Changes in Physical Activity Among University Students in Indonesia from Before to During the COVID-19 Pandemic: A Retrospective Cohort Study

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Abstract

University life is an important phase for forming healthy physical activity habits among university students. However, little is known about the change in physical activity level during the COVID-19 pandemic among university students in Indonesia, which has a low stringency index. A retrospective cohort study was conducted among students of Universitas Gadjah Mada (n=153) from October to November 2020, where there were asked to recall their physical activity level and type of physical activity engaged in at four points of time: before the pandemic, early pandemic, Ramadan period, and relaxation period. Then, we conducted three-way mixed analyses of variance followed by Bonferroni's post hoc comparisons tests to compare the mean difference of total moderate-vigorous physical activity with a subject over time and between subgroups in a similar time. Containment measures during the pandemic resulted in a 69.4-minute drop (95% confidence interval: 40.1 to 98.7 minutes, p<.001) of total moderate-vigorous physical activity. While the relaxation of containment measures could restore non-health natural science students' physical activity to the pre-pandemic amount, it did not influence health science students' physical activity. Our findings provide evidence that pandemic situations in a low stringency index country also affected physical activity behavior among university students. More efforts are needed to increase university students' physical activity during the COVID-19 pandemic, particularly among health science students.

Keywords

COVID-19; exercise vital sign questionnaire; pandemics; physical activity; university students

Introduction

The role of physical activity (PA) in non-communicable disease prevention and treatment has been supported by solid evidence (Bull et al., 2020). Accordingly, promoting an active lifestyle has been a global agenda to reduce global physical inactivity levels. While PA promotion should target all ages, the formation of active lifestyle habits among university students could substantially increase public health awareness of the importance of regular exercise. Life while attending a university is a decisive period for habit formation since people start to make more autonomous decisions to adopt a lifestyle into a formed habit for later life phases (Carney et al., 2000).

The prevalence of physical inactivity among university students is alarming. A previous systematic review found that around half of all university students surveyed lacked regular exercise and PA (Keating et al., 2005). Several studies found a higher prevalence of physical inactivity among university students in Indonesia than the global prevalence. In Indonesia, the prevalence of physical inactivity among university students reached 60% (Riskawati et al., 2018; Rusyadi, 2017; Widyasari & Turnip, 2019).

The novel Coronavirus Disease 2019 (COVID-19) pandemic has led to unintended consequences of the 'stay at home' containment measures. These may influence the university students' PA level, which was still low before the pandemic occurred. An early systematic review found an overall reduction of PA among university students globally (López-Valenciano et al., 2021). However, primary studies in the systematic review come from countries with a high stringency index, indicated by the strict enforcement of the 'stay-at-home' policies with social distancing, school closings, and travel restrictions. The trend of PA among university students in a low stringency index has not been studied yet.

After identifying its first case on March 2, 2020, Indonesia's response trailed behind other countries with only a 37.04 to 50.93 stringency index in March-April 2020, while other Asian countries, such as Thailand, had a very high stringency index (Hale et al., 2021). However, universities in Indonesia started to close in this period, making university students among the first population affected by the COVID-19 pandemic (Djalante et al., 2020). Indonesia began tightening containment measures on April 10, 2020, by enacting social restrictions called *Pembatasan Sosial Berskala Besar* [Large Scale Social Restriction] in Jakarta, its capital city, followed by other cities (Djalante et al., 2020). As a result, this policy increased Indonesia's stringency index in April to 71.76 and reached the strictest index in May 2020 (Hale et al., 2021). In addition, in the period of highest stringency index, the Ramadan month in Indonesia was also postulated to influence PA patterns (Lessan et al., 2018). In June 2020, the Indonesian government relaxed its containment measures despite the uncontrolled increase of COVID-19 cases (Sparrow et al., 2020). The Indonesian policy in June 2020 could be hypothesized to have bidirectional effects on the PA level. It could raise opportunities to be physically active. Oppositely, it could also increase the fear of outdoor activities as a barrier for PA (Diamond & Waite, 2021). Since Indonesia's response has a unique timeline, this could result in a unique PA pattern compared to other countries. However, as far as we know, no study has examined the PA trend among university students in Indonesia during the COVID-19 pandemic. Thus, we aimed to conduct a retrospective cohort study to explore this trend.

Methods

Study design

This research was a retrospective study among Universitas Gadjah Mada (UGM) students following the ethical principles of the Declaration of Helsinki. The study was approved by the Medical and Health Research Ethics Committee of the Faculty of Medicine, Public Health, and Nursing UGM (approval number: KE/FK/1308/EC/2020).

The study protocol and manuscript were written according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist for cohort studies (von Elm et al., 2007). First-year students and failure to complete the questionnaire were the exclusion criteria. Convenient sampling was conducted by posting the survey's link on the UGM University Instagram account on October 26, 2020 (first semester of the 2020/2021 academic year) for one month.

Located in Daerah Istimewa Yogyakarta Province, UGM has 59,540 students in the 2020/2021 academic year. While the university had been closed since March 23, 2020, academic activities were resumed on September 14, 2020, through an online learning system (Rektor UGM, 2020). Several students lived in Daerah Istimewa Yogyakarta in their houses with families or in the students' boarding houses, but the rest had returned to their original homes.

A sample size estimation was conducted using G-Power analysis to detect changes within four dependent measurements of time spent in moderate-vigorous physical activity (MVPA) between three groups with repeated measures ANOVA. The G-Power analysis used the following criteria: effect size, alpha level, and power of 0.1, 0.05, and 0.8, respectively (Faul et al., 2007). With these criteria, it was estimated that 123 subjects would be needed. A total sample size of 148 subjects was required to anticipate any missing values with a ratio of 20%.

Outcome measures

The physical activity (PA) levels were measured retrospectively at four time points: before the pandemic (January-February 2020), early pandemic (March-April 2020), during Ramadan (April-May 2020), and current PA amount in the relaxation period (October-November 2020). These measurements were made using a self-administered online form of the Exercise Vital Sign Questionnaire (EVS). The EVS questionnaire has acceptable validity (sensitivity=56-59% and specificity=77-78%) and excellent reliability (intraclass correlation coefficient=0.99) (Golightly et al., 2017; Quiles et al., 2019). Additionally, it was utilized to minimize recall bias because it only consists of two questions about structured PA in each period, which are expected to be easily recalled (Falkner et al., 1999). To recall PA level before the pandemic, during the early pandemic, and during Ramadan, the EVS questionnaire was modified by changing the time frame from the last seven days to the desired time frame. The EVS asked the following two questions: the typical frequency and duration of moderate to strenuous exercise participated in a week during the time frame. For data collection, time spent in MVPA was measured in minutes/week by multiplying the frequency and duration.

The PA patterns were measured by asking participants' frequency in a week of participating in a certain type of PA during the four designated periods using a Likert scale from 1 to 5 for

very rarely to very often. The types of PA asked in the survey were walking, cycling, brisk walking or running, home PA, sports activities, online-guided PA, and relaxation PA. The online survey also contained questions about demographic data which could influence PA level, including the students' level of education, educational field, and gender (Chung et al., 2018; Naim et al., 2016; Rejali & Mostajeran, 2013). There were three categorical variables for the level of current education (diploma, bachelor, and postgraduate degree) and educational field (health science, non-health natural science, and social science).

Statistical analysis

Descriptive analysis was performed using absolute and relative frequencies for gender, level of current education, and educational field. PA category was defined by categorizing time spent in MVPA as meeting the PA guideline ($\geq$ 150 minutes/week) and not meeting the PA guideline (< 150 minutes/week) (World Health Organization, 2010). The Kolmogorov-Smirnov test showed that the time spent in MVPA and the frequency of each kind of PA in each categorical group were not normally distributed. Levene's test and Box's test of equality of covariances also showed that the homogeneity of variances was violated. Results indicated there was no widely accepted non-parametric alternative. With the large sample size, three-way mixed analyses of variance were performed to determine the change of time spent in MVPA and frequency of each kind of PA over the four time points. This approach could also examine the interaction between time, PA category and educational field, level of education or gender on time spent in MVPA, and frequency of each kind of PA (Blanca et al., 2017; Glass et al., 1972; Lumley et al., 2002). The Greenhouse-Geisser correction was applied because Mauchly's tests assessed sphericity's violations. Statistical significance was set for the three-way and two-way interactions at an alpha level of .05 with a 95% confidence interval (CI). After making the Bonferroni adjustment, a simple main effect was accepted at a significance level of .025. All data were analyzed using the SPSS V.25 (IBM, 2017.).

Results

One hundred and sixty-six students agreed to participate in this study, but only 153 subjects completed the survey. As shown in Table 1, most of our samples were female (66.7%), currently studying health science (53.6%), and currently pursuing a bachelor's degree (73.2%). Before the pandemic, more than 60% of our samples did not meet the physical activity (PA) guideline.

Table 1: Baseline Characteristics (n=153)

	n (%)
Gender	
Male	102 (66.7)
Female	51 (33.3)
Current level of education	
Diploma	20 (13.1)
Bachelor	112 (73.2)
Postgraduate	21 (13.7)

	n (%)
Current educational field	
Health science	82 (53.6)
Non-health natural science	45 (29.4)
Social science	26 (17.0)
PA level prior to pandemic	
Met the PA guideline	60 (39.2)
Did not meet the PA guideline	93 (60.8)

Note: PA= physical activity

Time spent in moderate-vigorous physical activity (MVPA) significantly decreased during the lockdown period and returned to an almost equal level to the pre-pandemic in the relaxation period (Figure 1). A total 69.4 minutes reduction (95% CI: 40.1 to 98.7 minutes, p<.001) of time spent in MVPA during the lockdown period resulted from a 57.7 minutes drop (95% CI: 31.8 to 83.6 minutes, p<.001) of total MVPA from before the pandemic (191.043 minutes/week, 95% CI: 171.9 to 210.2 minutes/week) to the early pandemic (133.373 minutes/week, 95% CI: 111.9 to 154.8 minutes/week) then followed by a non-statistically significant 11.7 minutes decline (95% CI: -8.2 to 31.6 minutes, p=.706) of time spent in MVPA from the early pandemic to Ramadhan (121.668 minutes/week, 95% CI: 97.5 to 145.9 minutes/week). A statistically significant 33.5 minutes increase (95% CI: 11.6 to 55.3 minutes, p<.001) of time spent in MVPA was observed between the Ramadan month and the period of containment measures' relaxation (155.157 minutes/week, 95% CI: 126.5 to 183.8 minutes/week). Thus, the PA level during the relaxation period almost reached the same level as the pre-pandemic period and met the PA recommendations (Table 2).

Figure 1: Overall Change in Time Spent in Moderate to Vigorous Physical Activity.

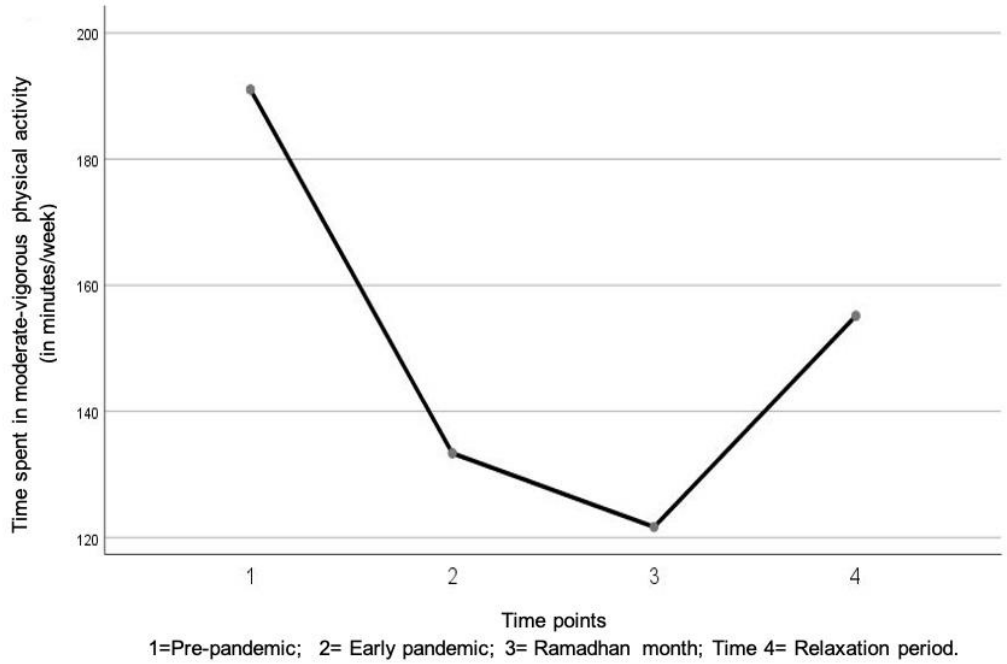


Table 2: Changes in Time spent in Moderate-Vigorous Physical Activity (in minutes/week)

			Time point 1 mean (95% CI)	**Time point 2 mean (95% CI)**	**Time point 3 mean (95% CI)**	**Time point 4 mean (95% CI)**
All subjects (n=153)			191.0 (171.9 to 210.2)	133.4 (111.9 to 154.8)***	121.7 (97.5 to 145.9)	155.2 (126.5 to 183.8)***
By baseline PA before the pandemic	$F_{(2.416, 294.704)}$ = 8.757, p<.001, partial η^2=0.067	Did not meet the PA guideline (n=93)	62.6 (37.8 to 87.50)	61.1 (33.3 to 88.9)	61.5 (30.0 to 92.9)	87.3 (50.1 to 124.5)
		Met the PA guideline (n=60)	319.4 (290.3 to 348.6)[c]	205.6 (172.9 to 238.2)***[c]	181.9 (145.0 to 218.7)[c]	223.0 (179.4 to 266.7) *[c]
By current educational field	$F_{(4.831, 294.704)}$ = 2.423, p= .038, partial η^2=0.038	Health science (n=82)	181.4 (157.5 to 205.2)	120.4 (93.8 to 147.1)***	95.3 (65.2 to 125.5)	115.2 (79.5 to 150.9)
		Non-health natural science (n=45)	160.2 (128.1 to 192.4)	95.3 (59.3 to 131.3)***	108.7 (68.0 to 149.4)	161.3 (113.1 to 209.5)*
		Social science (n=26)	231.5 (190.3 to 272.7)[a]	184.4 (138.3 to 230.5)[a]	160.9 (108.9 to 213.0)	189.0 (127.3 to 250.7)

Note: PA = physical activity, CI = Confidence Interval.

Time point 1=Pre-pandemic; Time point 2= Early pandemic; Time point 3= Ramadhan month; Time point 4= Relaxation period.

**Indicates a significant difference at p<.05 within subjects from the time point in the column on the immediate left.*

***Indicates a significant difference at p<.005 within subjects from the time point in the column on the immediate left.*

****Indicates a significant difference at p<.001 within subjects from the time point in the column on the immediate left.*

[a] Indicates a significant difference at p<.05 between subjects during a similar time point compared to the subgroup in the row directly above.

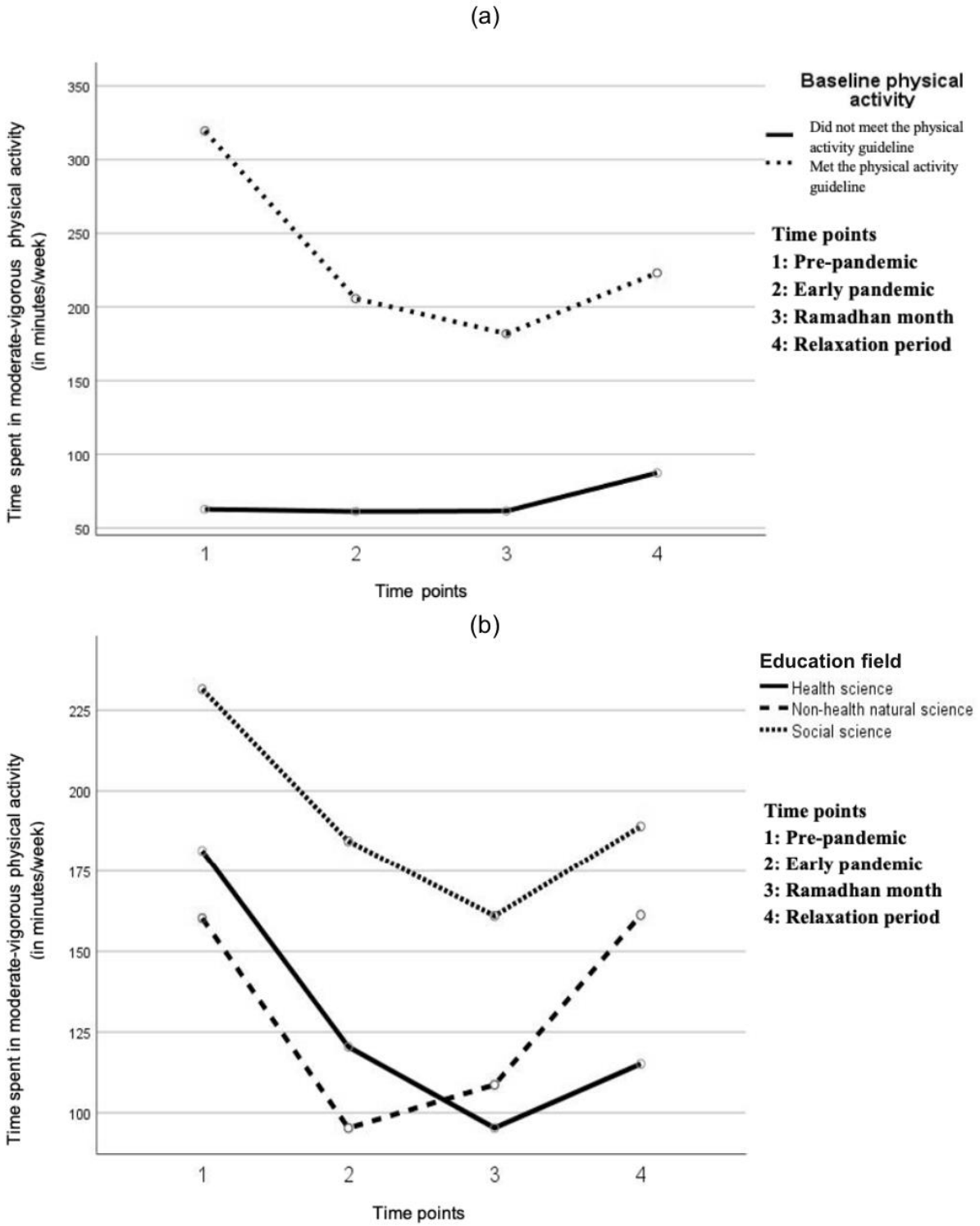
[b] Indicates a significant difference at p<.005 between subjects during a similar time point compared to the subgroup in the row directly above.

[c] Indicates a significant difference at p<.001 between subjects during a similar time point compared to the subgroup in the row directly above.

There were statistically significant main effects of baseline PA level and educational field on time spent in MVPA change, but the main effect of gender on the change of time spent in MVPA over time was not observed (Table 2). While containment measures and the relaxation period did not influence PA amount among social science students, they influenced the changes in time spent in MVPA among health science students and non-health natural science students. There were significant decreases of time spent in MVPA among health science and non-health natural science students from the pre-pandemic period to the early pandemic period with a mean difference of 60.92 minutes (95% CI: 23.81 to 98.03 minutes, p<.001) and 64.97 minutes (95% CI: 36.31 to 93.63 minutes, p<.001), respectively. The situation changes during the relaxation period resulted in a 52.60-minute increase (95% CI: 15.9 to 89.3 minutes, p=.001) in the time spent in MVPA among non-health natural science students from 108.7 (95% CI: 68.0 to 149.4) minutes/week spent in MVPA during the Ramadhan period to 161.3 (95% CI: 113.1 to 209.5) minutes/week spent in MVPA during the relaxation period. However, it did not affect health science students in the same way. It resulted in an overall 66.19-minute decrease (95% CI: 22.89 to 109.51 minutes, p=.001) of time spent in MVPA from pre-pandemic PA amount, and it left their PA amount below the recommended PA level (115.2 minutes/week, 95% CI: 79.5 to 150.9 minutes/week) during the relaxation period.

There were also different changes in time spent in MVPA over time between students who met the PA guideline before the pandemic and those who did not. The pandemic situation did not change the amount of MVPA among students who initially did not meet the PA guideline. On the contrary, a 96.4-minute drop (95% CI: 44.9 to 147.9 minutes, p<.001) of time spent in MVPA was observed among students who met the PA guideline from before the pandemic (319.4 minutes/week, 95% CI: 290.3 to 348.6 minutes/week) to the relaxation period (223.0 minutes/week, 95% CI: 179.4 to 266.7 minutes/week) (Table 2). The drops of time spent on MVPA among students who met the PA guideline resulted from a dramatic reduction from before the pandemic (319.4 minutes/week, 95% CI: 290.3 to 348.6 minutes/week) to the early pandemic (205.6 minutes/week, 95% CI: 172.9 to 238.2 minutes/week) with a mean difference of 113.8 minutes (95% CI: 74.4 to 153.2 minutes, p<.001) and a slight increase of time spent on MVPA from the Ramadan period (181.9 minutes/week, 95% CI: 145.0 to 218.7 minutes/week) to the relaxation period (223.0 minutes/week, 95% CI: 179.4 to 266.7 minutes/week) with a mean difference of 41.2 minutes (95% CI: 7.9 to 74.4 minutes, p=.007). While there were several observed changes in the total MVPA among physically active university students over time, their total MVPA still met the PA recommendation during the four-time points (Figure 2a). Different changes in the total MVPA by the educational field were also observed (Figure 2b).

Figure 2: Changes in Time Spent on Moderate to Vigorous Physical Activity Categorized by (a) Baseline of Physical Activity, and (b) Current Educational Field.



There were significant declines in almost all types of PA from before the pandemic to the relaxation period, except biking (p=1.00), domestic PA (p=1.00), online-guided PA (p=1.00), and mind-body PA (p=.800) (Table 3). Walking was the highest rated type of PA engaged before the pandemic (3.6 points, 95% CI: 3.3 to 3.8 points) but encountered the most significant

drop to the relaxation period (3.1 points, 95% CI: 2.8 to 3.4 points) with a mean difference of 0.732 points (95% CI: 0.432 to 1.032 points, p<.001). This significant drop in walking frequency resulted from consecutive declines from before the pandemic to the early pandemic (3.0 points, 95% CI 2.8 to 3.3 points) with a mean difference of 0.667 points (95% CI: 0.394 to 0.939 points, p<.001), and from the early pandemic to the Ramadan period (2.8 points, 95% CI: 2.5 to 3.0 points) with a mean difference of 0.281 points (95% CI: 0.045 to 0.517, p=.01).

The changes in the frequency of certain types of PA were influenced by gender and the educational field (Table 3). Gender resulted in simple main effects on the change of sport frequency over time (F (2.752,404.487) = 4.207, p=.008, partial η2=0.028). Males provided a higher rate of sport frequency before the pandemic (3.1 points, 95% CI 2.7 to 3.4 points) than females (2.3 points, 95% CI: 2.0 to 2.6). Then, only males rated significant drops in sport frequency from before the pandemic to the early pandemic (2.4 points, 95% CI: 2.0 to 2.8 points) with a mean difference of 0.702 (95% CI 0.2 to 1.2) points and p=.005. Thus, the decline of males' frequency in sports activities in the early pandemic balanced the difference of sport frequency between male and female students (2.2 points, 95% CI: 1.8 to 2.5 points) in this period. While it did not result in an interaction effect on domestic PA, female students rated that they were engaged in more frequent domestic PA than males over time, with a mean difference of 0.727 points (95% CI: 0.3 to 1.2 points, p=.001).

There was an exponential decline in walking, running, and sport frequency among health science students from before the pandemic to the relaxation period with a mean decline of 0.975 (95% CI: 0.5 to 1.5) points, 0.9 (95% CI: 0.4 to 1.4) points, and 0.5 (95% CI: 0.1 to 2.0) points. However, there were no changes in walking, running, and sport among social science students from before the pandemic to the relaxation period. Thus, those different patterns resulted in a significant difference in walking frequency (mean difference=1.1 points, 95% CI: 0.3 to 2.0 points, p=.004), and running frequency (mean difference= 0.9 points, 95% CI: 0.2 to 1.7 points, p=.007) between health science students and social science students in the relaxation period.

Table 3: Changes in Frequency of Engaged Physical Activity by Type

				Time point 1 mean (95% CI)	**Time point 2 mean (95% CI)**	**Time point 3 mean (95% CI)**	**Time point 4 mean (95% CI)**
Walking	All subjects (n=153)			3.6 (3.3 to 3.8)	3.0 (2.8 to 3.3)***	2.8 (2.5 to 3.0)*	3.1 (2.8 to 3.4)
	By current educational field	**$F_{(5.708, 419.552)}$ = 3,029, p=.008, partial η^2=0.040**	Health science (n=82)	3.6 (3.2 to 3.9)	2.9 (2.5 to 3.3)**	2.7 (2.3 to 3.0)	2.6 (2.2 to 3.0)
			Non-health natural science (n=45)	3.6 (3.2 to 3.9)	2.9 (2.4 to 3.3)*	2.5 (2.1 to 2.9)	3.0 (2.6 to 3.4)*
			Social science (n=26)	3.5 (3.1 to 4.0)	3.4 (2.8 to 3.9)	3.2 (2.6 to 3.7)	3.7 (3.1 to 4.3)++
	By gender	$F_{(2.854, 419.552)}$ = 0.709, p=.540, partial η^2=0.005	Female (n=102)	3.8 (3.5 to 4.1)	3.2 (2.8 to 3.5)***	3.0 (2.6 to 3.3)	3.2 (2.8 to 3.5)
			Male (n=51)	3.3 (3.0 to 3.7)	2.9 (2.5 to 3.3)	2.6 (2.2 to 3.0)	3.0 (2.6 to 3.5)
Swimming	All subjects (n=153)			1.6 (1.4 to 1.8)	1.3 (1.2 to 1.4)**	1.3 (1.2 to 1.4)	1.4 (1.2 to 1.5)
	By current educational field	$F_{(4.164, 306.037)}$ = 1.417, p=.226, partial η^2=0.019	Health science (n=82)	1.4 (1.2 to 1.7)	1.3 (1.1 to 1.5)	1.3 (1.1 to 1.5)	1.3 (1.1 to 1.5)
			Non-health natural science (n=45)	1.7 (1.4 to 1.9)	1.2 (1.0 to 1.4)*	1.1 (0.9 to 1.3)	1.2 (1.0 to 1.5)
			Social science (n=26)	1.6 (1.4 to 1.9)	1.4 (1.1 to 1.7)	1.5 (1.2 to 1.8)	1.5 (1.2 to 1.8)
	By gender	$F_{(2.082, 306.037)}$ = 2.036, p=.130, partial η^2=0.014	Female (n=102)	1.6 (1.4 to 1.8)	1.2 (1.1 to 1.4)***	1.3 (1.1 to 1.5)	1.207 (0.094)
			Male (n=51)	1.5 (1.3 to 1.8)	1.4 (1.2 to 1.6)	1.3 (1.1 to 1.6)	1.5 (1.3 to 1.7)
Running	All subjects (n=153)			2.8 (2.6 to 3.1)	2.4 (2.1 to 2.6)***	2.2 (2.0 to 2.4)	2.3(2.0 to 2.5)

				Time point 1 mean (95% CI)	Time point 2 mean (95% CI)	Time point 3 mean (95% CI)	Time point 4 mean (95% CI)
	By current educational field	**$F_{(5.332, 391.907)}$ = 2.788, p=.015, partial η^2=0.037**	Health science (n=82)	2.8 (2.4 to 3.10.175)	2.1 (1.8 to 2.5)**	2.1 (1.8 to 2.5)	1.9 (1.5 to 2.2)
			Non-health natural science (n=45)	2.9 (2.5 to 3.3)	2.2 (1.9 to 2.)***	1.9 (1.5 to 2.2)	2.1 (1.8 to 2.5)
			Social science (n=26)	2.8 (2.3 to 3.3)	2.7 (2.2 to 3.3)	2.6 (2.1 to 3.0)	2.8 (2.3 to 3.3) +
	By gender	$F_{(2.666, 391.907)}$ = 1.277, p=.282, partial η^2=0.009	Female (n=102)	2.7 (2.4 to 3.0)	2.3 (2.0 to 2.6)*	2.0 (1.7 to 2.3)	2.0 (1.7 to 2.3)
			Male (n=51)	2.9 (2.6 to 3.3)	2.5 (2.1 to 2.8)	2.4 (2.0 to 2.7)	2.6(2.2 to 2.9)[a]
Sport	All subjects (n=153)			2.7 (2.4 to 2.9)	2.3 (2.0 to 2.5)***	2.0 (1.8 to 2.2)*	2.2 (2.0 to 2.5)
	By current educational field	**$F_{(5.503, 404.487)}$ = 3.600, p=.002, partial η^2=0.047**	Health science (n=82)	2.4 (2.1 to 2.8)	2.3 (2.0 to 2.7)	2.2 (1.8 to 2.5)	1.9 (1.6 to 2.2)
			Non-health natural science (n=45)	2.8 (2.4 to 3.2)	2.1 (1.7 to 2.5)*	1.7 (1.3 to 2.0)	2.1 (1.7 to 2.5)
			Social science (n=26)	2.8 (2.3 to 3.3)	2.4 (1.8 to 2.9)	2.1 (1.6 to 2.5)	2.6 (2.1 to 3.1)
	By gender	**$F_{(2.752, 404.487)}$ = 4.207, p=.008, partial η^2=0.028**	Female (n=102)	2.3 (2.0 to 2.6)	2.2 (1.8 to 2.5)	2.0 (1.7 to 2.2)	2.0 (1.7 to 2.3)
			Male (n=51)	3.1 (2.7 to 3.4)[b]	2.4 (2.0 to 2.8)*	2.0 (1.6 to 2.3)	2.4 (2.1 to 2.8)
Cycling	All subjects (n=153)			2.0 (1.8 to 2.2)	2.0 (1.8 to 2.2)	1.8 (1.6 to 2.0)	1.9 (1.7 to 2.2)
	By current educational field	**$F_{(5.530, 405.435)}$ = 2.356, p=.034,**	Health science (n=82)	1.8 (1.5 to 2.0)	1.8 (1.6 to 2.1)	1.8 (1.4 to 2.1)	1.6 (1.2 to 1.9)
			Non-health	2.1 (1.8 to 2.4)	1.9 (1.6 to 2.3)	1.6 (1.3 to 2.0)	2.2 (1.8 to 2.6)*

				Time point 1 mean (95% CI)	Time point 2 mean (95% CI)	Time point 3 mean (95% CI)	Time point 4 mean (95% CI)
		partial η^2=0.031	natural science (n=45)				
			Social science (n=26)	2.2 (1.7 to 2.6)	2.3 (1.8 to 2.8)	2.1 (1.6 to 2.5)	2.0 (1.5 to 2.5)
	By gender	$F_{(2.765, 405.435)}$ = 0.302, *p*=.807, partial η^2=0.002	Female (n=102)	2.1 (1.8 to 2.3)	2.1 (1.8 to 2.4)	1.8 (1.6 to 2.1)	2.0 (1.7 to 2.2)
			Male (n=51)	1.9 (1.6 to 2.2)	1.9 (1.6 to 2.2)	1.80 (1.5 to 2.1)	1.9 (1.6 to 2.3)
Domestic	All subjects (n=153)			3.7 (3.5 to 4.0)	3.7 (3.4 to 3.9)	3.5 (3.3 to 3.8)	3.7 (3.4 to 4.0)
	By current educational field	$F_{(5.579, 410.064)}$ = 1.727, *p*=.119, partial η^2=0.023	Health science (n=82)	3.8 (3.6 to 4.1)	3.6 (3.3 to 3.9)	3.5 3.1 to 3.8)	3.4 (3.0 to 3.7)
			Non-health natural science (n=45)	3.7 (3.4 to 4.1)	3.7 (3.3 to 4.1)	3.5 (3.1 to 4.0)	3.7 (3.3 to 4.2)
			Social science (n=26)	3.7 (3.2 to 4.2)	3.8 (3.3 to 4.3)	3.6 (3.0 to 4.1)	4.0 (3.5 to 4.6)
	By gender	$F_{(2.790, 410.064)}$ = 2.309, *p*=.081, partial η^2=0.015	Female (n=102)	4.0 (3.8 to 4.3)	4.1 (3.8 to 4.4)	4.0 (3.7 to 4.3)	4.0 (3.6 to 4.3)
			Male (n=51)	3.4 (3.1 to 3.8)[a]	3.3 (3.0 to 3.7)[b]	3.0 (2.6 to 3.4)[c]	3.4 (3.0 to 3.8)
Online-guided physical activity	All subjects (n=153)			2.2 (2.0 to 2.5)	2.3 (2.0 to 2.5)	2.1 (1.8 to 2.3)	2.2 (1.9 to 2.5)
	By current educational field	$F_{(5.379, 395.359)}$ = 0.274, *p*=.936, partial η^2=0.004	Health science (n=82)	2.1 (1.8 to 2.5)	2.3 (1.9 to 2.6)	2.0 (1.6 to 2.4)	2.1 (1.7 to 2.5)
			Non-health natural science (n=45)	2.2 (1.8 to 2.5)	2.2 (1.8 to 2.6)	2.1 (1.7 to 2.5)	2.2 (1.7 to 2.6)
			Social science	2.4 (1.7 to 2.9)	2.4 (1.9 to 3.0)	2.2 (1.6 to 2.7)	2.4 (1.8 to 3.0)

				Time point 1 mean (95% CI)	Time point 2 mean (95% CI)	Time point 3 mean (95% CI)	Time point 4 mean (95% CI)
			(n=26)				
	By gender	$F_{(2.690, 395.359)}$ = 1.861, *p*=.142, partial η^2=0.012	Female (n=102)	2.6 (2.3 to 2.9)	2.6 (2.2 to 2.9)	2.3 (2.0 to 2.6)	2.4(2.0 to 2.7)
			Male (n=51)	1.8 (1.4 to 2.2)[b]	2.0 (1.6 to 2.4)	1.9 (1.5 to 2.3)	2.0 (1.6 to 2.5)
Mind-body physical activity	All subjects (n=153)			2.0 (1.8 to 2.2)	2.0 (1.8 to 2.3)	1.8 (1.6 to 2.0)	1.9 (1.6 to 2.1)
	By current educational field	$F_{(5.483, 403.008)}$ = 1.792, *p*=.106, partial η^2=0.024	Health science (n=82)	1.6 (1.4 to 1.9)	1.8 (1.5 to 2.2)	1.8 (1.5 to 2.1)	1.7 (1.4 to 2.1)
			Non-health natural science (n=45)	2.0 (1.7 to 2.4)	1.9 (1.6 to 2.3)	1.7 (1.3 to 2.0)	1.9 (1.6 to 2.3)
			Social science (n=26)	2.2 (1.8 to 2.6)	2.4 (1.9 to 2.9)	2.0 (1.5 to 2.5)	2.0 (1.5 to 2.5)
	By gender	$F_{(2.742, 395.359)}$ = 1.227, *p*=.299, partial η^2=0.008	Female (n=102)	2.0 (1.7 to 2.3)	2.1 (1.8 to 2.4)	1.9 (1.6 to 2.2)	1.8 (1.5 to 2.1)
			Male (n=51)	1.9 (1.6 to 2.3)	2.0 (1.6 to 2.4)	1.7 (1.4 to 2.1)	2.0 (1.6 to 2.3)

Note: PA, physical activity, CI, Confidence Interval.

Time point 1=Pre-pandemic; Time point 2= Early pandemic; Time point 3= Ramadhan month; Time point 4= Relaxation period.

**Indicates a significant difference at p<.05 within subjects from the time point in the column on the immediate left.*

*** Indicates a significant difference at p<.005 within subjects from the time point in the column on the immediate left.*

**** Indicates a significant difference at p<.001 within subjects from the time point in the column on the immediate left.*

a Indicates a significant difference at p<.05 between subjects during the similar time point compared to the subgroup in the row directly above.

b Indicates a significant difference at p<.005 between subjects during the similar time point compared to the subgroup in the row directly above.

c Indicates a significant difference at p<.001 between subjects during the similar time point compared to the subgroup in the row directly above.

+ Indicates a significant difference at p<.05 between subjects during a similar time point from the subgroup in two rows above.

++ Indicates a significant difference at p<.05 between subjects during a similar time point from the subgroup in two rows above.

Bold font indicates statistically significant interaction.

Discussion

Our retrospective cohort study examined the changes in physical activity (PA) behavior among Indonesian university students from before the pandemic to several time points during the COVID-19 pandemic. Prior to the pandemic, 60.8% of our respondents lacked PA. Overall, the containment measures in the early pandemic resulted in a 69.4-minute drop in total moderate-vigorous physical activity (MVPA) among university students. The increase of total MVPA during the relaxation period did not adequately restore university students' PA to the pre-pandemic amount. Our study is in accordance with a systematic review that indicated around 28-50% reduction of total MVPA due to the effect of the containment measures on university students' PA level (López-Valenciano et al., 2021). Our study also strengthens a recent study showing a reduced PA amount among medical students in Indonesia (Jahja et al., 2021). In addition, our findings indicated there were no PA level changes during the Ramadan period, similar to the previous studies, which found no changes in PA among healthy young women and people with type 2 diabetes mellitus at that time (Alghamdi et al., 2020; Al-Hourani & Atoum, 2007).

The reductions in PA amount were noticeably observed among university students who met the PA recommendations prior to the pandemic. In this study, the reduction of time spent in MVPA could be explained by the decline in students' frequency of engaging in walking, running, swimming, and sports activities. Since university activities were conducted virtually and sports facilities were closed during the early pandemic, physically active students would have additionally lost some of their opportunities to walk between places to do sports activities.

The previous meta-analysis found that walking was not the popular form of PA among university students (Keating et al., 2005). This study showed that walking got the highest frequency rating among university students, and the containment measures dramatically influenced this type of PA during the pandemic. Parking management implemented in Universitas Gadjah Mada (UGM) could be the reason for our respondents' highly-rated walking behavior before the COVID-19 pandemic. As a result, the students reduced their walking frequency because they did not have to go to the university during the containment period (Petrunoff et al., 2017). Gómez-López et al. (2010) suggested that the availability of nearby sports facilities is the highlighted PA barrier among university students. Thus, the closure of sports facilities in the early pandemic could be one of the possible factors for the significant change in sport frequency over time.

Students who met the PA recommendations prior to the pandemic could maintain their PA level above the minimum PA recommendations despite declining during the lockdown period. It could be assumed that students who were already active before the pandemic were in the maintenance stage since a previous study indicated that the containment measures did not influence students in the maintenance stage during the pandemic (Romero-Blanco et al., 2020). They also increased their PA amount during the relaxation period. However, this increase did not lead them to reach the pre-pandemic PA amount. However, the relaxation period did not influence the PA amount among students who initially did not meet the PA guideline. This finding emphasizes the need for intervention efforts to promote an active lifestyle in this specific population in addition to PA promotion through guidelines released by the university during the pandemic.

In response to the pandemic school closures and travel restrictions, the university released guidelines to encourage domestic, online-guided, and mind-body physical activities which could be conducted at home (Chen et al., 2020). However, it could be assumed that university students' PA behaviors were not significantly influenced by the guidelines since there was no observed rise in those kinds of PA compensating for the decline in walking and sports activities. Lack of social support from friends could be one of the reasons that university students did not replace walking and sports activities with domestic PA (Van Luchene & Delens, 2021). The increasing trend in cycling during the pandemic was also not observed among university students. Jakpat (2020) reported that mainly mid-20s and older people experienced the pandemic bike boom. Most of them purchased their bike during the pandemic and were also social bikers, who tend to do cycling to enhance their social status (Jakpat, 2020). While we do not know the definite reason why the cycling trend did not influence the sampled university students during the pandemic, one of the possible reasons could be the influencing factors of consumptive behavior among university students, which are determined mainly by the product usage and purchasing power rather than maintaining their social status (Enrico et al., 2014).

The change in sports activity frequency was more pronounced in male students than in females. Gender disparity in sport participation could be the reason for the noticeable alteration among male students since males are more motivated to achieve mastery and engage in competition than females (Katewongsa et al., 2021; Molanorouzi et al., 2015; The Lancet Public Health, 2019; Vilhjalmsson & Kristjansdottir, 2003). Thus, male students reacted differently by doing more sports activities when the sports facilities were reopened in the relaxation period. While observing an effect of gender on sport frequency, no observed effect of gender was found on the change of total time spent in MVPA. Our result aligns with a longitudinal study conducted in the United Kingdom (McCarthy et al., 2021). The gender equality in MVPA could be explained by the higher frequency of females spending time in domestic and online-guided PA than males to compensate for the discrepancy in sports activity frequency. Our findings align with a previous study suggesting domestic PA contributed to the significant proportion of self-reported MVPA among females (Bergier et al., 2016; Murphy et al., 2013).

Our study also observed the effects of the educational field on change in time spent in MVPA and frequency of certain types of PA. The findings highlighted the need for increased PA interventions, particularly among health science students during the pandemic. As far as we know, there was no previous study examining the different PA patterns among university students according to students' different fields of study. Our study results are contrary to the observational study conducted on Spanish health science students, which found an increased PA level during the pandemic (Romero-Blanco et al., 2020). Our findings demonstrated that health science students could not maintain their PA level to meet the minimum PA recommendation during the pandemic. While non-health natural science students had different PA trends than social science students, both could meet the PA recommendation during the relaxation period. The difference in the pattern of change in PA among students from different educational fields could be caused by the differences in students' knowledge regarding PA and COVID-19, study environment during the pandemic, or their motivation related to PA and COVID-19 behavior (Spence et al., 2021). It would be interesting to conduct further study to examine determinants of PA among university students in different educational fields. In addition to considering baseline PA and gender, identifying the barriers and facilitators of PA could improve the effectiveness of university interventions in achieving PA maintenance among university students in different fields of study (Michie et al., 2011; Murray et al., 2017).

Our findings could provide important data for designing PA interventions during the reopening of universities in Indonesia at the end of 2021. Similar to the previous study conducted in Shanghai, China (Ding et al., 2021), we also found certain groups that were slow in recovering their initial level of PA. Based on our findings, universities in Indonesia should pay attention to health science students who still have not recovered their previous PA level during the relaxation period. Different patterns in the change of the type of PA during the pandemic could be considered by universities in Indonesia to choose and prioritize interventions and policies for promoting PA when they reopen for in-class learning.

Our study is the first study conducted in a country with a low stringency index to observe the change in PA level among university students in four-time points, including a Ramadan period during the COVID-19 pandemic. Our study has several limitations, including selection bias resulting from convenience sampling, recall bias resulting from the self-administered questionnaire, and the retrospective recall process. In addition, we also recruited samples from only one public university. However, our sample is closely similar to the Higher Education Students statistics in 2021 (female, 51%; bachelor's degree, 76.4%), representing the university student population in Indonesia. Conducting a prospective multicenter study utilizing more objective measurements is recommended to confirm our findings.

Conclusions

Our study found a striking decline in time spent in MVPA during the lockdown period, followed by a slight increase in time spent in MVPA during the relaxation period. The change in PA amount was more pronounced among students who had previously met the PA guideline than those who did not. In addition to the baseline PA level before the pandemic, the change in time spent on MVPA was also influenced by the field of education. While students in other educational fields restored their PA amount during the relaxation period and met the PA guideline, health science students experienced a drop in PA amount from before the pandemic to the relaxation period and did not reach the recommended PA level during the relaxation period. The COVID-19 pandemic also affected the type of PA in which university students engaged. Field of education and gender also influenced the change in the type of PA engaged in. Efforts to promote PA should be intensified for health science students who decreased their PA because of the pandemic and could not restore their PA amount during the relaxation period.

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