It also ensured that the data were interpreted accurately. A reflexive dialogue ensued and a consensus to any disagreement was reached after a few discussions (Braun and Clarke, 2019).

Results

PA patterns of the sample

Mean MET. There was no significant difference between groups, F (1, 34) = 1.935, p = .173 over the three time points (see Figure 2). However, within subject effects, there was a significant difference, F (2, 68) = 7.142, p = .002.

MVPA. There was no significant difference in the average blocks of MVPA between the two groups, F (1, 34) = .945, p = .338 (see Figure 3). However, there was a significant difference within the groups over the three time points F (2, 68) = 7.142, p = .002.

VPA. There was no significant difference found for average blocks of VPA between the two groups, *F* (1, 34) = .714, p = .404 (see Figure 4). There was also no significant difference found within the two groups during the three time points F (2, 68) = .934, p = .398.

Step count recorded by pedometer app on smartphone

There was no significant difference between the two groups F (1, 34) = 1.065, p = .309. However, there was a significant interaction effect within subject effects, F (2, 68) = 7.703, p

= .001 (see Figure 5). Post-hoc analysis showed that while there was no significant difference between the experimental and control group in terms of mean step count for week 0 and week 4, there was a significant difference in the mean step count between experimental and control groups during week 2, t (34) = .276, p = .784. This could be attributed to the novelty effect of using the new MMF app by the experimental group. However, this trend could not be sustained till the end of the intervention.

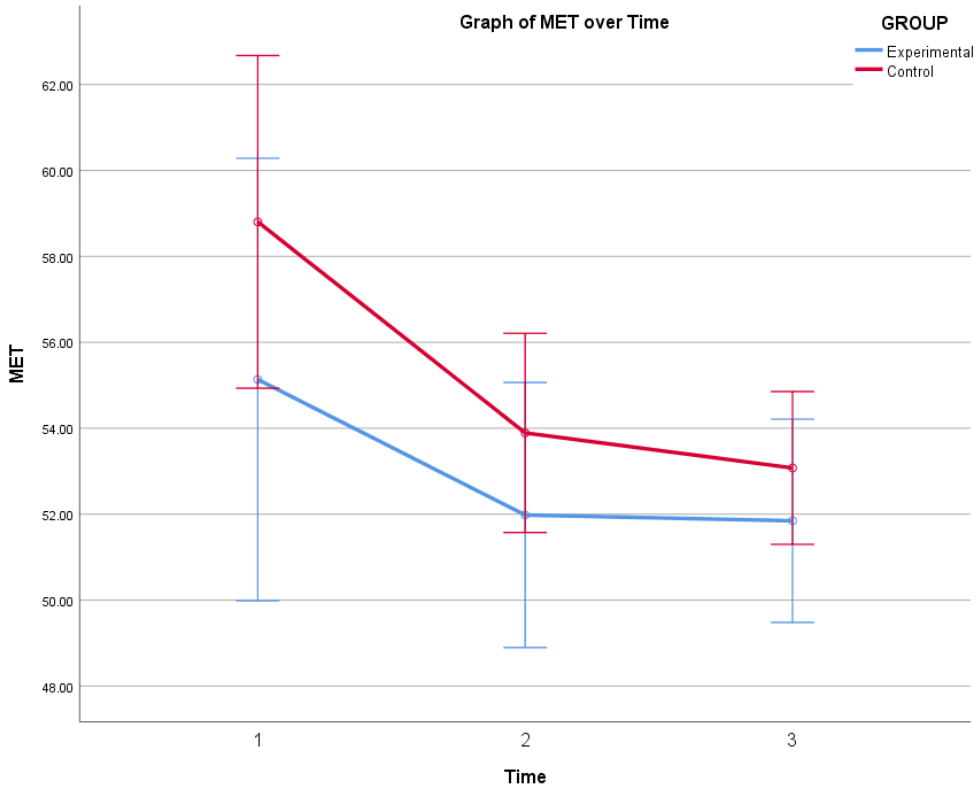

Figure 2. Comparison of MET between the experimental and control groups across three time point.

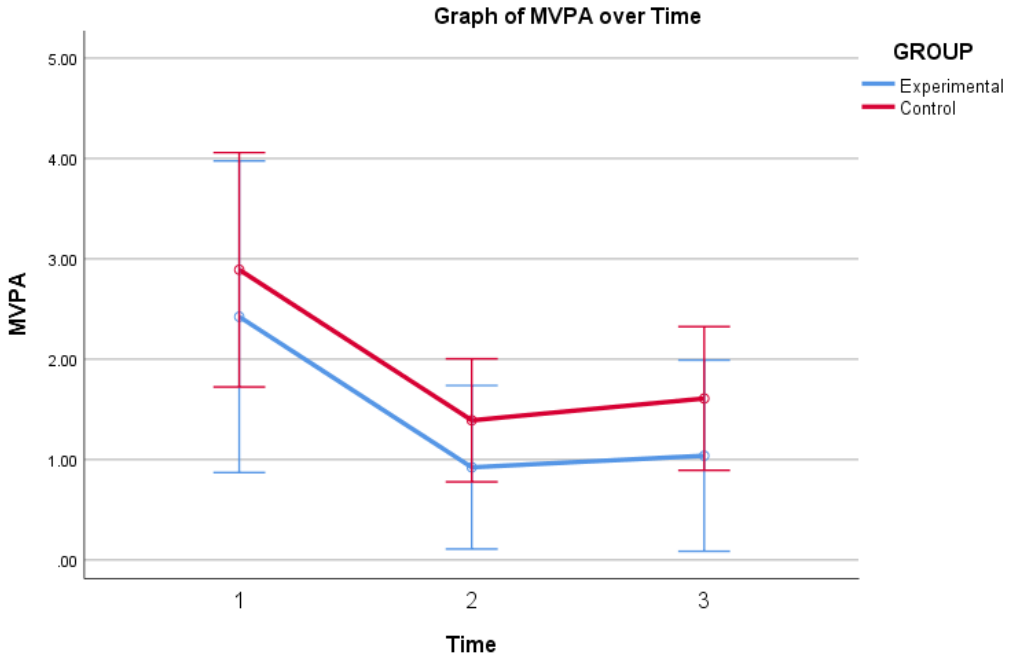

Figure 3. Comparison of the moderate-to-vigorous intensity physical activity (MVPA) between the control and experimental group across three time points.

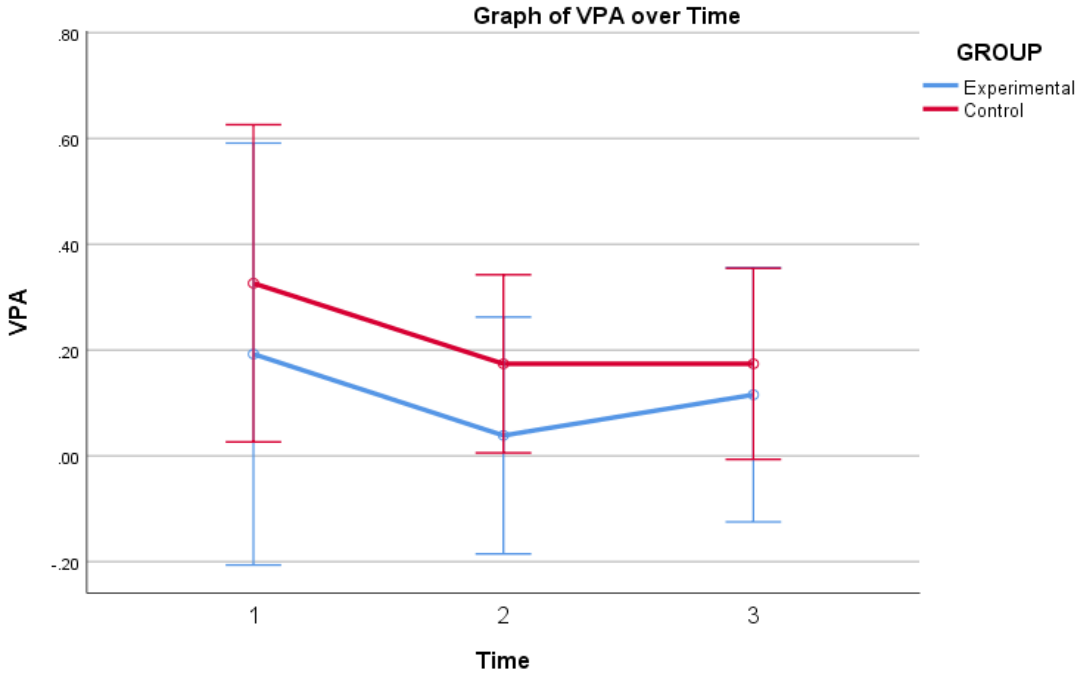

Figure 4. Comparison of the vigorous intensity physical activity (VPA) between the control and experimental group across three time points.

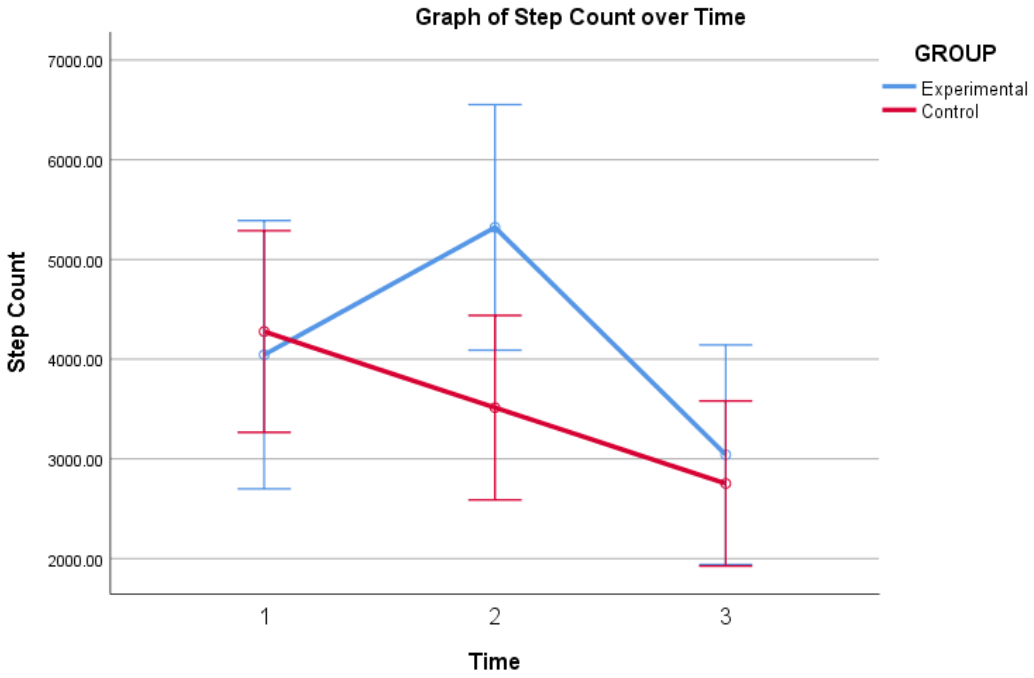

Figure 5. Comparison of the step counts between the control and experimental group across three time points.

Perceived benefits and challenges of using the MMF and pedometer mobile apps

A total of 102 codes were formed and categorised into 15 higher-order sub-themes and three main themes (see Table 1). The frequency of codes gathered on the perceived benefits of the MMF app to PA was higher in the Low MET group compared to the High MET group. The perceived challenges were higher in the High MET group compared to the Low MET group.

Table 1. Themes and sub-themes with frequencies for perceived benefits and challenges of the use of mobile apps to increase PA level.

Themes		Sub-themes	Frequency (units) ($N = 8$)	
			High MET	Low MET
Perceived benefits	i.	Motivated to perform PA	4	6
	ii.	Facilitated self-monitoring of PA	4	1
	iii.	Motivated by friends' PA postings	0	5
	iv.	Sense of autonomy in selecting the type of PA	0	2

	Total:		8	14
Perceived challenges	i.	Negative perception about MMF app's potential to increase PA level	13	14
	ii.	App features were cumbersome and confusing	12	10
	iii.	Did not encourage user to perform more PA	5	1
		Total:	30	25

The participants in the Low MET group were more receptive to the use of the MMF app than the High MET group. Four main perceived benefits cited by the participants were: (1) motivated to perform PA, (2) facilitated self-monitoring of PA, (3) motivated by friends' PA postings and (4) a sense of autonomy in selecting the type of PA.

Motivated to perform PA. Participants felt that the *behaviour change technique* features such as goal-setting in the MMF app helped to motivate them to perform PA. L5 said, "It was effective because if you used it to set the goals you wanted to achieve, it inspired and motivated us to work out." L3 further added, "It was good. It helped you to have a vision. It helped you get a goal in life."

Facilitated self-monitoring of PA. In terms of regulating PA behaviour, getting feedback and tracking one's PA performance using real-time information were perceived to be very useful. It helped participants to monitor themselves and make plans for future engagement in PA. H1 said, 'The app made it easier for me to gain knowledge about my PA, like the pace and the calories burned. It also lets you know the intensity levels of the different kinds of PA.'

Motivated by friends' PA postings. Participants from the Low MET group mentioned that friends' PA postings on the MMF app platform motivated them to perform more PA. L2 said, 'I

think the app was good that it allowed us to connect with friends. We can get to know what were their status and PA.' L1 agreed and further added,

> I think the app motivated us. Basically, there was the friends' sharing. Other apps don't include the friends' thing. So, when my friends did something related to PA, I felt motivated to also exercise. So, I felt the app was a good form of motivation. There was rarely anything else that could motivate me to exercise except friends.

Sense of autonomy in selecting the type of PA. Participants in the Low MET group mentioned that having the choice to select the PA that they wanted to do motivated them to engage more in PA. L3 said, 'I think it was effective because it allowed you to choose what you want according to your preference.' L4 echoed the same thoughts, saying, 'The thing that I liked about this app was that it offered a lot of choices. A lot of different types of workouts that you could choose from.'

While there were benefits in using mobile apps to increase PA level, there were also perceived challenges. These included (1) negative perception about the MMF app's potential to increase PA level, (2) app features were cumbersome and confusing and (3) did not encourage user to perform more PA.

Negative perception about the MMF app's potential to increase PA level. Participants felt it was time consuming to learn how to use the MMF app. The MMF app was seen as unnecessary for PA and incompatible with participants' lifestyles. The incurrence of additional data usage charges also made participants feel negatively about using it. The fact that participants needed to invest time to learn and register to use the app properly put them off. H2 commented, 'If you go and find out how to use it (MMF app) properly, then I think it may be useful. But the fact that you have to take time to learn, it makes you feel unmotivated to use the

app.' Participants also perceived the app as unnecessary with their lack of health concerns at their age since they do not feel the negative effects of poor health. H2 said, 'I think maybe if we grow older, we will start to have more health concerns, and the app may be useful but not now....' H1 agreed and said, 'I think we know that health is very important, but we don't feel the negative effects of it now.'

In addition, participants did not have the habit of using mobile apps for PA. Hence, they found it incompatible with their lifestyle. H3 said, 'I'm used to doing PA without the phone. I use my phone only for listening to music without tracking my PA.' The concern of incurring additional data usage charges further spiked their negativity towards using the app: '…because it was a bit complicated to use, and also it used up my data' (H3).

App features were cumbersome and confusing. Participants from both the High and Low MET groups found many functions on the MMF app daunting to operate i.e. having too many steps to be taken for a simple exercise or PA. They felt that the app was not user-friendly. H3 said, 'When I opened the app, it already looked so confusing and it made me lazy to open it again. So, I wouldn't really know what is inside the app. I only used it like a few times.' L2 encountered a similar problem:

> The app was pretty disruptive. It was not just this app, but all other apps. Whenever I want to do PA, I don't find the need to open the app, press this and that. I just go and run. Whenever I feel like going, I just go, I don't need to track anything.

L3 recounted her episode of confusion at using the app, saying, 'For me, before I start the workout, I forgot to change the workout I'm doing. So, it mistook… I was walking, and it said that I ran xxx kilometres.'

Did not encourage users to perform more PA. Participants from the High MET group became disinterested in continuing to use the MMF app after a while. They pointed to self-

determination as a driving force to perform PA, and not the app itself. H2 said, 'I feel like it's a matter of you wanting to exercise or not. I feel that the app didn't really help because if you really don't want to exercise, the app won't help you.' H1 agree and commented,

> At the start, you felt a bit more motivated to use it and that was why I used it once. After that it slowly died down and I didn't really want to use it (MMF app) anymore… I just didn't feel the motivation to use it. I thought mobile apps could help to a small extent only. What was more important was still how you motivate yourself to exercise and whether the people around you could motivate you enough to go and exercise.

Participants made various recommendations (see Table 2) such as to (1) allow users to customise their account, (2) simplify the MMF app's functions and (3) include rewards and videos as motivators to enhance users' PA experience.

Table 2. Themes and sub-themes with frequencies for recommendations on the use of mobile apps to increase PA level.

Theme		Sub-themes	Frequency (units) (N = 8)	
			High MET	Low MET
Recommendations	i.	Allow users to customise their account	5	4
	ii.	Simplify the app's functions	8	2
	iii.	Include rewards and videos as motivators	2	4
		Total:	15	10

Allow users to customise their account. Both High and Low MET group participants requested to customise their app account. Suggestions such as removing features like friends, goals-setting and training plans were mentioned to simplify the use of the MMF app. H3 said,

'Maybe the friends part can be removed…it's not really needed, and you can improve by making the app look simpler.' On the removal of goals-setting features, H2 explained,

> I do not know why they can have so many components. Not everyone is motivated by this way of motivating themselves to exercise. People may not like to set their own goal or training plans…I feel like it's a bit unnecessary to have so many components. If you want to exercise, you can just exercise on your own…if you want to set goals for yourself, you can just do it on your own without having to use the app. It just feels like it makes the app more confusing.

Simplify the app's features. There were too many features on the MMF app that confused users. Suggestions to simplify it included focusing on one type of PA and to track workouts automatically. L4 said, 'Instead of putting so many functions, like tracking so many things, I would prefer if it's just focused on one thing, like tracking calories because that's what most of us like.' L2 made the similar comment, suggesting that the app should 'focus on just one type of exercise.' H1 also had a similarly confusing experience, saying, 'I think the app can be designed to be more concise. A lot of functions are everywhere. I don't know where to go, how I can change the functions, and where to go...' On preference for the app to track PA automatically, L5 would like to have '… one app that just needs to press the buttons. If possible, don't ever need to press the buttons – it just tracks PA automatically.'

Include rewards and videos as motivators. While using extrinsic rewards to motivate people to perform PA may not have a long lasting effect, both groups still echoed the desire to include them to encourage users to participate in more PA. H1 said, 'I think we should have rewards such as vouchers for food to get more people to be on board...' L2 suggested having a '…points system among friends so that I will be more motivated to exercise if I see I have zero

points...may be good to have prizes to get more people going...' In addition, participants preferred fitness videos to be made easily accessible on the app to facilitate greater PA involvement at home. L1 said, 'I think there should be videos on aerobics because many of us stay home during the weekends. So, if there are aerobic videos or age-suitable videos, we can watch it and exercise at home.'

Discussion

The purpose of the present study was to investigate the efficacy of using mobile apps in changing adolescent girls' physical activity behaviour during weekends. It was evident from the step count results that there were significant differences between the experimental and control groups. Indeed, there was an increase in the number of step counts reported by adolescent girls from the experimental group during week 2, probably due to the introduction of the MMF app. However, the upward trend of PA levels could not be sustained till the end of the intervention due to poor functionality, lack of aesthetics and engagement of the MMF app as supported by the qualitative results. The qualitative results are also in line with past studies that show digital devices and mobile apps could enhance learners' experience and motivation in PA participation (Brannon and Cushing, 2015; Harries et al., 2016; Wang et al., 2020). In particular, apps that possess features of tracking behaviours (e.g. step count, distance covered, calories burned etc.), offer users an avenue or a choice to plan and follow the goal plan (e.g. decide on distance to cover, how many calories to burn etc.), and promote socialisation among users (Wang et al., 2020).

Moreover, the MVPA/VPA standards did not correspond with the mean MET score in the present study. Most of the participants also did not meet the daily recommendation of at least 60 minutes of MVPA (WHO, 2018b). Such differences could be explained as the measurement of the mean MET score did not consider if the same PA may involve a range of intensity in effort (Mcaleese et al., 2016), or is just an accumulation of light intensity PA carried out throughout the

day. Nevertheless, this was a good starting point for adolescent girls to start performing some PA, although it might not be beneficial enough to reap substantial health benefits in the long run when the intensity of PA is too low (Mcaleese et al., 2016). Furthermore, WHO also recommended that VPA should be incorporated into adolescents' activities at least three times a week (WHO, 2018b) to bring about additional health benefits.

One unique finding from the present study was that the MMF mobile app was more suitable for Low MET participants who desired relatedness from others such as online support from their peers in contrast to High MET participants. This result contradicts past studies that mobile apps that provide online support (e.g. interactive and social functions) can promote PA, better facilitate lifestyle change(s) and peer influence (Johnston et al., 2016; Nightingale et al., 2017), as well as the capability to motivate adolescents to perform more PA (Coleman et al., 2008; Wiese-Bjornstal et al., 2009). In fact, the High MET group found this form of social support demoralising when they could not match up to their peers. Such feelings of social support may or may not be manifested online due to the contradictory nature of online social networking groups. Indeed, Chang et al. (2016) found that middle-aged participants were more accepting of social support than female undergraduate students. Hence, when selecting mobile apps for promoting PA in the future, researchers may have to consider the PA base (High/Low MET score) and the age of the adolescents. Our results showed that online social support may not be the greatest influence for adolescent girls' participation in PA. Instead, it was intrinsic motivation that sustained the behaviour of the participants (Ryan and Deci, 2002). The development of intrinsic motivation for PA in adolescent girls would be a long-lasting solution to increase their current level of PA, instead of relying on online support (relatedness) which has been shown to be ineffective in motivating the adolescent girls in the present study (Di Battista et al., 2019).

The benefits of using mobile apps to promote PA such as goal-setting, self-monitoring of PA, and the autonomy to select the PA to participate in, have been repeatedly mentioned in many research studies (Bort-Roig et al., 2014; Schoeppe et al., 2016; Wang et al., 2020). Our findings are consistent with the past studies. However, one interesting finding was the discontinued interest or motivation of participants in using the mobile apps to perform PA after some time, despite prior motivation. Most participants had strong opinions that the MMF app lacks functionality, aesthetics and engagement (Wang et al., 2020). With these features missing from the app, it was harder to sustain the continued interest of the participants in using such mobile apps in performing PA. Schoeppe et al. (2017) study showed that entertainment and social connectedness are required to engage adolescents, and this was absent in the MMF app. Indeed, Martin et al. (2015) revealed that smartphone apps for PA should meet the developmental needs of adolescents such as fun, affiliation, success, skill development, excitement and fitness, in order to appeal to them and sustain their interest in PA in the long run.

Significant improvements in behavioural outcomes would have been expected when multi-component interventions (such as the MMF app) that included *behaviour change techniques* were used (Schoeppe et al., 2016). However, this was not true in the present study. Challenges such as cumbersome and confusing app functions were perceived as factors that discouraged users from performing PA (Schoeppe et al., 2017). Participants also recommended for customisation of app user accounts, simplifying the app functions, and including rewards and videos as motivators to encourage and motivate more adolescent girls to be involved in PA. Indeed, these findings correspond with past studies that highlighted mobile apps users tend to choose fun, easy-to-use, functional apps, which offer visual appeal (Schoeppe et al., 2017).

In the customisation of one's app account and the simplification of app functions, participants preferred to have more control of performance data, such as adding/removing goals, settings and social connectivity. Most of the participants were not keen on the fine details of their

PA performance, such as pace and elevation. They preferred apps that could automatically track PA or certain indicators of interest such as the number of calories burnt. Although Bort-Roig et al. (2014) identified features such as PA profiles, socialisation online, timely feedback on PA and goal-setting as crucial factors that helped engage users in PA, these were more relevant to adults rather than adolescents. Our results suggest that researchers should consider the target participants' general behaviour, and their competence level in using digital PA devices to promote PA. Indeed, teachers are facing a generation of young learners who have ready access to mobile devices, apps, and social networks on a daily basis (Casey et al., 2017). Leveraging on information communication and technologies (e.g. mobile apps) with attractive functions and features to encourage and motivate adolescent girls to be physically active beyond physical and health education (PHE) lessons (e.g. weekends) could be another option to promote PA (Kemp et al., 2020).

While customisation of one's MMF app account and the simplification the app functions were operational, the desired inclusion of rewards and videos reminded us of the motivation factor that spurred adolescent girls to perform PA in the present study. Extrinsic motivation such as rewards have been known widely to drive PA in participants. However, the sustainability of such means is unpredictable (Deci and Ryan, 2002). On the other hand, intrinsic motivation such as fun and enjoyment is more likely to drive one to perform PA regularly according to SDT (Ryan and Deci, 2007). This tension needs to be mitigated carefully (i.e. use of appropriate awards at the right time) to ensure long term gains from PA.

With the inclusion of videos in mobile apps for PA, it is more likely that adolescent girls may engage in PA for a longer period if it piques their interest. Indeed, previous studies have found that videos which are engaging to adolescents increase intrinsic motivation in fitness (Gao et al., 2011 as cited by Martin et al., 2015). Similarly, fitness videos that provide instructions on

how to carry out certain exercises or PA and encouragement may sustain participants' engagement.

In sum, to ensure sustained engagement of adolescent girls in using mobile apps for PA, developing appropriate app functions is important. App designers should invest more in providing better app functionality, aesthetics, and engagement in order to attract more potential users (Wang et al., 2020), especially adolescent girls. With the empowerment to choose the type of PA to perform, users will naturally participate in PA they felt they are competent in, and with people whom they feel comfortable with. Taken together, intrinsic motivation in PA participation beyond formal structured curriculum can be developed with the continued feelings of autonomy, competence and relatedness (Deci and Ryan, 2002) through the use of appropriate mobile apps.

Limitations, future directions and implications

The present study contributed to the existing literature by investigating if mobile apps can help to increase the level of PA in adolescent girls. The results suggest that the use of the MMF app seems to be able to attenuate the decline of adolescent girls' PA level during weekends. The mixed methods approach employed in the present study also provided unique insights on the efficacy of using mobile apps in changing adolescent girls' PA behaviour during weekends, and the perceived benefits, challenges and recommendations beyond formal PHE settings. While acknowledging the contributions of the present study, there are some limitations which should be mentioned. First, the length of a three-day monitoring protocol may not be of sufficient sustained duration to investigate if the effects of the intervention are sustainable as Stewart et al. (2000) suggested that a seven-day monitoring protocol would provide a better estimate on an adolescent's usual PA behaviour. This referred to weekdays and would translate to at least three and a half weekends. Hence, to get reliable data of the adolescent girls' PA on weekends, it would be good to ensure that the intervention period is extended to more than four weekends and

is uninterrupted by any school events. Second, the cross-sectional study of the small sample size did not give a good representation on the overall level of PA of adolescent girls. Longitudinal studies with a bigger sample size that investigate changes in levels of PA and perceptions of PA of adolescent girls over time will be useful in ascertaining if mobile apps could influence the level of PA in adolescent girls during the weekends. Finally, the present study only investigated the influence of one mobile app, MMF. While this mobile app is free and convenient to the participants in tracking their PA, it has not been validated empirically. Hence, readers should be cautious when reading and interpreting the results. In addition, the pedometer app was used as an additional source of data for triangulation, which may be a confounding variable in the study as participants may refer to it as feedback for performance. Future interventions should use apps that are validated, or utilise accelerometers to overcome this limitation.

In terms of practical implications, results of the present study suggest that there is a strong need to educate adolescent girls on the importance of engaging in PA beyond weekdays. This goal can be achieved in a few ways: Firstly, PHE lessons in schools should focus on the importance of PA, extending to weekends. Teachers may educate students on how they can take ownership of their health using mobile apps during weekends by: (a) providing students with a sense of autonomy to select the mobile apps that they prefer to use, and make the choice of social connectivity optional; and (b) building up the motivation and competency level in students using mobile apps for PA through exposing them to such use during PHE lessons. Such a strategy, coupled with appropriate development of PHE teachers to embrace information communication technologies in their lessons may improve the chances of success in educating students through mobile apps (Tou et al., 2020). Furthermore, it is necessary that teachers provide guidance and close monitoring for the students in the early phases of such usage to better engage them in taking responsibility of their own health (Greenhow and Lewin, 2016). In retrospect, mobile apps

should be confined to use for individual PA as they have the tendency to reduce social interactions in PHE classes due to its individualistic nature, thus diminishing the social interactive nature of PHE lessons (Depper and Howe, 2017). Secondly, the attitudes of adolescent girls in using the MMF app repeatedly to change their PA behaviour are the premise underlying the efficacy of a given digital behavioural intervention (Wang et al., 2020). Rewards may be incorporated in the mobile apps to motivate adolescent girls to perform more PA. For example, using awards to recognise parent-child pair(s) or groups of friends who have achieved improvements in a certain level of PA may motivate them to perform more PA or at a regular basis. This may promote a stronger sense of relatedness with parents, peers and the PA culture both at home and in school. Tokens of appreciation may also be given to participants to show appreciation for their effort in PA engagement. However, this is just a short term strategy. Hence, it is imperative that PHE teachers create an optimal climate that facilitates intrinsic motivation of students so that they may engage in regular and sustainable PA beyond school curriculum hours (Di Battista et al., 2019; Wang et al., 2008). Finally, instead of gathering MET scores and step counts as indicators of adolescent girls' levels of PA, an awareness of and education on the guidelines on MVPA and/or VPA should be made known to students through PHE lessons. Performing PA that is of moderate to vigorous intensity would be more beneficial than one that is of light intensity, even if the MET score or step count is high. As identified in the present study that the MMF app was more suitable for Low MET students, schools may adopt a targeted approach in encouraging behavioural change towards PA of this particular group of students. If adopted, such a strategy may be key in addressing constraints in curriculum time, insufficient practitioners and large class sizes in PHE lessons (McNeill et al., 2009).

Conclusion

The present study examined the efficacy of using mobile apps in changing adolescent girls' PA behaviour during weekends in a single-sex school setting. Three key findings were delineated: (a) the use of mobile apps may potentially help to attenuate the decline in PA level of adolescent girls during weekends; (b) the benefits of using mobile apps to promote PA include a sense of autonomy in selecting the type of PA, the ability to view friends' posting of PA, and self-monitoring of PA. On the other hand, cumbersome and confusing app functions were perceived as challenges that discouraged participants from performing PA; and (c) allowing users to customise their account, simplifying the app's functions, and including rewards and videos as motivators may enhance users' PA experience. As research on the use of mobile apps to increase the level of PA in adolescent girls during the weekends is relatively new and emerging, more studies are needed to understand how the design and development of mobile apps can appeal to the users to sustain engagement in PA.

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Author biographies

Ming Li Carol Seah is a Master degree holder from the Physical Education and Sports Science Academic Group at the National Institute of Education, Nanyang Technological University, Singapore. She is currently teaching Physical Education at River Valley High School.

Koon Teck Koh is an Associate Professor and Head of Department for the Physical Education and Sports Science Department at the National Institute of Education, Nanyang Technological University, Singapore. His research interests are in pedagogy and sport coaching to improve practices. He is currently the president of the Singapore Physical Education Association, and Technical Commission at FIBA.