

Physical activity and depression during the COVID-19 pandemic in Nigeria: does age and gender make a difference?

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Abstract

Background There is overwhelming evidence indicating that depression may be reduced by physical activity (PA), but studies in lower- and middle-income countries and those that involved data at higher physical activity doses were underrepresented. The current study investigated the associations between PA levels (vigorous, moderate, walking and sitting) and depression and tested whether age and gender moderate the link between PA and depression during the COVID-19 pandemic.

Method The participants were 857 adults (51.0% women; aged 18–69, mean age = 29.71, $SD = 10.84$ years) who completed an online survey as part of the General Health, Speech and Physical Activity Relationship Assessment Study in Nigeria. Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ) short form, while depression was measured using the Patient Health Questionnaire (PHQ-9).

Results The results of the Hayes PROCESS macro indicated that those who engaged in vigorous PA reported lower levels of depression ($B = -0.02, p < 0.01$). Sitting ($B = -0.00, p = 0.050$), walking ($B = 0.00, p = 0.054$) and moderate ($B = 0.00, p = 0.064$) PA were not significantly associated with depressive symptoms. Older participants reported fewer symptoms of depression ($B = 0.11, p < .001$). Women had higher depressive symptoms than men ($B = 0.91, p < 0.05$). The interactions of age and gender with PA levels were not significant, which showed that age and gender did not moderate the relationships of PA and depression.

Conclusion Engagement in vigorous PA may be helpful to reduce levels of depression and improve mental health in the general population.

Keywords Age · COVID-19 · Depression · Gender · Public mental health

1 Introduction

In most parts of the world, the outbreak of the highly infectious coronavirus (COVID-19) has generated serious public health and economic crises [1, 2]. COVID-19 was declared a pandemic on March 11, 2020 after more than 118,319 confirmed cases and 4292 deaths had been recorded from various continents of the world [2]. Shortly before this declaration, Nigeria, the most populous country in Africa, recorded her first case on February 27, 2020 [3]. By October

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24, 2020, Nigeria had 61,930 confirmed cases with 1129 deaths [38] (NCDC COVID-19 NIGERIA 2020) and became the first West African country with a confirmed case of novel COVID-19 [4].

Following the burden caused globally by COVID-19, such as the high spread and mortality rate of the virus, in addition to the inadequate mental health care system in Nigeria, inhabitants experience fear, anxiety and depression [5, 6]. Although depression remained a challenging issue among Nigerians before the onset of COVID-19, evidences abound that the pandemic caused a surge in depression cases [6–8]. The potential adverse mental health outcomes of the COVID-19 pandemic in Nigeria may be attributed to the disease's widespread fear and stigma, disruption of healthcare access during lockdowns, economic impact, overburdened and disparate healthcare systems, and the nation's already high prevalence of mental health disorders [9–12]. It is essential to comprehend the scope and nature of COVID-19's psychological effects in Nigeria to design the necessary preventive treatments to fend off or lessen the negative effects.

An increase in sitting time and sedentariness may increase the likelihood of developing depression, and may reduce the quality of life of even a healthy adult when the lockdown is relaxed [13]. Interestingly, regular participation in physical activity and exercise (walking, jogging, cycling, and dancing) is known to have many health benefits, especially during the COVID-19 lockdown [14]. It is recommended that adults undertake at least 30 min of moderate physical activity every day or at least 15 min of vigorous physical activity every day for at least 5 days a week [15].

A recent systematic review and meta-analysis has demonstrated that regular PA is associated with improved cognitive functioning, better overall mental health and enhanced well-being [16]. The beneficial association reported for engaging in PA and significantly low depression rates suggests substantial mental health benefits from being physically active, even at levels below the public health recommendations [16]. Physical activity may also have other potential positive effects that help prevent depression, such as improved pulmonary function and cardiovascular and aerobic fitness, stronger immunity, enhanced muscle strength, higher bone density, stress reduction, and better emotional stability [17]. It was observed that limited studies have been conducted in lower- and middle-income countries on the association between PA and mental health outcomes [18]. Given that studies on PA and depression in sub-Saharan African countries (e.g., Nigeria) are largely unexplored and data are underrepresented, the first aim of the present study is to examine the contributions of PA to depression among Nigerian adults during the COVID-19 pandemic.

Furthermore, a recent study reported that there are differences in the impact of PA on depression on account of activity level among Chinese adults [13]. Specifically, lower depression scores were associated with moderate PA but not vigorous PA and walking. Except for a few studies [13], the majority of studies on PA and depression have mostly considered the amount of PA (duration) and neglected other important characteristics of PA, such as frequency and intensity. This gap has been noted in the existing literature [13, 19, 20]. Therefore, the present study found it worthwhile to consider intensity differentiation in PA (that is, vigorous PA, moderate PA, and walking as well as time spent sitting on a weekday) and their impacts on depression in a sub-Saharan African sample.

Two sociodemographic characteristics that have received reasonable attention with respect to mental health during the pandemic are age and gender [21]. Evidences of age and gender differences in depression and anxiety as well as PA also exists in the literature. Older age was associated with less depression in Canada [22], China [23, 24], Japan [25], the United States [21, 25], and the United Kingdom [26]. Women were more likely than men to report symptoms of depression, as shown by studies in Australia [27], Europe [28], and China [23]. In a sample of Nigerian students, a study compared both genders, especially with regard to challenging situations such as COVID-19, and observed that females had more depression than males [29]. Most of the studies on age and gender differences in depression draw on data collected from developed countries and thus may underestimate the potential effects of the pandemic on mental health. The existing study in Nigeria obtained data from only medical students from three universities in southwestern Nigeria within the first six months of the first reported case of the COVID-19 pandemic [29]. Studies on a wider range of adults conducted at later stages of the pandemic in Nigeria are important. As a second objective, therefore, we examine age and gender differences in depression using data from the sub-Saharan African setting collected approximately one year into the COVID-19 pandemic. This is necessary to build a collective body of knowledge.

Studies have also shown that gender and age can be moderators of associations between several outcomes [30–32]. In some related studies, PA level was found to differentially influence the fear of COVID-19 depending on one's gender [33], and PA promoted wellbeing, especially in middle-aged adults compared to older adults [13]. Two meta-analyses tested the moderating effect of gender and age on the effectiveness of exercise interventions on depressive symptoms and found no such effect [34, 35]. However, moderator analysis in meta-analyses has methodological problems and limited power. Therefore, no firm conclusions can be drawn from the results [16, 36]. It is suggested the investigation of possible gender and age (or geographical subgroups) differences in the role of PA on mental health. Investigating the

impact of PA on the mental health of African populations and whether gender and age moderate these effects is urgent and key to developing targeted and effective strategies to address the challenge. As a second study objective, we focus on whether one's age and gender might moderate the relationship between PA and depression during the pandemic in Nigeria. We hypothesized the following: (1) PA will be associated with reduced levels of depression. (2) Older adults will report fewer symptoms of depression. (3) Women will report higher symptoms of depression. (4) Age will moderate the link between PA and depression such that PA will be strongly associated with less depression for older adults than for younger adults. (5) Gender will moderate the link between PA and depression such that PA will be strongly associated with less depression for men than for women.

2 Methods

2.1 Participants and procedure

Participants were 857 adults who took part in an international project that sought to understand how physical activity and nonlinguistic elements of speech are associated with anxiety, depression and coping during the COVID-19 pandemic. Ethical approval for this study was obtained from the Health Research Ethics Committee of the University of Nigeria Teaching Hospital Ituku-Ozalla (NHREC/05/01/2008B-FWA00002458-IRB00002323). The study was part of an international project that sought to understand how physical activity and non-linguistic elements of speech are associated with anxiety, depression and coping during the COVID 19 pandemic. The questionnaire package for the data collection was in English. The web-based platform Surveylex, which can be taken at any time through a URL link across devices such as laptops or smart phones, was used for data collection. The Nigerian research team employed the help of research assistants who were trained in the use of the Surveylex web-based survey developed by Sonde Health for data collection. To ensure that these assistants understood the use of Surveylex, they were asked to participate in the test run of the software, which was not part of the data collected for the analyses. Thereafter, participants were recruited from the community through social media platforms, especially WhatsApp, and through direct email invitations to prospective respondents, who in turn shared with their contacts. A click on Nigeria with her flag takes them to all the information about the research as well as informed consent form and right to participate. Participants needed to be 18 years of age or older, have access to the internet and voluntarily agree to participate in the study. They were informed of the confidentiality of the study and that their participation was anonymous. However, they were asked to include their phone numbers where it was required for an instant airtime reward upon completion and submission of the survey. Data collection took place between September 2021 and November 2022.

2.2 Measures

Participants completed a proforma that assessed their demographic characteristics as well as depression and physical activity measures using the Patient Health Questionnaire 9 (PHQ-9) and the International Physical Activity Questionnaire short form (IPAQ-SF), respectively.

2.3 Patient health questionnaire-9 (PHQ-9)

The PHQ-9 [37] assesses the occurrence of depressive symptoms over the past two weeks and monitors their severity. In other words, it rates the frequency of the symptoms that are factors in the scoring severity index. Each item is scored on a 4-point response scale ranging from 0 = "not at all" to 3 = "nearly every day". The total score ranges from 0 to 27, with scores of 5–9 indicating 'mild depression', 10–14 'moderate depression', 15–19 'moderately severe depression' and ≥ 20 'severe depression' [38]. Studies in other populations reported Cronbach's alphas of 0.85, 0.85 and 0.80, respectively [39–41], while the present data set yielded a Cronbach's alpha of 0.82.

2.4 International physical activity questionnaire (IPAQ-SF)

The IPAQ-SF [42] is a self-report measure of physical activity (PA) developed as an instrument for cross-national assessment and monitoring of physical activity and inactivity. It is a seven (7)-item questionnaire that collects information

on the number of days and time spent on physical activity in 'vigorous physical activities' 'moderate physical activities' and walking for at least ten (10) minutes at a time in the last seven (7) days as well as time spent sitting on a weekday. Respondents were asked to indicate the number of days per week, hours and minutes per day they spent doing PA within the categories. They may also indicate that they are not sure of the activity undertaken. These activity categories may be treated separately to obtain the specific activity: low activity, moderate or high activity level patterns that could be interpreted as below, meeting and exceeding recommendations, respectively [43]. The IPAQ-SF has been used in a Nigerian sample [44]. In the present study, we obtained a Cronbach's alpha of .84.

2.5 Statistical analysis

We present results of demographic characteristics using mean (*SD*) and percentages. Normality tests indicated the skewness and kurtosis for the measures: -0.14 and -0.28 for PHQ and 0.02 and 1.05 for IPAQ, which showed that the data were normally distributed. Pearson's correlation (*r*) was conducted to establish the relationships of the demographic factors, physical activity and depression. Hayes' regression-based PROCESS macro [45] for SPSS was used to predict each mental health outcome based on age, gender, and PA. The Hayes PROCESS macro is a logistic regression path analysis modeling tool used for estimating two-way interactions in moderation models along with simple slopes and regions of significance for probing interactions. The robust PROCESS macro is suitable for measuring the moderation or interactive effects [45], and it is preferable to ordinary regression analysis in moderation research. PROCESS conducts regression-based path analysis and creates product terms to analyze interaction effects, automatically centering the predictor variables prior to analysis. It is currently the most acceptable method in tests of moderation in behavioural sciences [30, 31]. If a product term (that is, interaction of predictor and moderator) was significant, it would mean that the association between the relationship variable (e.g., PA) and the criterion variable (e.g., depression) was either stronger or weaker in the presence of the moderator(s) (e.g., gender). The set value for all significance was $p < 0.05$.

3 Results

3.1 Sample characteristics

Table 1 shows that there were males and females were almost equally represented. Most of the participants have not been vaccinated for COVID-19. The mean age of study participants was 29.71 ± 10.84 years and most of them have been vaccinated for COVID-19 (75.5%). Their health status was mostly good to excellent (71.2%), and majority of them had normal weight. There were also more bachelor's degree holders in the sample (45.2%). They mostly reside in major towns and small towns. There were significantly more students in the sample (92.6%).

3.2 Correlations of demographic factors, physical activity and depression

In Table 2, it was found that age was positively associated with not being vaccinated and but negatively correlated with depression. The male gender was associated with being tested for COVID-19, high engagement in vigorous moderate physical activities, and walking, while the female gender was more associated with depression. Being tested for COVID-19 positively associated with being vaccinated and vigorous physical activity. Being vaccinated associated positively with higher level of education. Higher level of education associated negatively with vigorous and moderate physical activity, and depression, but associated positively with sitting time. Vigorous physical activity correlated positively with moderate physical activity and walking, but was associated negatively with depression. Moderate physical activity was associated positively with walking and sitting time, but negatively with depression. Walking associated positively with sitting time, but negatively with depression. Sitting time correlated negatively with depression.

3.3 Moderation analysis on the association between depression and vigorous physical activity, with age and gender as moderators

Results in Table 3 show that vigorous physical activity was negatively associated with depression ($B = -0.02, p < 0.01$). *B* showed that each unit increase in vigorous physical activity was associated with a -0.02 decrease in depression. Age was negatively associated with depression ($B = -0.11, p < 0.001$). *B* showed that each unit increase in age was

Table 1 Demographic characteristics of participants and mean scores on study variables ($N=857$)

Demographic variable	Description	Statistic
Age years, M (SD)	Range = 18–69 years	29.71 (10.84)
Gender, n (%)	Male	420 (49.0)
	Female	437 (51.0)
COVID-19 Vaccination, n (%)	Vaccinated	647 (75.5)
	Not vaccinated	210 (24.5)
Health status, n (%)	Poor	4 (0.5)
	Fair	44 (5.1)
	Don't know	6 (0.7)
	Good	193 (22.5)
	Very good	335 (39.1)
	Excellent	275 (32.1)
Residence, n (%)	Small village	36 (4.2)
	Major town	615 (71.8)
	Country capital	1 (0.1)
	Major village	27 (3.2)
	Small town	178 (20.8)
	Employment status, n (%)	Unemployed
Student		413 (48.2)
Formal employment		181 (21.1)
Sell employed/business		134 (15.6)
Consultancy		26 (3.0)
Homemaker		8 (0.9)
Retired		7 (0.8)
Education, n (%)	Secondary School	244 (28.5)
	Technical/vocational/college	115 (13.4)
	Bachelor's Degree	387 (45.2)
	Master's Degree	70 (8.2)
	PhD	41 (4.8)
Weight	Underweight	23 (2.7)
	Normal weight	760 (88.86)
	Overweight	70 (8.2)
	Obese	4 (0.5)
COVID test	0–3	.17 (.51)
Vigorous physical activity, M(SD)	Range = 0–11200	850.97 (1640.70)
Moderate physical activity, M(SD)	Range = -420–5600	435.53 (848.59)
Walking for 10 min, M(SD)	Range = 0–4620	742.37 (1005.32)
Sitting, M(SD)	Range = 0–1000	489.04 (361.63)
Depression, M(SD)	Range = 0–27	5.54 (6.38)

N number, M mean, SD standard deviation

associated with a -0.11 decrease in depression. The interaction of vigorous physical activity and age was not significant ($B=0.00$), indicating that age did not moderate the relationship between vigorous physical activity and depression. Gender was positively associated with depression ($B=0.94$, $p<0.05$), indicating that being female was associated with an increase in depression. The interaction of vigorous physical activity and gender was not significant ($B=0.00$), indicating that gender did not moderate the relationship between vigorous physical activity and depression. The R^2 of .05 for the model indicated that 5% of the variance in depression was explained by all the variables, $F(5, 851)=9.71$.

Table 2 Pearson’s correlations of demographic factors, physical activity and depression

Variables	1	2	3	4	5	6	7	8	9
1 Age	–								
2 Gender	0.04	–							
3 COVID Test	– 0.01	– 0.07*	–						
4 COVID Vaccine	0.11**	– 0.06	0.30***	–					
5 Education	0.49***	– 0.03	– 0.03	0.11**	–				
6 Vigorous Physical Activity	– 0.03	– 0.20***	0.10**	0.05	– 0.07*	–			
7 Moderate Physical Activity	– 0.03	– 0.13***	0.02	0.02	– 0.10**	0.61***	–		
8 Walking for 10 min	0.02	– 0.09*	– 0.00	– 0.04	– 0.02	0.30***	0.45***	–	
9 Sitting time	0.07	– 0.06	– 0.02	0.01	0.09**	0.04	0.09**	0.13***	–
10 Depression	– 0.17***	0.10**	0.02	– 0.03	– 0.13***	– 0.13***	– 0.08*	– 0.08*	– 0.08*

* $p < .05$; ** $p < .01$; *** $p < .001$; Gender (coded 0 = males, 1 = females), COVID test = number of times tested; COVID Vaccine (1 = No, 2 = Yes)

Table 3 The Hayes PROCESS Macro results for predicting depression by vigorous physical activity, with age and gender as moderators

Variables	B	t	p	95%CI	R ²	F
Vigorous physical activity (VP)	– 0.02	– 3.37	0.001	[– 0.04, – 0.01]	0.05	9.71 (5, 851)***
Age	– 0.11	– 5.29	0.000	[– 0.15, – 0.07]		
VP * age	0.00	– 0.65	0.517	[0.00, 0.00]		
Gender	0.94	2.29	0.022	[0.14, 1.75]		
VP * Gender	0.00	– 0.50	0.617	[– 0.00, 0.00]		

CI Confidence interval; * $p < .05$; *** $p < .001$; **Gender (coded 0 = males, 1 = females)**

Table 4 The Hayes PROCESS Macro results for predicting depression by moderate physical activity, with age and gender as moderators

Variables	B	t	p	95%CI	R ²	F
Moderate Physical Activity (MP)	0.00	– 1.86	0.064	[– 0.00, 0.00]	0.05	8.64 (5, 851)***
Age	– 0.11	– 5.27	0.000	[– 0.14, – 0.07]		
MP * Age	0.00	– 0.17	0.862	[0.00, 0.00]		
Gender	1.16	2.86	0.004	[0.36, 1.95]		
MP * Gender	0.00	1.56	0.118	[0.00, 0.00]		

CI Confidence interval; * $p < .05$; *** $p < .001$; **Gender (coded 0 = males, 1 = females)**

3.4 Moderation analysis on the association between depression and moderate physical activity, with age and gender as moderators

Table 4 shows that moderate physical activity was not significantly associated with depression ($B = 0.00, p > 0.05$). Age was negatively associated with depression ($B = -0.11, p < 0.001$). B showed that each unit increase in age was associated with a -0.11 decrease in depression. The interaction of moderate physical activity and age was not significant ($B = 0.00$), indicating that age did not moderate the relationship between moderate physical activity and depression. Gender was positively associated with depression ($B = 1.16, p < 0.01$), indicating that being female was associated with an increase in depression. The interaction of moderate physical activity and gender was not significant ($B = 0.00$), indicating that gender did not moderate the relationship between moderate physical activity and depression. The R^2 of .05 for the model indicated that 5% of the variance in depression was explained by all the variables, $F(5, 851) = 8.64$.

Table 5 The Hayes PROCESS Macro results for predicting depression by walking, with age and gender as moderators

Variables	<i>B</i>	<i>t</i>	<i>p</i>	95%CI	<i>R</i> ²	<i>F</i>
Walking (W)	0.00	− 2.02	0.054	[− 0.00, 0.00]	0.05	7.96 (5, 851)***
Age	− 0.10	− 5.18	0.000	[− 0.14, − 0.06]		
W * Age	0.00	− 0.21	0.833	[0.00, 0.00]		
Gender	1.16	2.88	0.004	[0.37, 1.95]		
W * Gender	0.00	− 0.74	0.460	[− 0.00, 0.00]		

CI confidence interval; * $p < .05$; *** $p < .001$; **gender (coded 0 = males, 1 = females)**

Table 6 The Hayes PROCESS Macro results for predicting depression by sitting, with age and gender as moderators

Variables	<i>B</i>	<i>t</i>	<i>p</i>	95%CI	<i>R</i> ²	<i>F</i>
Sitting (S)	− 0.00	− 1.97	0.050	[− 0.00, 0.00]	0.05	8.35 (5, 849)***
Age	− 0.10	− 5.17	0.000	[− 0.14, − 0.06]		
S * Age	0.00	1.07	0.287	[0.000, 0.00]		
Gender	1.25	3.11	0.002	[0.46, 2.04]		
S * Gender	0.00	0.51	0.612	[− 0.00, 0.00]		

CI Confidence interval; * $p < .05$; *** $p < .001$; **gender (coded 0 = males, 1 = females)**

3.5 Moderation analysis on the association between depression and walking, with age and gender as moderators

Table 5 shows that walking was not significantly associated with depression ($B = 0.00$, $p > 0.05$). Age was negatively associated with depression ($B = -0.10$, $p < 0.05$). B showed that each unit increase in age was associated with a -0.10 decrease in depression. The interaction of walking and age was not significant ($B = 0.00$), indicating that age did not moderate the relationship between walking and depression. Gender was positively associated with depression ($B = 1.16$, $p < 0.01$), indicating that being female was associated with an increase in depression. The interaction of walking and gender was not significant ($B = 0.00$), indicating that gender did not moderate the relationship between walking and depression. The R^2 of .05 for the model indicated that 5% of the variance in depression was explained by all the variables, $F(5, 851) = 7.96$.

3.6 Moderation analysis on the association between depression and sitting, with age and gender as moderators

In Table 6, sitting was not significantly associated with depression ($B = 0.00$, $p = 0.05$). Age was negatively associated with depression ($B = -0.10$, $p < 0.001$). B showed that each unit increase in age was associated with a -0.10 decrease in depression. The interaction of sitting and age was not significant ($B = 0.00$), indicating that age did not moderate the relationship between sitting and depression. Gender was positively associated with depression ($B = 1.25$, $p < 0.01$), indicating that being female was associated with an increase in depression. The interaction of sitting and gender was not significant ($B = 0.00$), indicating that gender did not moderate the relationship between sitting and depression. The R^2 of .05 for the model indicated that 5% of the variance in depression was explained by all the variables, $F(5, 849) = 8.35$.

4 Discussion

The present study investigated the associations between PA levels (vigorous, moderate, walking and sitting) and depression and tested whether age and gender moderate the link between PA and depression during the COVID-19 pandemic. We hypothesized that PA will be associated with reduced levels of depression. Based on our results, those who engaged in vigorous PA reported lower levels of depression. However, sitting, walking and moderate PA were not significantly associated with depressive symptoms. Previous research has reported that moderate PA is robustly associated with depressive symptoms in China [13]. Our current findings suggest that engagement in vigorous-intensity PA may be

helpful to Nigerian adults to reduce the potential risks of depression. The finding is inconsistent with the social withdrawal hypothesis, which suggests that sedentary behaviours might be linked to increased depression risks because of reduced social interactions [46]. Perhaps sitting was not associated with depression in this study because in an era of the COVID-19 pandemic, withdrawal from some forms of social activities and distancing were public health advisories aimed at reducing the risks of COVID-19 infections. It could also be that people engaged in social interaction via virtual platforms or networking via social media platforms while being sedentary.

As we hypothesized, older participants reported fewer symptoms of depression. Our finding is inconsistent with previous research showing that age was not related to depression [47], but it supports previous work suggesting that in response to the pandemic, older adults may have some mental health advantages [24, 26]. Despite the disproportionately higher risk of morbidity and mortality in this age group compared to the younger age group [48], older adults may face fewer stressors than younger people, whose life course may have been changed unexpectedly by the disruptions of the pandemic. For younger persons, their academic, social, occupational and economic prospects were likely to be more affected by COVID-19, which may partly account for their higher symptoms of depression. Older persons also tend to have less social engagement than younger ones and thus may be less severely affected by the social restrictions due to the pandemic and lockdown. The engagement of young people in social media and other emerging news outlets might also entail greater consumption of COVID-19 pandemic-related news, which may increase their mental distress. Young adults also seem to have fewer available coping resources than their older peers and are therefore relatively disadvantaged with regard to using life experiences to develop effective coping strategies [49–51]. Older persons are more likely to have experienced various major life events in the past and may have lived through past public health emergencies, thereby becoming more resilient. Ours is the first study using data from Nigeria during the pandemic to provide evidence of poorer mental health among younger adults compared to older persons.

It was hypothesized that women would report higher symptoms of depression than men. Consistent with previous studies [23, 29], our findings showed that women had higher depressive symptoms than men. Even though the pandemic affected both men and women, it is possible that women were more severely affected by the challenging situation of COVID-19. The inclination to nurture others may entail more worries on the part of women about meeting the needs of their family and greater fear of contracting COVID-19 infections through their family members. Women are more emotional in nature than men, which may mean that they may be more expressive of their emotional states than men, who tend to inhibit the expression of certain emotions and are less inclined to disclose some of their feelings [8].

The key central objective of this study was to investigate how age and gender may modify the relationship between PA and depression. We expected that PA would be more strongly associated with less depression in older adults than in younger adults. Age did not moderate the relationships between PA levels and depression in the present study. Although this finding contradicts previous evidence of the gender-based influence of PA on COVID-19-related emotions [33], it aligns with findings of meta-analyses that did not find such effects [34, 35].

We also hypothesized that gender will moderate the link between PA and depression, such that PA will be more strongly associated with less depression for men than for women. Our results showed that gender did not moderate the relationship between PA and depression. This finding is consistent with the results of a number of studies that have shown that for both men and women, engaging in vigorous PA was associated with a lower depression score [20, 35]. Vigorous PA is beneficial in reducing depression scores for both men and women. We suggest that PA should be included as part of cognitive behavior therapy and psychoeducational programs [52, 53] aimed at improving mental health during public health emergencies.

4.1 Limitations of the study and future directions

First, our study is cross-sectional, which did not provide evidence of a temporal order among variables in our models; thus, we do not claim causal relations of the variables. For instance, it is possible that those who were more depressed will be more likely to engage in less vigorous PA. Second, our study focused on depression as an indicator of mental health status. Third, responses to the online survey were self-reported, which may have resulted in over- or underestimation of PA and depression. We were unable to record the number of potential respondents who were approached and how many of them decided not to participate. Finally, we conducted the survey more than one year after the onset of the pandemic. This may have provided an opportunity to investigate the chronic mental health impact of the epidemic, but the acute real-time early impacts were not examined.

Longitudinal research with large sample sizes should provide a better understanding of long-term/causal effects regarding the connection between PA and depression. More components of mental health status could be assessed in

the future to investigate the impact of PA on a broader range of mental wellbeing outcomes and their differential associations across different age groups and genders. Future researchers should examine the role of PA amount, intensity and frequency in the association with depression. The use of less biased and more objective measurements of PA and depression (e.g., accelerometers and clinician administered interviews) would also be worthwhile.

Notwithstanding these limitations, the study has some notable strengths. One of the major strengths is the use of data obtained from adults in an era of the COVID-19 pandemic from a non-Western culture. This is relevant to provide evidence to policymakers with regard to PA and mental health. We believe our study has made an original contribution to the literature on PA and mental health by also considering the moderating roles of age and gender during the COVID-19 pandemic. As the world emerges from the pandemic, we hope that future research continues to assess how demographic factors may strengthen or weaken the impacts of physical/social engagements on mental health.

5 Conclusion

We conclude that the impacts of various aspects of physical activity on depression may vary. Engagement in vigorous PA may be particularly helpful to reduce levels of depression and improve mental health in the general population. Besides, older persons and women may also be more prone to depression during a pandemic. Hence targeted interventions to reduce depression may be beneficial to older adults and women.

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Data availability The datasets generated during the current study are not publicly available due to the personally sensitive information they contain and would compromise the privacy of research participants. However, the datasets that support the findings are available from the corresponding author on reasonable request.

Declarations

Competing interests The authors declare no competing interests.

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