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Effectiveness of social media with or without wearable devices to improve physical activity and reduce sedentary behavior: A randomized controlled trial of Chinese postgraduates

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ABSTRACT

The present study was aimed to verify whether an integrating of wearable activity tracker device and a social media intervention strategy would be better than a standalone social media intervention for improving physical activity (PA) and reducing sedentary time for Chinese postgraduate population. A total of 42 full-time postgraduate students participated in this study, which were randomized to receive a 4-week social media intervention through WeChat either with (Wearable Device group) or without (control group) a wearable activity tracker device. Energy expenditure, step counts, moderate to vigorous physical activity time (MVPA) and sedentary time were assessed before and after the intervention. Besides, anthropometric parameters of body weight, body mass index, body fat rate, waist-to-hip ratio, as well as self-reported quality of life were also evaluated. It was found that both energy expenditure and step counts were significantly increased, while sedentary time was significantly reduced during the post-intervention test compared to the baseline test for Wearable Device group. No significant difference of PA was found for the control group. The results demonstrated that the integrating of wearable activity tracker device and a social media intervention was effective in promoting PA, while a standalone social media intervention may have no effect on the influence of PA for Chinese postgraduates.

1. Introduction

College students have demonstrated increased health problems for the insufficient levels of physical activity (PA) and high levels of sedentary behavior (SB) [1,2]. This is especially true for the population of Chinese postgraduate students [3]. In the past few decades of China, with supportive policy for enrollment of postgraduate, the number of postgraduates has witnessed a substantially expansion with 3,332,373 full-time students in 2021 according to the statistics from Ministry of Education of People's Republic of China [4,5].

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The sharp increase in the number of postgraduate students has highlighted the health problems of postgraduates. It has been suggested that more than 80% of postgraduates in China was in sub-health status which can be mainly explained by insufficient PA and serious SB [6]. Therefore, it is urgent to develop effective strategies to promote PA and reduce SB in postgraduate population in China so as to reduce health problems.

Social media intervention has been suggested as a potential intervention strategy to promote physical activity [7,8]. Social media is highly interactive [9], and may help to increase physical activity participation by allowing users to connect with and support each other, and share their experiences or challenges [10,11]. However, relevant previous researches have demonstrated inconsistent results and the effect of social media on physical activity participation remains elusive [11–15]. For example, in the research of Pope et al. a significant increase of moderate-to-vigorous physical activity (MVPA) has been observed after a 12-week social media intervention [14]. On the contrary, an intervention of using an online social networking plus self-monitoring has not been found to produce desired outcomes for promotion of PA[11]. At present, there is little robust evidence on how social media interventions inform changes to behaviors related to physical activity, and well-established guidance cannot be achieved on how to responsibly and effectively use social media in physical activity interventions.

The emergence and rapid development of sophisticated consumer-targeted wearable technology have enabled participants to measure and track their own activity levels, heart rate, energy expenditure, sleep, sedentary behavior, and physical activity intensity rather than just basic pedometer step counts [16–18]. Currently, wearable activity tracker devices have been adopted in increasing studies to promote physical activity and reduce secondary behaviors [19,20]. These devices have been found to help individuals to objectively monitor their physical activity levels, and thus increase the participation and amount of daily physical activities [21,22], such as research of Wang et al. suggested a technology-based self-monitoring device (Fitbit One) led to a statistically significant (within group) increase in MVPA after a 6-week intervention [23]. Moreover, previous research has suggested that the combination of wearable device and other behavior change techniques (such as social media) may bring greater improvement in physical activity participation [24,25]. However, according to the research of Pope et al. wearable technology may not result in an additional benefit of PA based on a social media intervention [14]. At present, current literature struggles to provide a concrete conclusion on the effect of physical activity promotion as a result of social media intervention with or without wearable activity tracker devices.

Based on the above researches, this study aimed to assess and compare the effectiveness of a 4-week social media intervention through WeChat with (Wearable device group) and without (control group) a wearable activity tracker device for improving PA and reducing secondary outcomes for Chinese postgraduate population. It was hypothesized that a social media intervention with a wearable activity tracker device would be more effective in increasing PA and reducing overall sitting time compared with the social media intervention using traditional self-reports.

2. Materials and methods

2.1. Participants recruitment

Based on the experimental design, the sample size was estimated prospectively using G*power v3.1.0 (Franz Faul, University of Kiel, Germany) with a level of 0.05 and power of 0.80. We used a conservative effect size of 0.6 based on a previous study [26]. As a result, the sample size was estimated to be 24 subjects. To allow for study withdrawal and dropout, we decided to recruit an additional eighteen participants. Thus, the planned sample size of this study was 42.

Participants were recruited from the postgraduates of universities in Shanghai. A two-stage sampling method was implemented to recruit the participants. In the first stage, we randomly selected 42 classes of postgraduates and randomly assigned each class to 1 of the 2 groups for intervention, with a 1:1 allocation ratio. In the second stage, postgraduates in these 42 classes were noticed to sign up for the experiment voluntarily. Based on the health records and baseline survey, postgraduates were excluded if they cannot meet the inclusion criteria. The inclusion criteria were as following: (1) Healthy postgraduates with self-reported PA engagement less than 150 min of moderate or 75 min of vigorous-intensity activity per week based on the survey of the last month and were verified via scripted screening interviews; (2) body mass index (BMI) no more than 23.9 kg/m^2 and was able to participate in physical exercise independently; (3) had the daily habit and skillful ability to use smartphone; (4) had no history of using drugs, narcotics, and substances. (5) had no prior habit in using a smartwatch; (6) not participated in a PA and/or SB intervention within the last 3 months. Only one participant was randomly selected from candidates for each class to participant the experiment. Informed written consent was obtained from all participants before the experiment. The study received ethical approval from the Ethics Committee of Tongji University of Medical Sciences (NO. 2020TJDX006).

2.2. Experimental protocol

This study was designed as a two-arm randomized controlled trial lasted between 19 January and 5 March in 2021. Before formal experiment, each participant was instructed to familiar with the test and intervention protocol. Participants were randomized into 1 of the 2 groups for intervention. All participants received a 4-week social media intervention on physical activity via WeChat (a popular social media site with over 800 million active users, similar to Facebook and Twitter, is widely used in China). However, only 1 group (the Wearable Device group) received a Wearable Device (Redmi band, Xiaomi, CHN) to monitor daily physical activity during the intervention and the other group (control group) was told to refrain from using wearable devices during the 4-week intervention. Baseline and post-intervention test (physical activity recording of consecutive 3 days, anthropometry measurement and investigation of self-perceived quality of life) were conducted before and after the intervention for each participant. The scheme of the study design has been depicted in Fig. 1.

2.3. Interventions

2.3.1. Social media intervention strategy

Social media intervention was conducted via WeChat based on behavioral changing theory to promote PA and reduce SB of the participants. The first implemented strategy of the intervention was online health education. Online health education was conducted by online lecture on recommendations and tips to formulate personal exercise plans, and educational materials learning concerning the significance of sport health and guidelines on physical activity promotion and sedentary behavior reduction. The next strategy was daily PA supervision via WeChat. Each participant was asked to submit PA diaries of 5 items labeled "Whether engaged in moderate-to-vigorous PA", "Energy consumption", "Sedentary time", "Exercise type" and "Exercise time" during the intervention. The third strategy adopted in the social media intervention was social support. In this study, participants were allowed to interact with each other by exchanging user-generated information (e.g., exercise feelings and knowledge, mutual encouragement) and receive reminders, motivational messages and other support from researchers. The detailed description of the social media intervention strategy was described in Table 1.

2.3.2. Wearable device

Participants in wearable device group received a Redmi physical activity tracking wristbands along with an instruction booklet to inform participants the usage of the device. Briefly, the Redmi band is a fitness tracker that uses a three-axis accelerometer to detect any motion or movement and then converts it into measurable data. The Redmi band is similar to a regular watch with a wristband displayed the screen. The participants were able to objectively monitor their physical activity levels by tapping on the screen. Meanwhile, it synced with an associated smartphone mobile application (Redmi Sports Health, available in Apple and Android). The Redmi Sports Health enable personalized exercise goal-setting and sedentary-reminding, which would remind participants to take part in physical activities when sitting for a long time. Moreover, it provided feedback for participant to know about their own information on heart rate changing curve, PA energy expenditure, sedentary time, exercise intensity, sitting breaks and sleep. After one week familiarization with Redmi band, participants were suggested to set personal exercise goals and formula exercise plans in app and then wore the Redmi band until the intervention session was finished. During the intervention, participants were reminded to finish daily activity report questionnaire to collect PA amount of the participants.

2.4. Measurements

2.4.1. Physical activity

Data on PA of the participants during daily life were collected at baseline and post-intervention test, and have been accepted as the primary outcome measure for this study. In this study, PA was assessed using an ActiGraph GT3X accelerometer (ActiGraph, Pensacola, Florida, USA). The ActiGraph GT3X is an accelerometer measuring PA based on motion sensors across three axes. The device provides data on energy expenditure, steps taken, and activity/sedentary bouts via publicly available validated algorithms [29]. The accelerometer was initialized using 60-s epochs to collect data at a sampling rate of 30 Hz. During the test, participants were instructed to wear the ActiGraph on the right hip on an elastic waistband during waking hours, except when bathing, swimming, or doing other water activities, for 7 consecutive days. A valid ActiGraph day was defined as $\geq$ 600 min wear time [30]. Following data validation, activity counts per minute were translated into sedentary time and minutes in MVPA based on the cut-offs by Troiano et al. [31]. The protocol of physical activity measurement has been depicted in Fig. 2.

2.4.2. Anthropometric parameters

Anthropometric parameters were measured using an advanced bioelectric impedance analysis body composition analyzer (MC-980MA, Tanita Co., Guangzhou, China). The participants' height, age, sex and weight were inputted to the devices. All participants were prepared prior to measurement with the following protocol: wearing light clothing (same clothes for each participant at baseline and post intervention test), jewelry removed, barefoot, and wiping the soles of their feet with an alcohol swab, and bladder emptied.

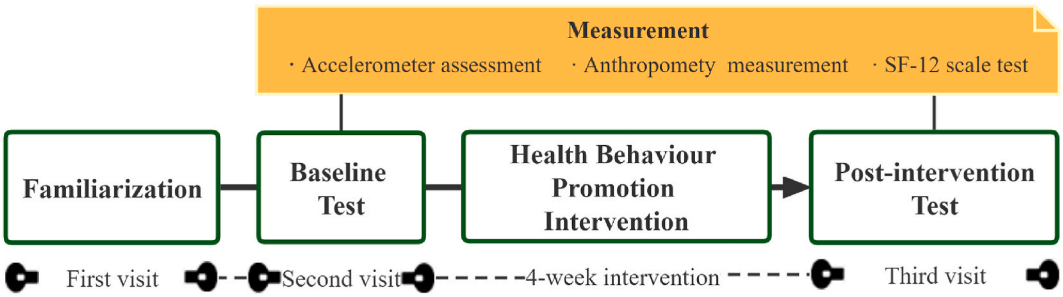

Fig. 1. Experiment design.

Table 1
Intervention component and participant activities for the online social media intervention.

Intervention component	Participant activities
Online health education	**Researcher activities**
	Online lecture
	Recommendations and tips to formulate personal exercise plans.
	Learning materials
	Global action plan on physical activity 2018–2030: more active people for a healthier world [27];
	WHO Guidelines on Physical Activity and Sedentary Behavior [28].
PA supervision	**Participant self-report diaries**
	Submit PA diaries of 5 items labeled "Whether engaged in moderate-to-vigorous PA", "Energy consumption", "Sedentary time", "Exercise type" and "Exercise time" each day during the intervention via WeChat.
Social support	**Participant activities**
	Connect with other participants in the WeChat group;
	Provide messages to support to other participants' PA participation;
	Share relevant information about exercise.
	Researcher activities
	Send self-report diaries reminder (daily);
	Post motivational messages to encourage exercise (weekly);
	Post exercise-related knowledge (weekly);
	Respond to participant questions and technical issues (as needed).

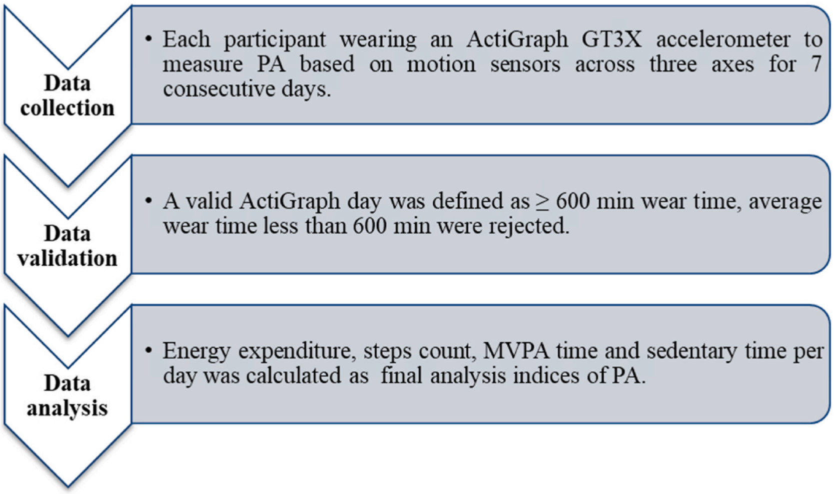

Fig. 2. The protocol of physical activity measurement.

The subjects then stepped onto the scale, ensuring that the heels of both feet were positioned above the two heel electrodes. The subjects were then instructed to stand still onto the scale with the heels of both feet positioned above the two heel electrodes with arms by their side until the body composition measurement was complete. Body weight, body mass index, body fat rate, and waist-to-hip ratio were recorded as secondary outcomes.

2.4.3. Quality of life

Physical and mental health-related quality of life for each participant was assessed by the Short Form (SF)-12 scale developed by the Health Education Institute in Boston, USA, and has been translated to Chinese by Zhejiang University School of Medicine in 1991, which has been verified to have good reliability and validity in previous researches [32]. In the scale, 12 items assessed both physical and mental health quality of life, in which a higher final score indicated a better quality of life [33]. The participants were surveyed via an online questionnaire (https://www.wjx.cn/), during the baseline test and post-intervention test. Scale scores were also considered as secondary outcomes.

2.5. Statistical analysis

The statistical analysis was conducted in SPSS Statistics version 26 (IBM Corp, Armonk, NY). The S–W test (Shapiro-Wilk test) was used to test the normality of analytical data. Independent sample *t*-test was adopted to test the difference of weight, body mass index, body fat ratio and all PA indicators, while Kolmogorov–Smirnov test was adopted to test the difference of waist-to-hip ratio and SF-12 scores between Wearable Device group and the control group at baseline test. The difference of waist-to-hip ratio and energy consumption between baseline and post-intervention test for Wearable Device group and body mass index, step counts and SF-12 scores for control group were determined by Wilcoxon signed rank test, while paired-sample T test was adopted to determine the difference of the rest parameters between baseline and post-intervention test for the two group participants. For normal distributed variable, results were expressed as mean ± SD, while for abnormal distributed indices, data were expressed as median (Interquartile Range). The significance level for all statistical analyses was set at $p < 0.05$.

3. Results

3.1. Basic characteristics of the Respondents

A total of 42 full-time postgraduate students (64% female) aged 21–28 years (23.59 ± 1.39 years) from universities of Shanghai City in China volunteered to participate in this study. Participants were randomly assigned to the Wearable Device group (n = 21) and the control group (n = 21).

All 41 recruited participants completed baseline test and randomization, including 15 males (37%) and 26 females (63%), with an average age of 23.59 ± 1.39. However, one participant lost in assessment of quality of life.20 participants were excluded from the analysis of accelerometer results for reasons of incorrect wearing of accelerometer that induce poor data quality. Thus, 41 individuals aged 23.58 ± 1.41 (63% females) were included for the analysis of anthropometric parameters, with 21 in the Wearable Device group and 20 in the control group. For PA parameters analysis, 22 participants were included with an average age of 23.68 ± 1.46 years (55% females) and 11 individuals for each group. For SF-12 scale score parameters analysis, 40 participants were included with an average age of 23.58 ± 1.41 (64% females), and 21 participants for the Wearable Device group and 19 participants for the control group.

3.2. Baseline and post-intervention test

Table 2 provides descriptive statistics for physical activity, anthropometric parameters and quality of life during the baseline and post-intervention test. For physical activity indicators of both Wearable device group and Control group, the averages of energy consumption, MVPA time, steps counts all increased while sedentary time decreased at post-intervention test compared to baseline test. For anthropometric parameters and quality of life, it seemed that Wearable device group showed more significant changes in Body Weight, Body Fat Rate, Waist-to-hip Ratio, BMI and SF-12 scores indices.

3.2.1. Physical activity

Fig. 3 showed the comparison of physical activity results between the baseline and post-intervention test for Wearable Device group and control group subjects. For the Wearable Device group subjects, the energy consumption tested during the baseline and post-intervention test were 233.99 ± 122.03 and 261.92 (284.91) kcals per day (Fig. 3a), while the results of step counts were 9564.75 ± 2966.06 and 11450.84 ± 3114.14 (Fig. 3d). Both energy expenditure and step counts tested during the post-intervention test were significantly increased compared to baseline test (energy consumption: $p = 0.026$, Cohen's d = 0.526; step counts: $p = 0.013$, Cohen's

Table 2
The overall results of the physical activity, anthropometric parameters and quality of life during the baseline and post-intervention test.

	Group	Baseline	Post-intervention
Physical activity (per day)			
Energy consumption (kcals)	*Wearable device group*	196.70 (175.11)#	261.92 (284.91)#
	Control group	268.33 (246.66)#	248.61 (170.12)#
Sedentary Time (min)	*Wearable device group*	717.35 ± 109.72	661.97 ± 105.31
	Control group	643.09 ± 102.74	624.16 ± 108.36
MVPA Time (min)	*Wearable device group*	61.15 ± 24.98	81.91 ± 32.77
	Control group	62.19 ± 24.05	72.47 ± 39.52
Steps Counts	*Wearable device group*	9445.33 (5078.00)#	11097.67 (4846.00)#
	Control group	8904.00 (4794.33)#	8250.67 (5861.67)#
Anthropometric parameters			
Body Weight (kg)	*Wearable device group*	57.11 ± 7.16	56.90 ± 7.27
	Control group	61.00 ± 9.96	61.29 ± 9.89
Body Fat Rate (%)	*Wearable device group*	24.30 ± 5.02	23.73 ± 4.95
	Control group	23.74 ± 8.40	23.38 ± 8.67
Waist-to-hip Ratio	*Wearable device group*	0.81 (0.10)#	0.80 (0.10)#
	Control group	0.84 (0.07)#	0.84 (0.08)#
BMI (kg/m^2)	*Wearable device group*	20.30 (2.85)#	20.00 (2.70)#
	Control group	22.15 (2.68)#	22.10 (2.90)#
Quality of Life			
SF-12 scores	*Wearable device group*	25.95 ± 5.58	26.33 ± 5.35
	Control group	29.78 ± 7.49	29.68 ± 7.09

Note.#Represents that data was not normal distributed. For normal distributed variable, results were expressed as mean ± SD, while for abnormal distributed indices, data were expressed as median (Interquartile Range).

d = 0.710). For Sedentary time showed in Figure-3b, the result has significantly reduced from 717.35 ± 109.72 min per day at baseline test to 661.97 ± 105.31 min per day at the post-intervention test ($p = 0.031$, Cohen's d = 0.757). No significant differences were found between the post-intervention and baseline test for the MVPA time showed in Figure-3c for the Wearable Device group (P = 0.101, Cohen's d = 0.545), and the total four indices of physical activity results for the control group subjects (energy consumption: $p = 0.649$, Cohen's d = 0.141; Sedentary time: $p = 0.334$, Cohen's d = 0.306; MVPA time: $p = 0.362$, Cohen's d = 0.288; step counts: $p = 0.461$, Cohen's d = 0.231).

3.2.2. Anthropometric parameters

The comparison of anthropometric parameters results between the baseline and post-intervention test for Wearable Device group and control group subjects were illustrated in Fig. 4. For the Wearable Device group subjects, the body weight tested during the baseline and post-intervention test were 57.11 ± 7.16 and 56.90 ± 7.27 kg, the results of body fat rate were 24.30 ± 5.02 and 23.73 ± 4.95% (Figure-4a), the results of waist-to-hip ratio showed in Figure-4c were 0.81(0.10) and 0.80(0.10), and the results of BMI showed in Figure-4d were 20.3(2.85) and 20(2.70) kg/m^2. The results of the control group tested during the pre- and post-intervention were 61.00 ± 9.96 and 61.29 ± 9.89 kg for the indices of body weight, 23.74 ± 8.40 and 23.38 ± 8.67 for the indices of body fat rate (Figure-4b), 0.84(0.07) and 0.84(0.08)% for the indices of waist-to-hip ratio, and 22.15(2.68) to 22.10(2.90) Kg/m^2 for the indices of BMI. Table 3 showed the statistics p values and effect sizes of different compare group for anthropometric parameters. No significant differences were found between the post-intervention and baseline test for all the indices of anthropometric results for both the Wearable Device group and the control group subjects. However, for the body fat rate index of the Wearable Device group subjects, a significant difference of one-tailed test has been reached between the post-intervention test and the baseline test (one tailed p = 0.0385), with an average of 0.57% decrease during post-intervention test compared to the baseline test.

3.2.3. Quality of life

The results of SF-12 scores for both Wearable Device group and control group subjects during the baseline and post-intervention test were presented with their 95% confidence intervals in Fig. 5. The results of the Wearable Device group tested during the pre- and post-intervention were 25.95 ± 5.58 and 26.33 ± 5.35, and 29.78 ± 7.49 to 29.68 ± 7.09 for the control group. No significant difference was found between the baseline and post-intervention test for both Wearable Device group ($p = 0.734$, Cohen's d = 0.075) and Control group ($p = 0.943$, Cohen's d = 0.017), and between the Wearable Device group and control group participants during the baseline ($p = 0.078$, Cohen's d = 0.585) and post-intervention test ($p = 0.098$, Cohen's d = 0.537).

4. Discussion

This study presented some of the first findings of the impact of social media support combined with wearable activity tracker

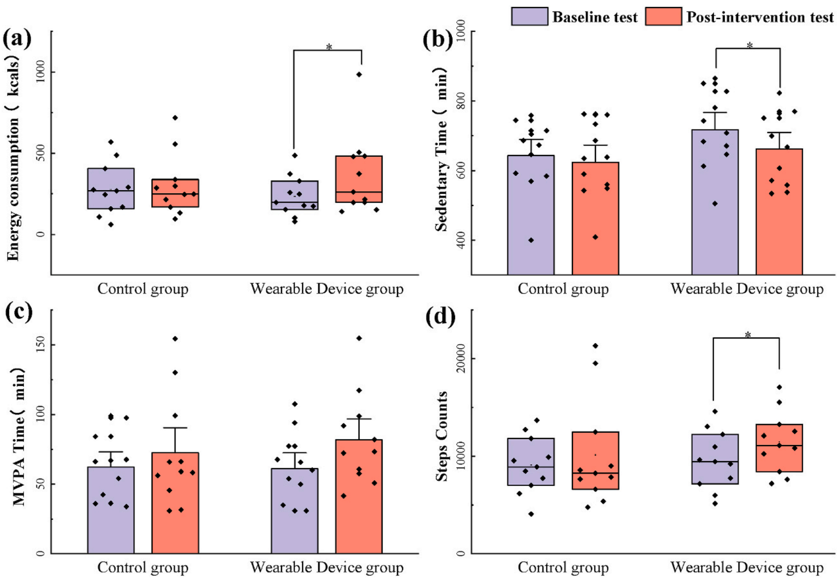

Fig. 3. Comparison of the results of energy expenditure (a), sedentary time (b), MVPA time (c) and step counts (d) between Wearable Device group and control group subjects during the baseline and post-intervention test. For Wearable Device group, both energy expenditure and step counts tested were significantly increased, while sedentary time was significantly reduced during the post-intervention test compared to the baseline test. For normal distributed variable (sedentary time and MVPA time), results were expressed as mean ± SD, while for abnormal distributed indices (energy consumption and steps counts), data were expressed as median (Interquartile Range). Significant differences are indicated by asterisks (p < 0.05).

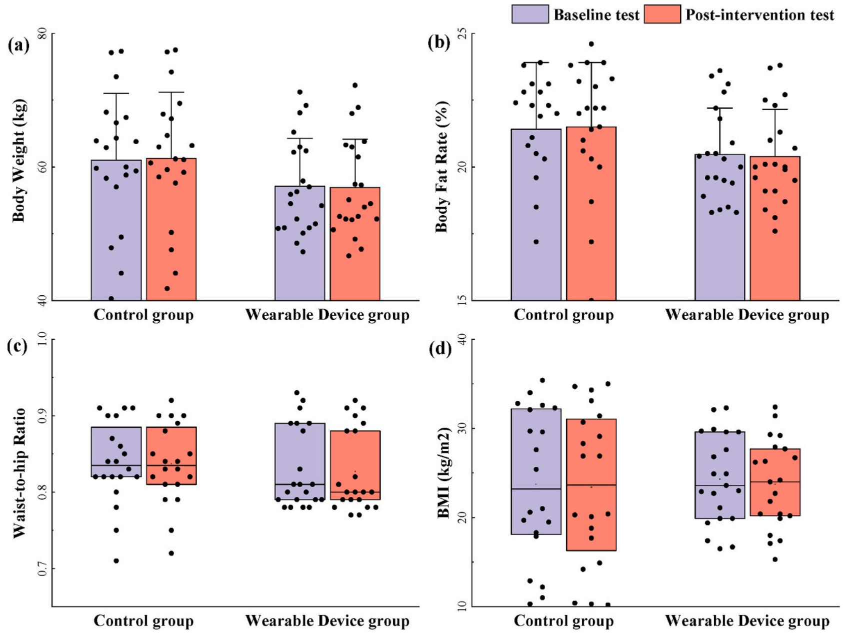

Fig. 4. Comparison of the results of body weight (a), body fat rate (b), waist-to-hip ratio (c) and BMI (d) between the baseline and post-intervention test for Wearable Device group and control group subjects. For normal distributed variable (body weight and body fat rate), results were expressed as mean ± SD, while for abnormal distributed indices (waist-to-hip ratio and BMI), data were expressed as median (Interquartile Range). For both Wearable Device group and Control group, no significant differences were found between the post-intervention and baseline test for the indices of body weight, body fat rate, waist-to-hip ratio and BMI.

Table 3
The statistics p values and effect sizes of different compare group for anthropometric parameters.

Compare group	*p*	Cohen's d
Body Weight		
Baseline: *WD group vs. Control group*	0.158	0.450
Post: WD group vs. Control group	0.112	0.508
WD group: baseline vs. post	0.424	0.178
Control group: baseline vs. post	0.239	0.272
Body Fat Rate		
Baseline: *WD group vs. Control group*	0.797	0.082
Post: WD group vs. Control group	0.875	0.050
WD group: baseline vs. post	0.077	0.406
Control group: baseline vs. post	0.284	0.247
Waist-to-hip Ratio		
Baseline: *WD group vs. Control group*	0.677	0.131
Post: WD group vs. Control group	0.555	0.186
WD group: baseline vs. post	0.119	0.356
Control group: baseline vs. post	0.577	0.127
BMI		
Baseline: *WD group vs. Control group*	0.167	0.440
Post: WD group vs. Control group	0.099	0.528
WD group: baseline vs. post	0.381	0.195
Control group: baseline vs. post	0.378	0.202

Note. Post is for the short of *Post-intervention, WD group is short for Wearable device group*.

strategies on physical activities and sedentary behaviors of Chinese postgraduate students. It was interestingly found that the integrating of wearable activity tracker device into a social media intervention showed better effects in increasing PA and reducing sedentary time of Chinese postgraduates compared with the social media intervention using traditional self-reports, which has verified the hypothesis of the current study.

Social media intervention has been suggested as a potential intervention strategy to promote physical activity, although at present there is little robust evidence on how social media interventions inform changes to behaviors related to physical activity [34,35]. In the present study, the use of Online health education, WeChat groups and the accessibility of information and interaction were the main characteristics of social media interventions used to elevate participation of physical activity. However, no significant enhancement of

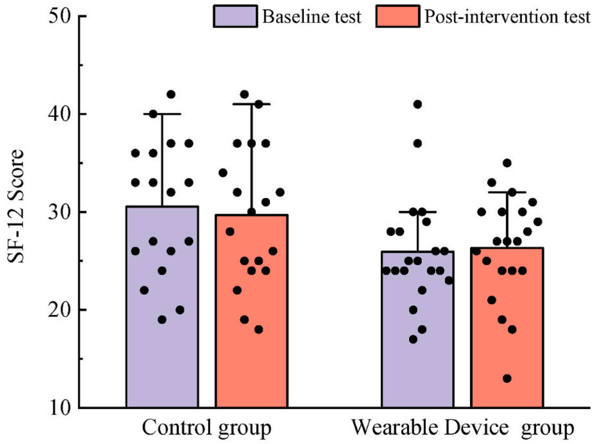

Fig. 5. Comparison of SF-12 scores results between the baseline and post-intervention test for Wearable Device group and control group subjects. No significant differences were found between the baseline and post-intervention test for both Wearable Device group and Control group subjects. Data were represented as Mean ± SD.

PA was found as a result of a 4-week social media intervention without wearable activity tracker device in the present study. The results were consistent with the conclusion of a meta-analysis research that social media interventions relating to healthy lifestyles tend to show low levels of participation [10]. Even so, elevated PA has also been found after social media intervention for many researches [36–38]. Compared to relevant previous researches, it seemed that the unpromising outcomes of the social media only intervention would be related to the specific population of Chinese postgraduates, the result of some participants being discouraged by the act of self-monitoring, as well as the relatively shorter duration time of intervention.

Up to date, only a few studies have examined the use of wearable activity tracker device in combination with social media intervention. For example, Vandelanotte1 et al. demonstrated the effectiveness of integrating physical activity trackers into a web-based computer-tailored intervention for the promotion of PA[39], and another randomized trial observed that a website added to pedometer use improved daily step counts[38]**.** However, a combination of wearable device and social media strategy may not result in an additional benefit of PA compared to standalone social media intervention [14]. In this study, both energy expenditure and step counts tested were significantly increased, while sedentary time was significantly reduced during the post-intervention test compared to the baseline test for wearable device group. Moreover, although most parameters of anthropometric parameters and quality of life showed no significant change after intervention, the body fate rate index of the Wearable Device group has decreased by an average of 0.57% and reached a significant difference of one-tailed test. All the results indicated that the integrating of wearable activity tracker device and a social media intervention may be effective in promoting physical activities for Chinese postgraduates.

In terms of wearable devices adopted in PA intervention, it has been suggested that a more mainstream, intuitive and smaller smart device would be helpful when seeking to enhance PA awareness and self-regulation among college students [14,40,41]. In the research of Vandelanotte et al. [39] a Fitbit activity tracker was adopted while in the researches of Wan et al. [38], an Omron HJ-720 ITC pedometer was adopted on the basis of web-based intervention. The wearable devices used in the above two researches were smart and intuitive, and have demonstrated the effectiveness of integrating physical activity trackers into a web-based computer-tailored intervention for the promotion of PA. In this study, a smart wearable device of fitness-tracking wristband has been adopted for the monitoring of PA, heart rate and sedentary time. The wearable device was well designed and accepted, which may explain the better results of the current study. However, in the research of Zachary et al. in which no additional benefit was found as a result of combination of wearable device and social media strategy compared to standalone social media intervention, participants were often frustrated with the Polar M400's syncing capabilities, its less intuitive design versus other smartwatches, and the bigger watch size [14].

In relevant previous researches, significant increase of MVPA has been mainly revealed as the effective indictor of intervention [12,42,43]. However, in the current study, although the average of MVPA of wearable device group has increased by about 1/3, no significant increase of MVPA has been found after PA intervention compared to baseline test. It can be inferred from the PA results that the increase of PA was mainly attributed to the increase of low intensity exercise (decrease of sedentary time) rather than the increase of MVPA physical exercise for Chinese postgraduates.

4.1. Strengths and limitations

To our knowledge, it is the first study to compare the effectiveness of a 4-week social media intervention with and without a wearable activity tracker device for improving PA and reducing secondary outcomes for Chinese postgraduate population. Therefore, the current research may establish a baseline on which other studies could expand on. In the current research, we have collected data of physical activity by ActiGraph GT3X accelerometer, and anthropometric parameters and quality of life by e-questionnaire. The data have been inspected before formal analysis to ensure validity, while the e-questionnaire was administered in Chinese to ensure comprehensive understanding and spontaneous responses for each question. Therefore, reliable information of the baseline and post-intervention test was assured. Considering the expansion of postgraduates' numbers and the severe situation of insufficient PA and serious SB, our findings had significant implications for exercise and health management of Chinese postgraduate population, which provided suggestions for development of intervention pathways to promoting physical activity and reducing sedentary time.

However, it also should be acknowledged that this study has several limitations. First, the current study didn't have a wearable device only group and the significant enhancement of the outcomes may be induced by the effect of the wearable device itself rather than the combination of social media and wearable trackers. A more robust study design with a wearable device only group would be needed to clarify the issue in the future study. Second, the sample size of the current study was relatively small, which may influence the credibility of the current research. A larger sample size would be effective to acquire a more generalizability results in the current research. Third, Academic year breaks of the Spring Festival may have biased daily habit and PA behaviors of the participants. If possible, future trials' recruitment and intervention implementation strategies should avoid such festivals. Fourth, other variables such as diet have not been strictly controlled in the current research, which may influence the results of the anthropometric indicators and reduce the credibility of relevant indices results. Lastly, to allow for study withdrawal and dropout, we have employed a number of subjects 75% more than the required sample size, whereas many participants have been excluded in the analysis of physical activity results for less than 600 min accelerometer wear time per day. Due to the unsatisfactory data collection of PA for many participants, the actual result of the current study, and thus the representative of the sample and the generalizability of the study would be interpreted with caution.

5. Conclusion

In conclusion, the integrating of wearable activity tracker device and a social media intervention was effective in promoting physical activities for Chinese postgraduates, while no significant effect of standalone social media intervention was found on PA. However, a more robust study design with a wearable device only group and a larger sample size would be needed to confirm these outcomes.

Author contribution statement

Jiaqi Li: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper. Hua Yang: Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper. Xiaoqian Song, Minjie Qiao and Haifeng Tao: Performed the experiments. Wenxin Niu: Analyzed and interpreted the data; Wrote the paper. Jingyuan Chen: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper. Lejun Wang: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper

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Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors of this manuscript declare no relationships with any companies, whose products or services may be related to the subject matter of the article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e20400.

References

[1] N.E. Peterson, J.R. Sirard, P.A. Kulbok, M.D. DeBoer, J.M. Erickson, Sedentary behavior and physical activity of young adult university students, Res. Nurs. Health 41 (1) (2018) 30–38, https://doi.org/10.1002/nur.21845.

[2] T. Deliens, B. Deforche, I. De Bourdeaudhuij, P. Clarys, Determinants of physical activity and sedentary behaviour in university students: a qualitative study using focus group discussions, BMC Publ. Health 15 (201) (2015), https://doi.org/10.1186/s12889-015-1553-4.

[3] M. Pan, B. Ying, Y. Lai, G. Kuan, Status and influencing factors of physical exercise among college students in China: a systematic review, Int. J. Environ. Res. Publ. Health 19 (1346520) (2022), https://doi.org/10.3390/ijerph192013465.

[4] Ministry of Education of the People's Republic of China, Number of Students of Formal Education by Type and Level, 2021. http://www.moe.gov.cn/jyb_sjzl/moe_560/2021/quanguo/202301/t20230104_1038061.html.
[5] Ministry of Education of the People's Republic of China, Statistical report on China's educational achievements in 2022, 2023, p. 2023, 04-03), http://en.moe.gov.cn/documents/reports/202304/t20230403_1054100.html.
[6] D.Z. Jie Men, Analysis of the Current Situation and Countermeasures of "physical Sub-health" of Postgraduate Students: A Case Study of 6 Universities in Jilin Province. Chinese Postgraduate04), 2014, pp. 4–5. https://kns.cnki.net/kcms/detail/detail.aspx?FileName=YJSZ201404003&DbName=CJFN2014.
[7] S.M. Schembre, Y. Liao, M.C. Robertson, G.F. Dunton, J. Kerr, M.E. Haffey, T. Burnett, K. Basen-Engquist, R.S. Hicklen, Just-in-Time feedback in diet and physical activity interventions: systematic review and practical design framework, J. Med. Internet Res. 20 (e1063) (2018), https://doi.org/10.2196/jmir.8701.
[8] S.M. Schembre, Y. Liao, M.C. Robertson, G.F. Dunton, J. Kerr, M.E. Haffey, T. Burnett, K. Basen-Engquist, R.S. Hicklen, Just-in-Time feedback in diet and physical activity interventions: systematic review and practical design framework, J. Med. Internet Res. 20 (e1063) (2018), https://doi.org/10.2196/jmir.8701.
[9] A.M. Kaplan, M. Haenlein, Users of the world, unite! The challenges and opportunities of Social Media, Bus. Horiz. 53 (1) (2010) 59–68, https://doi.org/10.1016/j.bushor.2009.09.003.
[10] G. Williams, M.P. Hamm, J. Shulhan, B. Vandermeer, L. Hartling, Social media interventions for diet and exercise behaviours: a systematic review and meta-analysis of randomised controlled trials, BMJ Open 4 (2) (2014), e3926, https://doi.org/10.1136/bmjopen-2013-003926.
[11] D.N. Cavallo, D.F. Tate, A.V. Ries, J.D. Brown, R.F. DeVellis, A.S. Ammerman, A social media–based physical activity intervention, Am. J. Prev. Med. 43 (5) (2012) 527–532, https://doi.org/10.1016/j.amepre.2012.07.019.
[12] G. McKeon, E. Papadopoulos, J. Firth, R. Joshi, S. Teasdale, J. Newby, S. Rosenbaum, Social media interventions targeting exercise and diet behaviours in people with noncommunicable diseases (NCDs): a systematic review, Internet Interventions 27 (2022), 100497, https://doi.org/10.1016/j.invent.2022.100497.
[13] R.G. LaChausse, My student body: effects of an internet-based prevention program to decrease obesity among college students, J. Am. Coll. Health 60 (4) (2012) 324–330, https://doi.org/10.1080/07448481.2011.623333.
[14] Z.C. Pope, D.J. Barr-Anderson, B.A. Lewis, M.A. Pereira, Z. Gao, Use of wearable technology and social media to improve physical activity and dietary behaviors among college students: a 12-week randomized pilot study, Int. J. Environ. Res. Publ. Health 16 (357919) (2019), https://doi.org/10.3390/ijerph16193579.
[15] E. Brindal, J. Freyne, I. Saunders, S. Berkovsky, G. Smith, M. Noakes, Features predicting weight loss in overweight or obese participants in a web-based intervention: randomized trial, J. Med. Internet Res. 14 (e1736) (2012) 114–129, https://doi.org/10.2196/jmir.2156.
[16] L. Laranjo, D. Ding, B. Heleno, B. Kocaballi, J.C. Quiroz, H.L. Tong, B. Chahwan, A.L. Neves, E. Gabarron, K.P. Dao, D. Rodrigues, G.C. Neves, M.L. Antunes, E. Coiera, D.W. Bates, Do smartphone applications and activity trackers increase physical activity in adults? Systematic review, meta-analysis and metaregression, Br. J. Sports Med. 55 (8) (2021) 422–432, https://doi.org/10.1136/bjsports-2020-102892.
[17] K. Brickwood, G. Watson, J. O'Brien, A.D. Williams, Consumer-based wearable activity trackers increase physical activity participation: systematic review and meta-analysis, JMIR mHealth and uHealth 7 (4) (2019), e11819, https://doi.org/10.2196/11819.
[18] L.A. Cadmus-Bertram, B.H. Marcus, R.E. Patterson, B.A. Parker, B.L. Morey, Randomized trial of a fitbit-based physical activity intervention for women, Am. J. Prev. Med. 49 (3) (2015) 414–418, https://doi.org/10.1016/j.amepre.2015.01.020.
[19] R.T. Larsen, V. Wagner, C.B. Korfitsen, C. Keller, C.B. Juhl, H. Langberg, J. Christensen, Effectiveness of physical activity monitors in adults: systematic review and meta-analysis, BMJ (2022), e68047, https://doi.org/10.1136/bmj-2021-068047.
[20] C. Lynch, S. Bird, N. Lythgo, I. Selva-Raj, Changing the physical activity behavior of adults with fitness trackers: a systematic review and meta-analysis, Am. J. Health Promot. 34 (4) (2020) 418–430, https://doi.org/10.1177/0890117119895204.
[21] D.M. Bravata, C. Smith-Spangler, V. Sundaram, A.L. Gienger, N. Lin, R. Lewis, C.D. Stave, I. Olkin, J.R. Sirard, Using pedometers to increase physical activity and improve health - a systematic review, JAMA, J. Am. Med. Assoc. 298 (19) (2007) 2296–2304, https://doi.org/10.1001/jama.298.19.2296.
[22] A.W. Vaes, A. Cheung, M. Atakhorrami, M.T.J. Groenen, O. Amft, F.M.E. Franssen, E.F.M. Wouters, M.A. Spruit, Effect of 'activity monitor-based' counseling on physical activity and health-related outcomes in patients with chronic diseases: a systematic review and meta-analysis, Ann. Med. 45 (5–6) (2013) 397–412, https://doi.org/10.3109/07853890.2013.810891.
[23] J.B. Wang, L.A. Cadmus-Bertram, L. Natarajan, M.M. White, H. Madanat, J.F. Nichols, G.X. Ayala, J.P. Pierce, Wearable sensor/device (Fitbit one) and sms text-messaging prompts to increase physical activity in overweight and obese adults: a randomized controlled trial, Telemedicine and e-Health 21 (10) (2015) 782–792, https://doi.org/10.1089/tmj.2014.0176.
[24] Y. Kim, A. Lumpkin, M. Lochbaum, S. Stegemeier, K. Kitten, Promoting physical activity using a wearable activity tracker in college students: a cluster randomized controlled trial, J. Sports Sci. 36 (16) (2018) 1889–1896, https://doi.org/10.1080/02640414.2018.1423886.
[25] M.S. Patel, D.A. Asch, K.G. Volpp, Wearable devices as facilitators, not drivers, of health behavior change, JAMA, J. Am. Med. Assoc. 313 (5) (2015) 459–460, https://doi.org/10.1001/jama.2014.14781.
[26] P.W.H. Kwong, G.Y.F. Ng, R.C.K. Chung, S.S.M. Ng, Bilateral transcutaneous electrical nerve stimulation improves lower-limb motor function in subjects with chronic stroke: a randomized controlled trial, J. Am. Heart Assoc. 7 (4) (2018), https://doi.org/10.1161/JAHA.117.007341.
[27] World Health Organization. Global action plan on physical activity 2018–2030: more active people for a healthier world. https://apps.who.int/iris/handle/10665/272722.
[28] World Health Organization, WHO Guidelines on Physical Activity and Sedentary Behaviour, 2020. https://apps.who.int/iris/handle/10665/336656.
[29] O. Kossi, J. Lacroix, B. Ferry, C.S. Batcho, A. Julien-Vergonjanne, S. Mandigout, Reliability of ActiGraph GT3X+placement location in the estimation of energy expenditure during moderate and high-intensity physical activities in young and older adults, J. Sports Sci. 39 (13) (2021) 1489–1496, https://doi.org/10.1080/02640414.2021.1880689.
[30] R.E.D. Matlary, P.A. Holme, H. Glosli, C.S. Rueegg, M. Grydeland, Comparison of free-living physical activity measurements between ActiGraph GT3X-BT and Fitbit Charge 3 in young people with haemophilia, Haemophilia 28 (6) (2022) E172–E180, https://doi.org/10.1111/hae.14624.
[31] C.E. Matthews, Physical activity in the United States measured by accelerometer: comment, Med. Sci. Sports Exerc. 40 (6) (2008) 1188, https://doi.org/10.1249/MSS.0b013e31817057da.
[32] W.J. E, M. Kosinski, S.D. Keller, A 12-item short-form health survey: construction of scales and preliminary tests of reliability and validity, Medical CareMedical Care (1996) 220–233.
[33] J.N. Burdine, M. Felix, A.L. Abel, C.J. Wiltraut, Y.J. Musselman, The SF-12 as a population health measure: an exploratory examination of potential for application, Health Serv. Res. 35 (4) (2000) 885–904.
[34] D. Capurro, K. Cole, M.I. Echavarria, J. Joe, T. Neogi, A.M. Turner, The use of social networking sites for public health practice and research: a systematic review, J. Med. Internet Res. 16 (e793) (2014) 213–226, https://doi.org/10.2196/jmir.2679.
[35] T. Chang, V. Chopra, C. Zhang, S.J. Woolford, The role of social media in online weight management: systematic review, J. Med. Internet Res. 15 (e26211) (2013), https://doi.org/10.2196/jmir.2852.
[36] T. Dorje, G. Zhao, K. Tso, J. Wang, Y. Chen, L. Tsokey, B. Tan, A. Scheer, A. Jacques, Z. Li, R. Wang, C.K. Chow, J. Ge, A. Maiorana, Smartphone and social media-based cardiac rehabilitation and secondary prevention in China (SMART-CR/SP): a parallel-group, single-blind, randomised controlled trial, Lancet Digital Health 1 (7) (2019) E363–E374, https://doi.org/10.1016/S2589-7500(19)30151-7.
[37] J.A. Naslund, K.A. Aschbrenner, L.A. Marsch, G.J. McHugo, S.J. Bartels, Facebook for supporting a lifestyle intervention for people with major depressive disorder, bipolar disorder, and schizophrenia: an exploratory study, Psychiatr. Q. 89 (1) (2018) 81–94, https://doi.org/10.1007/s11126-017-9512-0.
[38] E.S. Wan, A. Kantorowski, D. Homsy, M. Teylan, R. Kadri, C.R. Richardson, D.R. Gagnon, E. Garshick, M.L. Moy, Promoting physical activity in COPD: insights from a randomized trial of a web-based intervention and pedometer use, Respir. Med. 130 (2017) 102–110, https://doi.org/10.1016/j.rmed.2017.07.057.
[39] C. Vandelanotte, M.J. Duncan, C.A. Maher, S. Schoeppe, A.L. Rebar, D.A. Power, C.E. Short, C.M. Doran, M.J. Hayman, S.J. Alley, The effectiveness of a web-based computer-tailored physical activity intervention using Fitbit activity trackers: randomized trial, J. Med. Internet Res. 20 (12) (2018), e11321, https://doi.org/10.2196/11321.

[40] J.B. Wang, L.A. Cadmus-Bertram, L. Natarajan, M.M. White, H. Madanat, J.F. Nichols, G.X. Ayala, J.P. Pierce, Wearable sensor/device (Fitbit one) and sms text-messaging prompts to increase physical activity in overweight and obese adults: a randomized controlled trial, Telemedicine And E-Health 21 (10) (2015) 782–792, https://doi.org/10.1089/tmj.2014.0176.

[41] K. Moon, M. Sobolev, J.M. Kane, Digital and mobile health technology in collaborative behavioral health care: scoping review, Jmir Mental Health 9 (2022), e308102, https://doi.org/10.2196/30810.

[42] H. Junaid, A.J. Bulla, M. Benjamin, T. Wind, D. Nazaruk, Using self-management and social media to increase steps in sedentary college students, Behavior Analysis in Practice 14 (3) (2021) 734–744, https://doi.org/10.1007/s40617-020-00445-8.

[43] K.E. Uhm, J.S. Yoo, S.H. Chung, J.D. Lee, I. Lee, J.I. Kim, S.K. Lee, S.J. Nam, Y.H. Park, J.Y. Lee, J.H. Hwang, Effects of exercise intervention in breast cancer patients: is mobile health (mHealth) with pedometer more effective than conventional program using brochure? Breast Cancer Res. Treat. 161 (3) (2017) 443–452, https://doi.org/10.1007/s10549-016-4065-8.