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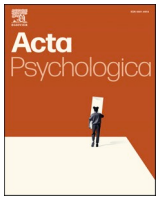

Intensity of physical activity, VO_2max, and mental health in women: Does motherhood matter?

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ABSTRACT

Introduction: Anxiety and depression are among the leading global public health problems, especially among women. This study aimed to investigate the effect of intensity of physical activity, VO_2max, and motherhood on mental health in women. Additionally, the study sought to develop a predictive equation for anxiety and depression in women based on the evaluated variables.

Methods: The study included 167 healthy women (mean age: 43.3 ± 15.6 years; weight: 63.0 ± 12.0 kg; height: 1.62 ± 0.06 m) who completed four questionnaires: the International Physical Activity Questionnaire (IPAQ), Patient Health Questionnaire-9 (PHQ-9), General Anxiety Disorder-7 (GAD-7), and motherhood-related question (Do you have children?). Maximal oxygen consumption (VO2max) was assessed through an incremental exercise test.

Results: Eighty-eight women were mothers (52.7%) and 79 women were childless (47.3%). Mothers had significantly lower depression levels compared to childless women ($p = 0.012$), with no significant differences in anxiety levels ($p = 0.075$). The number of children did not significantly influence depression ($p = 0.182$) or anxiety symptoms ($p = 0.380$). Vigorous physical activity was negatively associated with depression ($r = -0.361$, $p < 0.001$) and anxiety ($r = -0.198$, $p = 0.010$). Depression levels (PHQ-9 score) were predicted by weekly minutes of vigorous physical activity ($\beta = -0.367$, $t = -5.132$, $p < 0.001$) and motherhood status ($\beta = -0.181$, $t = -2.532$, $p = 0.012$) ($r^2 = 0.163$, $p < 0.001$).

Conclusion: High-intensity physical activity and motherhood, regardless of the number of children, predict the frequency of depressive symptoms but do not affect anxiety symptoms.

1. Introduction

Anxiety and depression are common mental disorders and are among the leading global public health problems (Marwaha et al., 2023). The situation after the Coronavirus Disease 2019 (COVID-19) pandemic provided a fertile ground for anxiety and depression (Santomauro et al., 2021). Before COVID-19, women were more prone to major depression than men (Li et al., 2022), and during the pandemia this scenario is even worse (Dotsikas et al., 2023; Marwaha et al., 2023). Additionally, more recently, in 2023, the World Health Organization reported that

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depression symptoms are about 50% more common in women than in men (World Health Organization, 2023). Furthermore, anxiety symptoms are more prevalent in women than in men (Farhane-Medina et al., 2022). The higher depression and anxiety incidence among the women is reported to be due to a combination of greater exposure to stressful life events, economic challenges, and social dynamics. Research indicates that women reported higher levels of stress related to caregiving, social isolation, and health issues, which significantly contributed to the decline in their mental health (Kaugars et al., 2023; Qian & Fan, 2024). Furthermore, women faced greater job losses and income reductions compared to men, exacerbating their mental health issues (Hwang & Shin, 2023).

Traditionally, mental health treatment includes pharmacotherapy and a comprehensive biopsychosocial approach (Marwaha et al., 2023). Although antidepressants are effective, a third to half of the people with depression do not respond satisfactorily to pharmacotherapy (Cuijpers et al., 2020; Jakobsen et al., 2017). Additionally, the side effects, such as sexual dysfunction, loss of libido, headache, gastrointestinal symptoms, anxiety, and agitation, are common (Marwaha et al., 2023). in this context, other approaches have been suggested with the aim of improving the effectiveness of treatment.

Physical activity has been proven to be an effective therapeutic intervention for depressive and anxious symptoms, with results comparable to those achieved through psychotherapy (O'Neil et al., 2024; Wang, Fan, & Wang, 2025).

According to the Clinical Guidelines for the Use of Lifestyle-Based Mental Health Care in Major Depressive Disorder, which is a document from the World Federation of Societies of Biological Psychiatry (WFSBP) and a task force of the Australian Society for Lifestyle Medicine (ASLM), one of the recommendations with the highest ratings to improve MDD was the use of physical activity and exercise (O'Neil et al., 2024; Wang, Fan, & Wang, 2025). In the same direction, the WHO presents a clear recommendation regarding the minimum volume/intensity of physical activity required for physical and mental health benefits. However, despite the minimum recommendation of 150 to 300 min per week of moderate-intensity aerobic physical activity or 75 to 150 min per week of vigorous-intensity aerobic physical activity (Singh et al., 2023), it is not known whether the intensity of the physical activity performed is capable of generating additional benefits for mental health. (Marx et al., 2023).

Regular physical activity, especially vigorous-intensity exercise, improves the maximum oxygen consumption (VO_2max) (Marx et al., 2023). Some studies indicate that improvements in VO_2max are associated with better mental health outcomes, whereas simply increasing the volume of physical activity without corresponding gains in cardiorespiratory fitness may not be sufficient to reduce the risk of depression in healthy populations (Blumenburg et al., 2022). However, it remains unclear whether the association between physical activity and a lower incidence of depression and anxiety is driven by engagement in exercise per se or by the improved functional capacity (i.e., VO_2max) observed in physically active individuals, which may contribute to better mood regulation. The understanding that mental health is associated with engaging in physical activity or with the level of cardiorespiratory fitness is of fundamental importance for guiding physical activity programs that aim to improve mental health. This is because if the key to improving mental health is the practice of physical activity itself, any activity can be recommended. However, if mental health is more closely associated with the level of cardiorespiratory fitness, the program should include physical activities directed and planned to generate the physiological adaptations that improve VO_2max.

To better guide patients presenting with depression or anxiety symptoms and health providers, it is necessary to explore whether symptoms show a higher association with moderate or vigorous-intensity exercises or with the VO_2max values.

Another factor that may contribute to the higher incidence of depression in women is childlessness (World Health Organization, 2020). Childlessness is increasing in several countries worldwide, and it affects women's mental health (Kailaheimo-Lönnqvist et al., 2024). Although childlessness is associated with a worse mental health status during the reproductive years, after that age, it seems to be better for the well-being of women (Graham et al., 2011). Conversely, mothers often face heightened demands from childcare and household duties. These responsibilities significantly limit their time for physical activity, which has been identified as the primary barrier for mothers (Graham, 2015). This lack of time can also negatively impact their mental health (Kwon et al., 2023). However, data on these issues are still quite scarce and they deserve further exploration.

Therefore, this study aimed to determine whether the intensity of weekly exercise, and the VO_2max level were associated with depression and anxiety symptoms in women. Secondarily, this study sought to determine if mental health is associated with whether women have children or not. Additionally, the study evaluated the importance of each independent variables (weekly spending time with low, moderate or vigorous intensity exercise, VO_2max and having our not children) in predicting depression and anxiety levels. We hypothesized that women who practice vigorous-intensity exercises and those who have children, regardless of their VO_2max level, experience lower depression/anxiety levels than those who practiced moderate- or low-intensity exercise and those who have no children.

2. Materials and methods

2.1. Participants and the study design

This was a cross-sectional study that recruited participants through social media (Instagram, Facebook, and WhatsApp) from the researchers affiliated institutions. Initially, 174 women were selected. The inclusion criteria included being literate, being aged between 18 and 80 years, and having no medical contraindications for maximal exertion exercises. The exclusion criteria comprised incomplete questionnaire responses, myopathies, systemic inflammatory diseases, parenchymal lung diseases, cardiomyopathies, peripheral vascular diseases, and orthopedic conditions that would limit maximal performance in the assessments. While online questionnaires facilitate broad and rapid data collection, they can be susceptible to inattentive or automated responses. To mitigate these issues, responses were assessed for completeness and internal consistency, and duplicate or implausible entries were excluded. Out of the initial 174 selected, seven participants were excluded from the study due to incomplete questionnaire responses. Thus, 167 women participated in the study, with a mean age of 43.3 $\pm$ 15.6 years, mean body mass of 63.0 $\pm$ 12.0 kg, mean height of 1.62 $\pm$ 0.06 m. Other characteristics of the participants were presented in Table 1. All participants completed a questionnaire with questions on age, body mass, height, whether they had children, number of children, physical activity level (IPAQ), depression level (PHQ-9), and anxiety level (GAD-7). Out of the 167 women, 81 also underwent assessments of body composition through dual-energy X-ray absorptiometry (DXA) and functional capacity through cardiopulmonary exercise testing, therefore the analyses involving the questionnaire results were conducted with 167 women, while analyses involving the VO_2max and DXA data were performed with 81 women.

Data were collected between March 01, 2023 and January 20, 2024. The questionnaire was self-administered and contained four sections as described below.

2.2. Experimental procedures

2.2.1. Questionnaire

The first section contained general questions related to sex (men or women), age in years (open-ended question), body mass in kg (open-ended question), height in cm (open-ended question), and whether they had children or not (yes or no). For analysis purposes, no children were

Table 1
Characteristics of the participants.

Characteristics	n	%
Sex		
Female	167	100,0%
Parental status: has children (yes/no)		
Yes	79	47,3%
No	88	52,7%
Number of children		0,0%
None	89	53,3%
1	33	19,8%
2	32	19,2%
3	10	6,0%
4	3	1,8%
Daily working hours		
Does not work	33	19,8%
1–4 h	12	7,2%
5–8 h	75	44,9%
9–14 h	47	28,1%
Education level		
Primary education I (grades 1–5)	2	1,2%
Primary education II (grades 6–9)	1	0,6%
Secondary education (high school)	28	16,8%
Higher education (college/university)	60	35,9%
Postgraduate (master's, PhD, etc.)	76	45,5%

classified as zero, and having children was classified as one (regardless of the number of children).

The second section aimed to screen for anxiety and depression symptoms. To this end, the Patient Health Questionnaire-9 (PHQ-9) and General Anxiety Disorder-7 (GAD-7) were used. PHQ-9 is an instrument widely used to identify individuals at risk of depression (Juwono et al., 2021; Santos et al., 2013). It contains nine quick-to-apply questions that assess depressed mood, anhedonia (loss of interest or pleasure in activities), sleep problems, fatigue or lack of energy, changes in appetite or weight, feelings of guilt or worthlessness, concentration problems, feeling slow or restless, and suicidal thoughts. The final score can range from 0 to 27 points. The classification criteria were as follows: no depression, 0–4 points; mild depression, 5–9 points; moderate depression, 10–14 points; moderately severe depression, 15–19 points, and severe depression, 20 to 27 points (Spitzer et al., 2006).

GAD-7 aims to identify possible generalized anxiety disorders (Santos et al., 2013; Zimmerman, 2019). The questionnaire contained seven items on feeling nervous, controlling worrying, worrying too much, having trouble relaxing, being restless, being annoyed or irritable, and feeling afraid. It helps in screening for anxiety (Moreno et al., 2016). The final score ranges from 0 to 21 points. The classification criteria were as follows: no anxiety, 0 to 4 points; mild anxiety, 5 to 9 points; moderate anxiety, 10 to 14 points, and severe anxiety, 15 to 21 points (Zimmerman, 2019).

The third section assessed the physical activity levels of participants, and the International Physical Activity Questionnaire (IPAQ) proposed by the World Health Organization in 1998 was applied (Toussaint et al., 2020). IPAQ is a validated questionnaire for estimating physical activity levels (Toussaint et al., 2020) and it was validated (Bauman et al., 2009; Craig et al., 2003). This questionnaire includes seven questions about the duration and intensity of physical activity performed, as well as inactivity time (Matsudo et al., 2001). The weekly times spent on low, moderate, and vigorous-intensity exercises were analyzed separately.

2.2.2. Body composition evaluation

To assess body composition, we used the DXA. This technique involves the emission of two X-ray beams, allowing for the precise measurement of fat, lean mass, and bone mass in total and specific body areas (Bertoldo Benedetti et al., 2007). Due to its reproducibility and precision, the DXA method is widely recognized by researchers as the gold standard for monitoring body composition (Shepherd et al., 2017). A trained evaluator performed the data analysis. Anthropometric measurements were obtained by weighing on a calibrated scale and measuring height with a properly adjusted wall-mounted stadiometer.

2.2.3. Cardiopulmonary exercise testing

The cardiopulmonary exercise testing (CPET) was performed using a treadmill (Imbrasport, ATL, Brazil) and a metabolic system for measuring pulmonary gas exchange (Quark CPET, Cosmed, Italy) to measure VO_2max. Before starting the test, the metabolic system was calibrated according to the manufacturer's specifications. The treadmill test protocol was as follows: after a resting period (1 min), a warm-up was undertaken (3 min at a constant speed of 7 km/h for women up to 59 years old and 6 km/h for women over 60 years old), followed by an increment of 1 km/h per min until voluntary exhaustion. The initial speed was adjusted to ensure a total test duration of 8–12 min, avoiding excessively fast speeds, which may reduce the peak O_2 consumption by up to 10%, or excessively slow speeds, which may transform the test into a localized muscular endurance exercise, leading to lower limb fatigue (Haarbo et al., 1991). The test was performed at a 1% grade. Throughout the test, standardized verbal encouragement was provided by the same trained evaluator. The participants wore a heart rate monitor for the entire test (Ambit @S, Suunto, Finland).

Gas exchange measurements were taken using a silicone face mask (V2Mask, Hans Rudolph Inc., USA), secured with a cap provided by the manufacturer to prevent air leakage. Data were collected breath-by-breath and fitted every 20 s.

VO_2max was estimated as the oxygen consumption achieved at the end of the CEPT that could not be increased by less than 150 $ml \cdot min^{-1}$ despite further increases in exercise intensity (Buchfuhrer et al., 1983). If the participant did not meet this requirement, but the respiratory quotient was >1.1, the maximum age-predicted heart rate and Borg's perceived exertion scale = 20 were reached, the highest VO_2 was considered VO_2max; if not, the highest VO_2 was considered VO_2 peak (Wasserman et al., 2007).

2.3. Statistical analysis

The data are presented as mean ± standard deviation. The Kolmogorov–Smirnov test and Levene's test showed that all quantitative response variables exhibited a normal distribution and homogeneous variability, respectively.

The Pearson's linear correlation coefficient was used to measure the level of linear association between PHQ-9 and GAD-7 with weekly minutes of walking, moderate and vigorous activities, and the VO_2 max values. The independent samples Student's *t*-test was used to compare the PHQ-9 and GAD-7 values between women who had children and those who did not. One-way analysis of variance was used to compare the levels of PHQ-9 and GAD-7 in women with varying numbers of children. Significantly correlated variables were used for the stepwise adjustment of the multiple linear regression model. For the regression equation, the coefficient of determination (r^2), Durbin-Watson Test (to detect autocorrelation), variance inflation factor (VIF), and tolerance (to detect multicollinearity) were presented. The analyses were outperformed using the IBM SPSS Statistics (version 22, USA) software, with the level of significance set at $p < 0.05$.

3. Results

Reponses to the IPAQ questionnaire showed that during a regular week, the women performed 257.5 ± 349.9 min of walking activities, 236.7 ± 289.4 of moderate activities, and 141.3 ± 171.8 of vigorous activities. Finally, 79 (47.3%) of the women were mothers and 89 (52.7%) had no children. Of the women who were mothers, 33 (41.8%) had one child, 32 (40.5%) had two children, and 13 (16.5%) had three or more children.

Women who had children exhibited significantly lower depression levels, as measured by the PHQ-9, than childless women [2 (1–6), 4.5

(2–7), $p = 0.012$, respectively] (Fig. 1). However, anxiety levels did not differ significantly between the two groups of women [3 (1–6), 4 (2–6), $p = 0.075$, respectively]. The number of children mothers had had no significant impact on the PHQ-9 ($F(3, 163) = 1.641$, $p = 0.182$, observed power = 0.425) or GAD-7 ($F(3, 163) = 1.033$, $p = 0.380$, observed power = 0.277) values.

The weekly number of minutes spent on vigorous physical activity had a stronger correlation with depression symptoms than the weekly number of minutes spent on moderate physical activity ($r = -0.361$, $p < 0.001$ and $r = -0.036$, $p = 0.649$, respectively) and with anxiety symptoms ($r = -0.198$, $p = 0.010$ and $r = 0.043$, $p = 0.584$, respectively). Similar to moderate activities, number of weekly minutes spent on walking activities (low intensity exercises) showed no significant correlations with depression and anxiety symptoms (Table 2).

There was no significant correlation between VO_2max, and the frequency of depression and anxiety symptoms (Table 2).

Multiple linear regression models were fitted to determine if depression and anxiety levels could be predicted through the outcomes measured. The analyses resulted in the statistical models presented in Table 3. The independent variables measured in this study were not able to predict the anxiety level, as only one measured independent variable (vigorous physical activity) significantly correlated with anxiety levels (Table 2), but this correlation was very weak ($r = -0.198$). However, the variables that best fit the model for depression level were: vigorous physical activity (min/week) ($\beta = -0.367$, $t = -5.132$, $p < 0.001$) and having or not having children ($\beta = -0.181$, $t = -2.532$, $p = 0.012$) (Table 3).

4. Discussion

The main findings of this study were as follows: (i) the weekly number of minutes of vigorous physical activity, but not moderate or walking physical activity, were significantly associated with depression and anxiety symptoms, (ii) VO_2max level was not significantly associated with depression and anxiety symptoms, (iii) childless women presented a higher frequency of depression, but not anxiety symptoms, than those who had children, (iv) the number of children that mothers had did not influence the levels of depression and anxiety among women, (v) depression level can be predicted by the weekly number of minutes of vigorous physical activity and by whether the women have children or not.

These findings support our hypothesis that vigorous activity has a stronger association with symptoms of mental disorders than moderate activity. This is probably due to the more intense physiological effects of vigorous physical activity on mental health, which are discussed below. Furthermore, women with children have a lower frequency of depression symptoms than childless women, a result likely linked to traditional gender roles and social expectations.

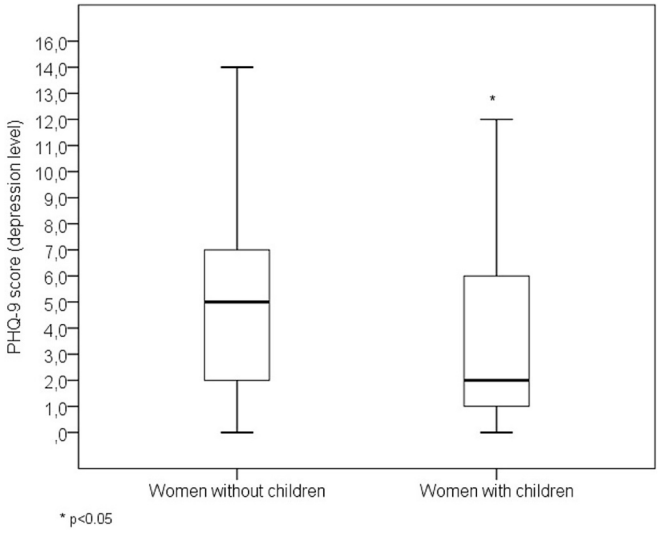

Fig. 1. Comparison of depression levels (PHQ-9) between women with children and those without children.

Table 2
Coefficient of correlation between mental health and physical activity habits and VO_2max among women.

	Depression level (PHQ-9)	Anxiety level (GAD-7)
Vigorous activity (min/week)		
Coefficient of correlation	−0.361	−0.198
p-Value	<0.001*	0.010*
Moderate activity (min/week)		
Coefficient of correlation	−0.036	−0.043
p-Value	0.649	0.584
Walking activity (min/week)		
Coefficient of correlation	−0.166	0.003
p-Value	0.033*	0.965
Sedentary activity (min/day)		
Coefficient of correlation	0.199	0.130
p-Value	0.010*	0.094
VO_2max (mL/kg/min)		
Coefficient of correlation	0.078	0.106
p-Value	0.491	0.348

It's important to clarify that the study participants were asked about the weekly minutes spent on physical activity of different intensities.

Physical activity is defined as any bodily movement that increases calorie expenditure, which is distinct from exercise. The latter assumes a structured, repetitive and planned activity with well-defined performance improvement and maintenance goals (Meyer et al., 2005). As a result, activities such as sweeping, dancing, and gardening were included in the analyses.

The results showed that the there was a significant negative correlation ($r = -0.361$) between frequency of symptoms of depression and number of minutes of vigorous physical activity per week, suggesting that women who engaged in more minutes of vigorous physical activity per week had a lower frequency of symptoms of depression than those who engaged in less. Conversely, despite the statistical significance, the correlation between weekly number minutes in vigorous physical activity and anxiety symptoms was very low ($r = -0.198$). The number of weekly hours of moderate activity and walking were not associated with depression and anxiety symptoms, implying that the intensity of physical activity is important to mental health among women. These findings corroborate those of a previous study reporting that increasing the intensity of physical activity from moderate to vigorous resulted in a 30% reduction in the frequency of depression (Caspersen et al., 1985). Additionally, another recent meta-analysis reported a 25% lower depression risk (95% CI, 18%–32%) among those who performed vigorous physical activity than in non-active individuals (Yang et al., 2022). Furthermore, maximal or supramaximal interval training can reduce frequency of depressive symptoms (Pearce et al., 2022). In contrast to our findings, a previous study reported that any level of physical activity, including moderate-intensity activity, was associated with an 18% decrease in the prevalence of depressive symptoms (95% CI, 13%–23%) (Yang et al., 2022). Rahmati et al. (2024) reported a lower odds ratio for depression with moderate-intensity physical activity (OR = 0.79, 95% CI: 0.72–0.87) compared with vigorous activity (OR = 0.77, 95% CI 0.72–0.82); however, no direct comparison between intensities was performed, which limits conclusions regarding the superiority of one intensity over another and hinders direct comparison with our findings (Rahmati et al., 2024).

The underlying mechanisms by which intensity of physical activity influences depression symptoms remain unclear. Nevertheless, some hypotheses have been formulated to comprehend and explain this association. One hypothesis is that people who engage in physical activity

Table 3
Multiple regression models for estimating depression level among women.

Split	r^2	F	Df	*p*	Standard error of estimate	Tolerance	VIF	Durbin-Watson
Depression level	PHQ-9 score = 6.112 − 0.008 (vigorous activity in min/week) − 1.322 (having or not children[a])							
	0.163	15.952	2, 164	<0.001	3.36	0.999	1.001	1.892

[a] Number one represents women who have children, and number zero represents women without children.

produce higher levels of certain neurochemicals, such as opioids and endocannabinoids (anandamide and 2-arachidonoylglycerol), which bind to CB1 and CB2 receptors (Viana et al., 2019). These substances are implicated in the regulation of mood, sensation of pleasure, sleep, appetite, memory, learning, and low pain sensitivity (Ferreira-Vieira et al., 2014; Godse et al., 2015). Another proposal is that physical activity can improve the functioning of the hypothalamus-pituitary-adrenal axis, modulating cortisol secretion (Brellenthin et al., 2017), which also has a positive effect on leptin and ghrelin balance, which is essential for regulating appetite and body mass (Mahindru et al., 2023). Another important effect of physical activity is that it has a positive impact on brain-derived neurotrophic factor production, resulting in a high plasma level of the hippocampus and concentrations of these neurotrophins in some brain regions, in addition to neuroplasticity improvement (Telles et al., 2018). Furthermore, it has been hypothesized that the consequences of regular exercise facilitate the homeostatic processes necessary for maintaining, repairing, and reorganizing the impaired circuits in depressed individuals (Zarza-Rebollo et al., 2024). Finally, lactate plays a role as an intercellular signaling molecule in synaptic plasticity, and structural and functional plasticity is altered in major depression. These findings have motivated investigations into the potential of lactate as a novel antidepressant, particularly given its ability to induce antidepressant-like effects in animal models of depression when administered peripherally (Karnib et al., 2019; Phillips, 2017). This provides further support for a hypothesis linking high-intensity physical activity to a decreased prevalence of depressive symptoms. Therefore, there are various potential biological mechanisms that collectively contribute to and may explain the positive effects of physical activity on depression (Carrard et al., 2018).

Our results did not show any significant relationship between VO_2max and depression or anxiety symptoms. Whereas spending a long time in physical activity, especially with vigorous physical activity, is associated with low depressive symptoms, our findings suggest that the level of cardiorespiratory capacity, as measured by VO_2max, is not a significant factor in depression. Therefore, for mental health, performing physical activity, regardless of fitness level, is important. These findings contradict the established link between high VO_2max and "positive health"; or low VO_2max and "negative health," suggesting that lower functional capacity (VO_2max) is associated with increased mortality risk (Wang, Zhu, et al., 2025).

This study also explored the role of motherhood as a potential contributing factor to the high rates of depression among women. Our results showed that women without children exhibit a higher frequency of depression symptoms that those with children. The impact of motherhood on women's mental health is a complex issue, and findings of previous studies offer conflicting evidence, potentially influenced by the woman's age. In line with our findings, Graham (2015) found that women without children report low levels of physical and mental health, as well as low overall well-being, during their prime reproductive years. In contrast, women aged 65 and above show a different pattern, with better well-being later in life (Graham et al., 2011). Perhaps, during their reproductive years, childless women face societal pressure to procreate, which may negatively impact their mental health (Booth et al., 2012; Ross & Hess, 2019). Additionally, motherhood can provide a social support network that childless women may lack, acting as a buffer against feelings of isolation. In contrast, childless women demonstrate the ability to construct satisfying and healthy lives, surpassing mothers in terms of well-being (Graham et al., 2011). Regarding motherhood, the results showed that the number of children does not affect the levels of anxiety and depression. However, this finding should be interpreted with caution, as the statistical power of the analysis was low. This suggests that the lack of a significant difference may be a result of the small sample size, particularly among women with three or more children.

The regression model used in this study to predict depression levels was composed of the weekly time spent on vigorous physical activity and whether one has children or not. High level of engagement in vigorous physical activity per week and parenthood were associated with a low frequency of depressive symptoms. These variables jointly accounted for 16.3% of the variance in depression scores. These findings are specific to the population of the study authors' home country, as cultural factors may influence the relationship between having children and depressive symptoms. Additionally, as the study used a cross-sectional design, the observed correlations do not imply causality. To further investigate these relationships, we recommend conducting longitudinal studies and stratifying women into various age groups.

4.1. Study limitation

The study was not free from limitations. Biochemical analyses were not conducted to support data on the physiological and biochemical mechanisms underlying the association between vigorous physical activity and the frequency of depressive or anxiety symptoms. Participants were recruited through social media platforms, which may introduce selection bias, as individuals more engaged with digital media or more interested in health-related topics may be overrepresented. In addition, the level of physical activity was self-reported through a questionnaire, making the data susceptible to self-report bias. Information regarding different types, intensities, and durations of physical activity, as well as whether activities were performed individually or in structured classes, may also be relevant and was not fully captured. Another limitation of the study lies in the fact that factors like gender, race, ethnicity, and socioeconomic background were not assessed among the participants, introducing potential bias into the findings. Last but not least, the women assessed had a very wide age range, and the effects of motherhood on mental health may vary depending on a woman's age. However, despite these limitations, the novel findings presented here still allow for robust conclusions.

4.2. Implication for practice and policy

The results of the present study revealed that weekly engagement in high-intensity physical activity demonstrated a stronger correlation with a reduction in depression symptoms than time spent on moderate-intensity activity.

These findings underscore the importance of promoting physical activity, especially high-intensity activity, as an effective strategy to mitigate depressive symptoms in women. The stronger association between vigorous exercise and reduced depressive symptoms suggests that the focus should extend beyond the mere volume of physical activity, highlighting the critical role of exercise intensity in mental health. Based on the WHO's recommendations of 150 to 300 min per week of moderate-intensity aerobic physical activity or 75 to 150 min per week of vigorous-intensity aerobic physical activity[1], the focus could be on the 75–150 min of vigorous activity when the main goal is mental health. Although our findings highlight the importance of vigorous physical

activity, there is also recent evidence indicating that substantial mental health benefits already occur when individuals move from no physical activity to some level of activity, with volumes equivalent to approximately 2.5 h of brisk walking per week reducing the risk of depression by up to 25%. These findings underscore the importance of raising public awareness about the value of initiating a physical activity program (Pearce et al., 2022). It is worth noting that the positive impact occurs both in the prevention and in the reduction of symptoms in individuals with mental disorders, including depression, anxiety, and stress (Abbaszadeh Hajiabadi et al., 2024; Vancampfort et al., 2025).

Additionally, the finding that childless women report higher levels of depressive symptoms highlights the potential influence of social pressure on women to have children. This social pressure can manifest through social expectations, family scrutiny, and reproductive coercion, as evidenced by previous studies.

These insights can inform public health policies by encouraging programs that promote high-intensity exercise in an accessible and inclusive manner, tailored to the diverse needs of women. Simultaneously, they reinforce the importance of promoting social and family support networks, respecting each woman's choice regarding motherhood and not equating motherhood with femininity.

The authors of the present study recommend that future studies explore the intersection of motherhood, mental health, and exercise. These relationships should be contextualized from a sociological/social sciences perspective, specifically by examining the roles of childlessness and socioeconomic status.

5. Conclusion

Our findings indicate that whereas spending a long time on vigorous weekly exercise and having children can protect against depressive symptoms, they do not have the same effect on anxiety. This suggests that targeted interventions for depressive symptoms should focus on promoting vigorous-intensity physical activity.

Abbreviations

PHQ-9	Patient Health Questionnaire-9
GAD-7	General Anxiety Disorder-7
IPAQ	International Physical Activity Questionnaire

CRediT authorship contribution statement

Lucca Vallini: Conceptualization. **Vinícius Ribeiro dos Anjos Souza:** Conceptualization. **Lavínia Vivan:** Conceptualization. **Claudio Andre Barbosa de Lira:** Conceptualization. **João Victor Rosa de Freitas:** Conceptualization. **Gustavo de Conti Teixeira Costa:** Conceptualization. **Rodrigo Luiz Vancini:** Conceptualization. **Katja Weiss:** Writing – review & editing. **Thomas Rosemann:** Conceptualization. **Beat Knechtle:** Writing – review & editing. **Marilia Santos Andrade:** Conceptualization.

Informed consent statement

Participants read and signed a consent form after receiving information about the study objectives, experimental procedures, risks, benefits, and assurance of privacy and confidentiality.

Institutional review board statement

The University Human Research Ethics Committee of one of the authors reviewed and approved all experimental procedures. Furthermore, this study adhered to the principles outlined in the Declaration of Helsinki.

Equity, diversity, and inclusion statement

We affirm our commitment to equity, diversity, and inclusion in sports science research and academia. In adherence to the principles of equality, we disclose that two of the authors identify as Black, and three as women. In addition, we recognize the unique challenges faced by some of our authors. One of the women assumed sole financial responsibility for raising her child, demonstrating resilience and perseverance in the face of adversity.

Financial disclosure statement

None.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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