FORUM

CHANGES IN PHYSICAL ACTIVITY PATTERNS PRIOR TO AND DURING THE CORONAVIRUS PANDEMIC AND THEIR ASSOCIATION WITH MENTAL WELL-BEING: A MULTI-COUNTRY WEB-BASED STUDY AMONG HIGHER EDUCATION STUDENTS

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ABSTRACT: *Regular physical activity (PA) plays a key role in maintaining physical and mental well-being; and even during a pandemic it is of special importance. This study investigated the changes in patterns of moderate and vigorous PA prior to and during the coronavirus pandemic in a diverse sample of 110 higher education institutes from 26 countries. The association between changes in moderate and vigorous PA with mental well-being was also evaluated. Data for the present study were taken from the COVID–19 International Student Well-being Study (Van de Velde et al. 2021). Stratified convenience sampling design was applied. Data collection took place between April and July, 2020. Mental well-being was assessed using the Center for Epidemiological Studies Depression Scale (CES-D) short form, and moderate and vigorous PA was estimated using a single item. For data analysis, SPSS 26.0 statistical software was used. A total of 88,270 students of higher education aged 23.29 (SD=5.7 years; 72.8 per cent females) completed a web-based questionnaire. Results indicated a global decrease both in moderate ($p < 0.001$) and vigorous PA ($p < 0.001$), with women becoming more active ($p < 0.001$) than their male counterparts during the pandemic. There was a relationship between the change in physical activity patterns and mental well-being. The most unfavourable mental well-being was observed in students who reduced or stopped PA ($p < 0.001$). During the*

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pandemic, PA decreased globally; however, some students, particularly females, took the opportunity to increase their amount of PA. Changes in PA before and prior to the pandemic are associated with mental well-being. Promoting PA during the pandemic is a public health issue.

KEYWORDS: *coronavirus, mental health, pandemic, physical activity, students*

INTRODUCTION

SARS-CoV-2, originating from Wuhan city, China, in Winter 2020 spread rapidly and affected humanity in many ways. The global outbreak was declared a pandemic by the World Health Organization (WHO) on 11 March 2020 (WHO 2020a). The WHO published safety recommendations on how to manage and mitigate the pandemic, and governments introduced preventive measures to keep the spread of the virus under control. Efforts included social distancing, self-isolation, wearing masks in public areas, travel restrictions, and the cessation/closure of non-essential activities and businesses. The rapid change in everyday life and unpredictability about the future induced stress, anxiety, and depression in the general population (Xiong et al. 2020). Even aside from the pandemic, students in higher education are vulnerable to developing psychological distress due to academic stressors (Saleh et al. 2017; Sharp–Theiler 2018). Adding to this condition, educational institutes and cultural and sports facilities were closed, and the former switched to remote education. Students had to renounce their usual student life, move out of dormitories, separate from their friends, leave their social environment and deal with emergency-based remote teaching and learning. A meta-analytical study found evidence of reduced mental well-being in students compared to the pre-pandemic prevalence (Deng et al. 2021). Restrictions such as self-confinement and physical distancing and the closure of training facilities disrupted students' usual physical activity (PA). A series of studies has highlighted the positive association of PA with mental and physical health and well-being (Lahti et al. 2016; Rebar–Taylor 2017; Wiese et al. 2018; Chaturvedi 2021). Maintaining PA even during the pandemic was of special importance. Chastin and collegues' latest systematic review and meta-analysis (Chastin et al. 2021) consistently found that moderate to vigorous physical activity is associated with a lower risk of infectious diseases and mortality, enhances the effectiveness of the immune system, and increases the potency of vaccination. Regular PA can reduce chronic inflammation, and a combination of aerobic and anaerobic PA has an especially beneficial effect (Kasapis–Thompson 2005; Nimmo et al. 2013). The results of studies that examined COVID-19's effect on PA in various

nations were inconclusive. Some studies found a reduced incidence of PA (Busse et al. 2021; Bertrand et al. 2021; Peçanha et al. 2020). Lesser–Nienhuis (2020) measured the PA of Canadian students and found differences between active and inactive individuals. A large proportion of active students improved the amount of PA they did, whereas a great proportion of inactive participants engaged in less PA since the pandemic. Romero-Blanco et al. (2020) found an increase in PA regarding both the amount of time engaged in PA and the number of days on which individuals were physically active in Spain. Pálvölgyi et al. (2020) reported similar results for Hungarian students: less active students reduced, whereas physically more active students increased both the number and duration of training sessions per week during the pandemic period. As this key issue has not yet been clarified, the present research was designed to investigate the changes in patterns of PA prior to and during the COVID-19 pandemic in a diverse sample of 110 higher education institutes from 26 countries, and also to identify whether these changes were reflected in well-being.

METHODOLOGY

Study design, procedure and ethics

The COVID-19 International Student Well-being Study (C19 ISWS) is a project that measures the impact of the coronavirus pandemic in 26 countries with 110 higher-education institutions. This cross-sectional, multi-country, web-based study gathered a wide range of information about student life during the outbreak of coronavirus in Spring 2020, allowing high-priority socially relevant research to be undertaken. Data were collected by the consortium leaders and researchers of the University of Antwerp with the use of a Qualtrics® (Qualtrics, Provo, UT, USA) survey. The detailed protocol, the methodological considerations, the sampling and data collection process have previously been demonstrated (Van de Velde et al. 2021). A total of 123,532 national and international students provided usable data, but we focused on students' physical activity and the mental well-being of those who were citizens of the consortium countries in this study. Invitations to participate in the study were sent via e-mail and/or a student administration system. After a week, a reminder was sent to all participants. Some countries used newsletters, social media, and student-specific platforms. At the beginning of the questionnaire, a brief description of the study was provided and students were informed about the purpose of the survey, its anonymity, and voluntary nature. Students agreed

to take part in the survey by clicking a consent button. The survey was available for two weeks at each higher education institution.

The project was approved by the Ethics Committee for the Social Sciences and Humanities in Antwerp (SHW_20_38) and by the Ethics Committee for the Social Sciences of Ghent University. An institutional review board, rector or vice rector representing each member of the Consortium provided written consent for participation in the project.

Participants

Participants were BSc, MSc, PhD or other registered students of the participating countries, including Belgium (21.8%), Canada (3.0%), Czech Republic (6.7%), Cyprus (0.2%), Denmark (2.4%), Finland (1.2%), France (4.5%), Germany (7.7%), Greece (0.6%), Hungary (2.4%), Iceland (0.5%), Israel (0.4%), Italy (10.3%), the Netherlands (10.6%), Norway (3.2%), Portugal (0.9%), Romania (0.7%), Russia (3.1%), Slovakia (0.7%), South Africa (1.1%), Spain (0.9%), Sweden (1.2%), Switzerland (3.6%), Turkey (10.9%), the United Kingdom (1.3%), and the United States of America (0.2%). Eligible participants were aged 18 years and above, citizens, and officially enrolled in undergraduate, master's, and doctoral programmes in the consortium countries. No exclusion criteria were defined.

Outcome Measures

Sociodemographic characteristics

Sociodemographic characteristics included information on gender, age, relationship status, parents' educational level, current educational program, and funding of studies.

Mental well-being

For the concept of mental well-being, we relied on the WHO definition "Good mental health and well-being is a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community." (WHO 2021: 1). For evaluating the students' well-being,

the Center for Epidemiological Studies Depression Scale (CES-D) short form originally published by Radloff (1977) was used. Its reliability and validity have been confirmed across a wide selection of European countries (Van de Velde et al. 2010). In this study sample, the country-specific Cronbach's alphas ranged between 0.85 and 0.90 (Van de Velde et al. 2020). The two endpoints of the continuum of mental health range from well-being to experiencing depressive symptoms (Siddaway et al. 2017). CES-D includes eight items ("you felt depressed," "you felt everything you did was an effort," "your sleep was restless," "you were happy," "you felt lonely," "you enjoyed life," "you felt sad," "you could not get going") rated on a four-point scale from "rarely or none of the time" (0) to "most or all of the time" (3). Two items ("you were happy" and "you enjoyed life") were reverse-scored. The answers were summed (max. 24) and the lower scores indicated better well-being, whereas higher scores indicated the presence of more depressive symptomatology (Siddaway et al. 2017).

Physical activity (PA)

Based on Caspersen' formulation (Caspersen et al. 1985) and the WHO addendum, "Physical activity (PA) is any bodily movement produced by skeletal muscles that requires energy expenditure. PA refers to all movement including during leisure time, for transport to get to and from places, or as part of a person's work. Both moderate- and vigorous-intensity physical activity improve health." (WHO 2018: 14).

Moderate and vigorous PA in this study was measured using two single items. "On average, how often did you perform moderate physical activities like easy cycling or walking for at least 30 minutes?" and "On average, how often did you perform vigorous physical activities like lifting weights, running, aerobics, or fast cycling for at least 30 minutes?" Respondents could choose the following categories: "(almost) never," "less than once a week," "once a week," "more than once a week" and "(almost) daily." Students indicated the frequency prior to and during the COVID-19 outbreak.

Statistical analysis

For the statistical analysis SPSS version 26.0 was used (IBM Corp., Armonk, NY, US). Statistical significance was defined as $p < 0.05$. Descriptive statistics included mean and standard deviation, percentages, and frequency. The Wilcoxon signed-rank test indicated changes in moderate and vigorous PA.

Differences in mental well-being based on changes in PA were analysed using ANOVA methods. A χ^2 test was performed to examine the differences in PA change by gender. Student's t-tests were used for comparing mental well-being between males and females. Multivariable regression analysis was conducted to determine whether moderate and vigorous PA affects mental well-being.

RESULTS

Participants

A total of 109,730 respondents who were citizens of the consortium countries provided usable answers to the questions. Due to incomplete information on mental well-being and/or PA, 21,460 (19.56%) were discarded. The mean age of respondents was 23.29 (SD=5.70 years). Student participants studied in different fields of education: humanities and arts (10.9%), social and behavioural sciences, business and law (40.3%), education (7.5%), engineering, manufacturing and construction (7.1%), agriculture (2.4%), health and welfare (23.4%), personal services (1.9%), other (3.2%), and missing data (3.2%). The socio-demographic characteristics of participants are presented in Table 1.

Table 1. *Socio-demographic characteristics of the study participants (N=88,270)*

Socio-demographic characteristics		Frequency (%)
Gender	Male	26.5
	Female	72.8
	Other	0.7
Age group	18–20 years old	30.8
	21–24 years old	46.7
	25 years and older	22.5
Relationship status	Single	47.0
	In relationship	48.1
	Other	4.9
Mother's education	Less than secondary	16.8
	Secondary	33.9
	Higher education	47.5
	No information	1.8

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Socio-demographic characteristics		Frequency (%)
Father's education		
Less than secondary		17.3
	Secondary	33.4
	Higher education	45.8
	No information	3.5
Current educational program	Bachelor	65.8
	Master	22.1
	Doctoral	3.3
	Other	6.8
	No information	2.1
Funding of studies	Parents	38.1
	Self-supported	14.2
	Scholarship	8.9
	Bank loan	7.1
	Other or not relevant	31.6

Physical activity

Overall, a significant decrease in physical activity could be detected. This occurred with both moderate ($Z = -63.367$; $p < 0.001$) and vigorous physical activity ($Z = -24.819$; $p < 0.001$) (Figure 1 and Figure 2).

Figure 1. *Change in moderate PA prior to and during the coronavirus outbreak (%)*

Note: Z = –63.367; p < 0.001.

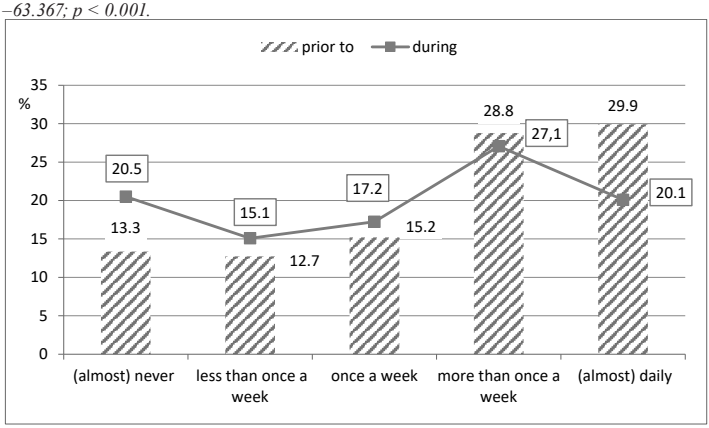
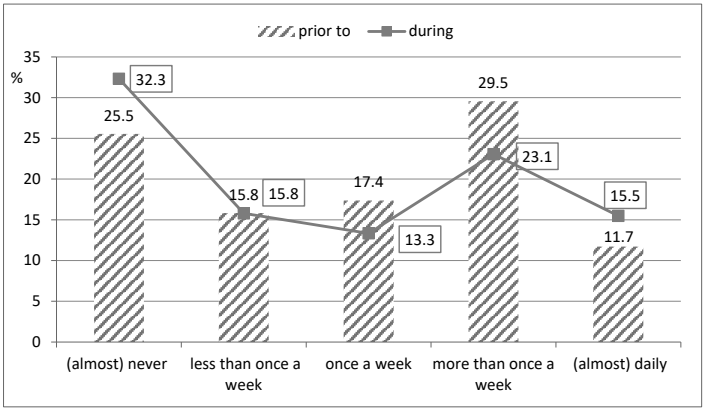


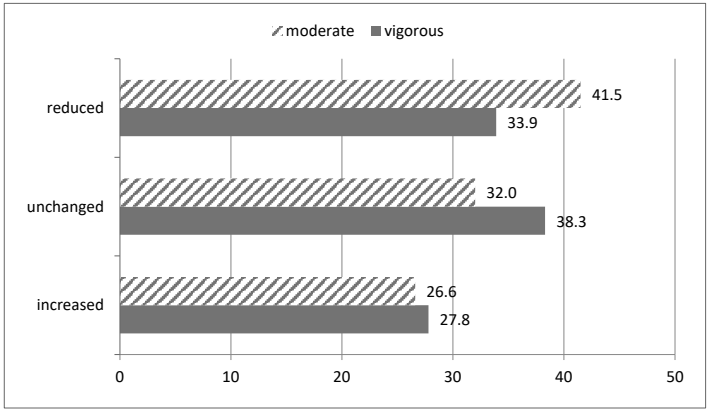
Figure 2. *Change in vigorous PA prior to and during the coronavirus outbreak (%)*



Note: Z = –24.819; p < 0.001

Regarding moderate PA, 41.5% of students reduced, 32.0% did not change, and 26.6% increased the frequency of PA during the outbreak of COVID-19. The proportion of students who increased the amount of vigorous PA was 27.8%, 38.3% recorded no change, and 33.9% reduced it (Figure 3).

Figure 3. *Proportion of change in moderate and vigorous PA prior to and during the coronavirus outbreak (%)*



There were gender differences in both types of PA (Moderate: $\chi^2 = 779{,}00$, $df = 2$; $p < 0.001$, Vigorous: $\chi^2 = 502{,}23$, $df = 2$; $p < 0.001$), with women becoming more active than their male counterparts. Changes in PA by gender are displayed in crosstabulation (Table 2).

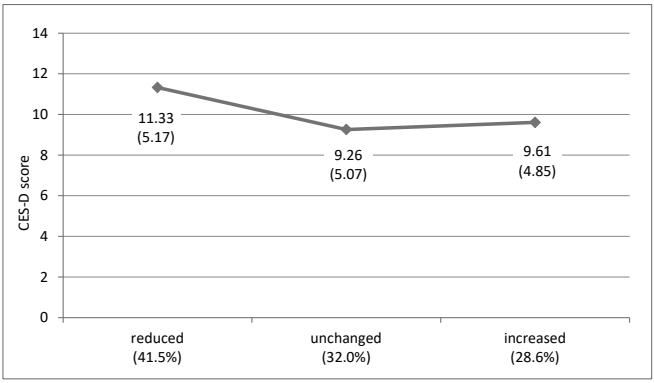
Table 2. *Crosstabulation of PA changes by gender (%)*

Within gender	Unchanged	Reduced	Increased	Total
Moderate PA ($\chi^2 = 779.00$, df = 2; p < 0.001)				
Men	37.1	42.3	20.6	100.0
Women	29.9	40.8	29.3	100.0
Vigorous PA ($\chi^2 = 502.23$, df = 2; p < 0.001)				
Men	40.5	37.2	22.3	100.0
Women	37.5	32.7	29.9	100.0

Mental well-being

The overall mental well-being score was 10.21 (SD = 5.14), and women scored one point more on average (10.46; SD = 5.12) than men (9.46; SD = 5.12, $p < 0.001$). We examined whether there is a relationship between mental well-being and moderate and vigorous physical activity. The regression analysis clarified that both moderate ($\beta = -0.17$, $t = -44{,}25$; $p < 0.001$) and vigorous PA ($\beta = -0.11$, $t = -29{,}10$; $p < 0.001$) affected mental well-being.

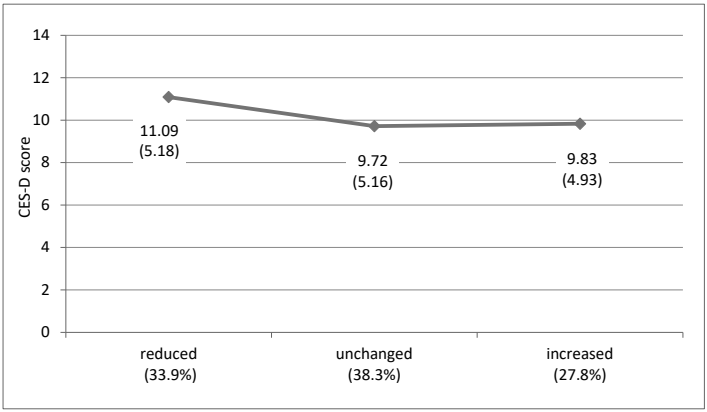
Figure 4. *Relationship between moderate physical activity change and mental well-being (Mean and SD)*



Note: N = 88270; F = 1562.97; p <0 .001.

We found significant differences between changes in physical activity and mental well-being. Students who reduced the frequency of PA reported poorer mental well-being ($p < 0.001$) than students who did not change or increase PA both at moderate and vigorous levels (Figure 4 and Figure 5).

Figure 5. *Relationship between vigorous physical activity change and mental well-being measured on the Center for Epidemiological Studies Depression Scale (CES-D) short form (Mean and SD)*



Note: N = 88270; F = 667.88; p < 0.001.

DISCUSSION

In this study, a large and diverse sample of higher education students from 26 countries was analysed to reveal whether there was a change in PA frequency before and after the outbreak of the COVID-19 pandemic. Due to the closure of higher institutions and sports facilities, and the restrictions implemented by governments, it seems that a notable proportion of students reduced the amount of PA they engaged in, especially moderate PA. A lack of PA has been identified for children (Berasategi Sancho et al. 2021) and adults (Stanton et al. 2020) during the coronavirus pandemic. The problem with a low level of PA is manifold; it is associated with reduced mental and physical health (Harris 2018; Bertheussen et al. 2011), an increased risk of cardiovascular disease and mortality (Lavie et al. 2015), and inactivity is one of the leading factors for non-communicable-disease-related mortality (Lee et al. 2012; WHO 2020b).

Regular PA is of elevated importance during a pandemic due to its anti-inflammatory effects (Ertek–Cicero 2012) and enhancement of the immune system (Gomes–Florida-James 2016). The restrictions appear to have had a largely negative impact on students' physical activity rates, with reductions noted for 34–41% of the students for both vigorous and moderate physical activity. However, on the other hand, it allowed some to increase vigorous PA. A smaller proportion of students (~4%) took advantage of their free time due to remote education and increased the amount of vigorous physical activity. Female students, interestingly, took more advantage of the opportunity to improve their previous activity, in accordance with Gallè et al.'s study (2020) on Italian students. A potential explanation might be that home confinement promotes weight gain. Female self-esteem is strongly influenced by body satisfaction, which is associated with thinness. Female students driven by fear of weight gain were more active than males. This hypothesis needs further investigation.

In line with findings by Faulkner et al. (2021) and Meyer et al. (2020), in this study we also found a close relationship between changes in physical activity patterns and mental well-being. The most unfavourable mental well-being score was observed for students who reduced or stopped PA. Although the CES-D scores had a floor and ceiling effect, it should be mentioned that mental well-being, in general, was not as problematic in this diverse sample of higher education students (M = ~10 out of 24). The severity of a coronavirus infection is strongly linked to an individual's health status before infection. As a result, regular physical activity can protect against the consequences of viral infection (Ametta et al. 2020).

Limitations of this study include sampling bias due to the stratified convenience sampling design which might compromise generalisability. The large variation in the sample size of the countries included in the survey was due to the voluntary nature of participation, and participants retrospectively rating their PA frequency prior to the outbreak of the pandemic make data prone to recall bias. The cross-sectional design precludes making causal associations among variables. Mental well-being was measured only during the outbreak of the pandemic. PA was measured with a single item, although when objective measures or lengthy self-reporting measures are not practical a single-item assessment is an alternate means of collecting information regarding PA (Milton et al. 2011; O'Halloran et al. 2020). Despite these shortcomings, these findings highlight the protective role of physical activity in maintaining mental well-being in unexpected situations such as a coronavirus pandemic.

CONCLUSION

In conclusion, students in higher education globally decreased their PA during the COVID-19 pandemic. A significant proportion of students encountered barriers to maintaining their previous habits of PA during self-confinement, although one group of students made use of the opportunity to increase the amount of PA, especially female students. The drop in PA is associated with a deterioration in mental well-being. Although the data do not indicate a very serious situation 6-8 weeks after the outbreak of the virus, this trend to engagement in regular PA and its association with mental well-being highlights the need to promote physical activity during lockdowns.

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