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Physical activity on anxiety symptoms during the COVID-19 pandemic: a systematic review

Atividade física nos sintomas de ansiedade durante a pandemia de COVID-19: uma revisão sistemática

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Abstract – This systematic review aimed to investigate the effect of physical activity on anxiety symptoms during the COVID-19 pandemic. Three databases (PubMed; Scopus and Web of Science) were searched in the period from 2020 to 2022 the following base terms were used: "Physical Activity", Exercise, Anxiety and COVID-19. Peer-reviewed, primary studies published in English, Portuguese and Spanish using valid and reliable measures were included. Eighteen studies met the eligibility criteria, of which 17 were cross-sectional, 2 were cohort studies. The number of participants ranged from 43 to 2,301, aged between 18 and 65 years or older. A decrease in PA practice or an increase in sitting time were associated with higher levels of anxiety symptoms. Additionally, participants who did not meet PA recommendations were more likely to experience moderate to severe anxiety symptoms. The results showed that physical activity is associated with the alleviation of anxiety symptoms during confinement in the COVID-19 pandemic.

Key words: Social Isolation; Mental Health; Lockdown; COVID-19; Angst; Physical activity.

Resumo – *Esta revisão sistemática teve como objetivo investigar o efeito da atividade física nos sintomas de ansiedade durante a pandemia de COVID-19. Foram pesquisadas três bases de dados (PubMed; Scopus e Web of Science) no período de 2020 a 2022 foram utilizados os seguintes termos base: "Physical Activity", Exercise, Anxiety e COVID-19. Foram incluídos estudos primários, revisados por pares, publicados em inglês, português e espanhol usando medidas válidas e confiáveis. Dezoito estudos preencheram os critérios de elegibilidade, sendo 17 transversais, 2 estudos de coorte. O número de participantes variou de 43 a 2.301, com idade entre 18 e 65 anos ou mais. Uma diminuição na prática de AF ou um aumento no tempo sentado foram associados a níveis mais elevados de sintomas de ansiedade. Além disso, os participantes que não atendiam às recomendações de AF eram mais propensos a apresentar sintomas de ansiedade moderados a graves. Os resultados mostraram que a atividade física está associada ao alívio dos sintomas de ansiedade durante o confinamento na pandemia de COVID-19.*

Palavras-chave: *Isolamento Social; Saúde mental; Confinamento; COVID-19; Angústia; Atividade física.*

INTRODUCTION

The COVID-19 pandemic has been the target of research regarding mental health, due to the impact it has on the global health of the population[1,2]. The restrictive measures of isolation and social interaction, used to reduce the spread of the virus[3,4] were important factors in modifying the habits of the entire world population, resulting in weight gain[5], restriction of leisure activities and reduction of physical activity (PA)[6,7] promoting deleterious effects on mental health[8,9].

Recent evidence suggests that people who are kept in isolation and quarantine experience significant levels of anxiety, anger, confusion, and stress[10-14], as it was also seen in the influenza epidemic in 2008[15], and H1N1 in 2009[16]. The first systematic review and meta-analysis on the prevalence of stress, anxiety, and depression in the general population resulting from the COVID-19 pandemic showed that the prevalence of stress, anxiety, and depression are 29.6, 31.9, and 33.7%, respectively[9], revealing that a significant portion of people is becoming mentally ill, not directly from the SARS-CoV-2 virus infection, but due to the nuisances of the pandemic in general. In a recent systematic review, it was found that the prevalence of anxiety and depression in 2020 were 32.6% and 27.6%, respectively[17].

One of the problems related to mental disorders during the COVID-19 pandemic was physical inactivity. Puccinelli et al.[18] showed that 30% and 23.3% of the subjects evaluated in their study (n=1853) had moderate/severe symptoms of depression and anxiety, respectively, associated with a reduction in PA. The health benefits of regular exercise are well established in the scientific literature[17,19-23], which can be an important intervention in combating the negative effects of the COVID-19 pandemic on mental health[22,24,25].

The recommendations for regular PA during this pandemic period follow the standards established by the World Health Organization (WHO) and the American College of Sports Medicine (ACSM)[26-28], as there are no studies that can guide the real need for changes in current recommendations. Thus, it is not known whether social distancing, lockdown, and other physical restrictions due to the COVID-19 pandemic allowed studies on exercise to be performed following the traditional parameters recommended by international institutions. The real effects of these training programs on anxiety disorder during the pandemic period are still unclear since there is still no compilation of studies performed to date.

Therefore, the present systematic review aimed to evaluate the effects of physical activity specifically on anxiety symptoms in studies conducted during the COVID-19 pandemic. Further, the training protocols were analyzed and compared to traditional recommendations provided by the WHO and ACSM.

METHODS

Study design

This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Checklist[29]. Studies were included according to the Participants, Intervention, Comparison, Outcomes, and Study design (PICOS) criteria: 1): men and women over 18 years old, physically active or sedentary, with no history of joint or musculoskeletal damage, and without psychiatric illness; 2): increased physical activity or exercise; 3): sedentary subjects or active control within the exercise group; 4): Anxiety symptoms; 5): randomized and non-randomized trials and observational studies. Conference abstracts, dissertations, theses, book chapters, and studies published in non-peer-reviewed journals were not included.

Search strategy

Original studies on physical activity and anxiety symptoms during the COVID-19 pandemic were analyzed. PubMed/MEDLINE, Scopus and Web of Science databases were used, where the following Mesh terms were combined: "Physical Activity", "Exercise", "Anxiety", "Angst", "Anxiousness", "COVID-19", "Coronavirus" and "Sars-Cov-2". For each database, adequacy of the search strategy was performed (Chart 1). The searches took place between February 2021 and January 2022. For each database, combinations of descriptors and terms and their respective synonyms in English were used.

Chart 1. Search strategy performed in each database.

Database	Search strategy	Restrictors	Results
PubMed/ MEDLINE Title and abstract	((("Physical Activity"[Title/Abstract]) OR (Exercise*[Title/Abstract])) AND (((Angst[Title/Abstract]) OR (Anxiousness[Title/Abstract])) OR (Anxiety[Title/Abstract]))) AND (((COVID-19[Title/Abstract]) OR (Coronavirus[Title/Abstract])) OR (Sars-Cov-2[Title/Abstract]))	2020 – 2022. only scientific articles, human.	603
Scopus Title, abstract and keywords	(TITLE-ABS-KEY("physical activity") OR TITLE-ABS-KEY(exercise*) AND TITLE-ABS-KEY(anxiety) OR TITLE-ABS-KEY(anxiousness) OR TITLE-ABS-KEY(angst) AND TITLE-ABS-KEY(COVID-19) OR TITLE-ABS-KEY(sars-cov-2) OR TITLE-ABS-KEY(coronavirus))	2020 – 2022. only scientific articles, human.	589
Web of Science TS = Topic (title, abstract and keywords)	(TS=(("Physical Activity" OR Exercise) AND (Anxiety OR Anxiousness OR Angst) AND (COVID-19 OR Coronavirus OR Sars-Cov-2)))	2020 – 2022. only scientific articles, human.	420

In July 2022, the searches were updated to include studies that were published between January and July. We selected ten studies for full reading. For the analysis, only one study met the eligibility criteria[30]. As five other studies[31-35] did not meet eligibility criteria, we could only use them for our discussion.

Study selection criteria

Studies were included in this review after adhering to the criteria: (i) studies performed during the COVID-19 pandemic period, published in English, Portuguese or Spanish, in peer-reviewed journals; (ii) intervention studies with exercise or observational studies (screening of physical activity or exercise); (iii) sample composed of people with an assessment of "anxiety" through validated instruments.

Data screening

Each study was selected based on "Titles and Abstract." Then, the full text was evaluated to confirm inclusion or exclusion. Title, abstract and full-text screening was performed by one reviewer and verified by three other independent reviewers (IRDDS; LFFF; EHES; EOB). Any discrepancies in the inclusion or exclusion of scientific articles were resolved in consultation with a fifth reviewer (RSMJ). The retrieved articles were cataloged, and the duplicates were removed.

Data extraction

The following information was extracted: author, year, type of study, objective, sample, instruments used, intervention, and results. Three independent reviewers extracted data. A fourth reviewer gathered the extracted information and organized the results.

Risk of bias

The Joanna Briggs Institute manual (JBI)[36] was used to evaluate the observational/cross-sectional studies. It contains eight analytical criteria for a cross-sectional study construction. As for the evaluation of cohort studies, the Joanna Briggs Institute for cohort studies was used, which contains eleven analytical criteria for this type of study. Responses consist of "yes", "no", "confused", and "not applicable" for both questionnaires. The aim of this evaluation is to estimate the methodological quality of a study and to determine the extent to which the possibility of bias has been addressed in its design, conduction, and analysis.

RESULTS

Study selection

The search resulted in 442 possible eligible studies (Figure 1). After removing 231 duplicates, 201 studies were selected for the title and abstract reading phase, resulting in forty-two studies for detailed analysis (Chart 1). A total of eighteen studies were eligible, which included seventeen cross-sectional studies and two cohort studies (Chart 2).

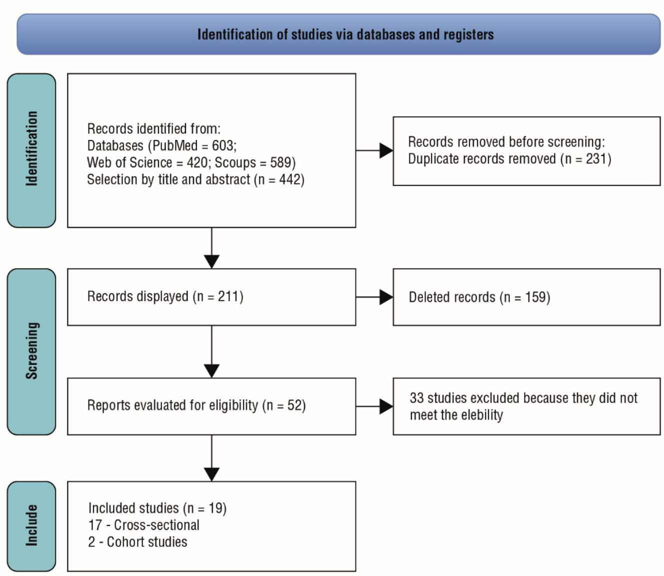

Figure 1. Flowchart of search strategy results.

Chart 2. Characteristics and information from observational studies.

Author	Objective	Sample	Instruments of screening		Main findings
			Physical Activity	Anxiety symptoms assessment	
Al-Ajlouni et al.[30]	To determine whether physical activity is associated with mental health and sleep outcomes in Jordan during COVID-19-induced lockdown.	In total, 1240 participants participated. There were more than 60% of participants younger than 40 years old, and the average age was 37.4 ± 11.0 years. Most participants (52.9%) were male. Among the participants, 31.5% met the physical activity guidelines. Based on levels of anxiety symptoms, 33.8% of participants had mild symptoms, 12.9% had moderate symptoms, and 6.3% had severe symptoms.	Using the IPAQ, participants were classified into two groups according to their compliance with the 2020 Adult Physical Activity Guidelines.	GAD-7	The prevalence of moderate or severe anxiety symptoms and increased levels of depressive symptoms was significantly higher for participants who did not meet PA guidelines. In those who did not meet physical activity guidelines, moderate or severe anxiety symptoms were significantly more prevalent (aPR = 1.36; 95% CI = 1.05-1.77); depressive symptoms were also more prevalent (aPR = 1.30; 95% CI = 1.14-1.49).
Wood et al.[37]	I. To examine the impact of UK border restrictions on PA behavior. II. To determine whether PA levels during the restriction differed according to the participants' perception of the importance of PA. III. Determining whether well-being differed according to participants' PA levels during the lockdown. IV. To determine which factors were the strongest predictors of PA and well-being during the lockdown.	315 participants (77 men and 237 women) aged 40.2 ± 13.5 years. Anxiety of 5.4 ± 6.4 points (normal classification).	IPAQ-SF - low, moderate, high	DASS-21	The mean anxiety scores with low, moderate, and high PA levels were 8.8 (9.0), 4.8 (5.5), and 4.2 (5.3), respectively. The effect of PA level during boundary blocking on anxiety scores was significant [F (2,283) = 9,890; p<0.001; η 2 = 0.065] between the moderate and elevated levels compared to the low level. There were no significant differences between the moderately active and highly active groups.
Marashi et al.[38]	To collect information from 1,669 respondents regarding PA, sedentary behavior, and mental health before and during the initial COVID-19 lockdown.	1669 participants, 82.4% women. Mean anxiety scores (19.0 ± 0.2) characterized as moderate symptoms. Age ranged from 18 to 65 years or older.	PASB-Q (Completely sedentary; slightly active; continually active; recreational athlete; elite athlete)	GAD-7	Respondents who reported a greater decrease in their aerobic and strength PA during the pandemic also experienced more anxiety (r (1544) = -0.12, p < 0.01). Negative correlations were found between moderate to vigorous PA (-0.18, p<0.01) and strength training (-0.14, p<0.01) in relation to anxiety.

Note. Physical Activity - PA; World Health Organization – WHO; Depression, Anxiety and Stress Scale-21 – DASS-21; Beck Anxiety Inventory – BAI; Brief Symptom Inventory - BSI; Self-Rating Anxiety Scale – SAS; International Physical Activity Questionnaire – IPAQ; Godin Leisure Questionnaire – GLQ; Moderate to vigorous physical activity – MVPA; Vigorous physical activity – VPA; Sedentary behavior – SB; Telephone risk factor surveillance survey – VIGITEL; University of Washington Twin Registry - WSTR; Patient Health Questionnaire-4 (PHQ-4); State-Trait Anxiety Inventory – STAI; Confidence interval - CI.

Chart 2. Continued...

Author	Objective	Sample	Instruments of screening		Main findings
			Physical Activity	Anxiety symptoms assessment	
Coakley et al.[39]	To explore the associations of PA and sedentary behavior with symptoms of depression and anxiety among young adult college students during COVID-19 restrictions in the fall semester of 2020.	697 undergraduate students aged 18 to 25 (21.29 ± 1.62) years old, 62% of whom were women. The overall mean GAD-7 score - 10.49 ± 6.07, classification of moderate symptoms.	IPAQ – classified as "met the recommendations of MVPA" and "did not meet the recommendations".	GAD-7	GAD-7 scores were positively correlated with sitting time (r s = 0.17, p < 0.0001) and had a negative association with vigorous exercise min/week (r s = 0.082, p = 0.03). Students who met the MVPA recommendations for PA compared to those who did not meet the guidelines had a mean GAD-7 score of 10.00 (± 5.97) and 11.04 (± 6.14), respectively, being significant with the value of p=0.024.
Kua et al.[40]	To investigate the association between changes in PA levels and the mental health burden of healthcare workers during the COVID-19 lockdown in Singapore.	707 health professionals. The mean age was 37.43 (10.23) years. Base anxiety score 14.74 ±5.99 (Moderate to strike).	Physical Activity Vital Sign - Duration and frequency were verified in the last 7 days. Being classified as active or insufficiently active.	DASS - 21	Half had anxiety, with 77.1% reporting moderate to severe symptoms. The practice of PA obtained significant reductions in frequency, duration, and intensity, all presenting p<0.001. However, there were no meaningful results regarding changes in PA and anxiety symptoms.
Pears et al.[41]	To investigate the association between PA and sitting time on mental health and the influence of mediators and confounders.	284 university students and the general population, 74.8% of which are women. The mean age was 33.5 (± 12.4) years. 27.1% of participants had a previous diagnosis of anxiety.	IPAQ - High sitting time and low PA; high sitting time and moderate or high PA; Low sitting time and low PA; Low sitting time and moderate or high PA.	GAD-2	The association between the different domains of PA (ie, work domain, transport domain, domestic domain, and garden and leisure) did not find significant differences related to anxiety. Sitting time and PA levels were also verified, no significant difference was found for anxiety levels.
Antunes et al.[42]	To examine whether individuals with various levels of PA reported various levels of anxiety and different perceptions of Basic Psychological needs satisfaction during the period of isolation due to COVID-19.	1,404 university students, 69.6% of which are women. The mean age was 36.4 (± 11.7). Trait anxiety score - 37.9 (± 10.3) and state anxiety - 45.1 (± 11.2)	IPAQ-short form - low (considered inactive), moderate and vigorous	STAI	The comparison between the IPAQ (low, moderate, and high) and anxiety (state and trait) categories were 46.94 (± 11.51) and 39.70 (± 10.71); 44.79 (± 11.04) and 37.42 (± 9.88); 42.68 (± 10.40) and 36.01 (± 9.98), respectively, following the order mentioned above. The results seem to point to two interesting trends from the low-level PA category to the high-level PA category: a decreasing trend in state anxiety and in trait anxiety.

Note. Physical Activity - PA; World Health Organization – WHO; Depression, Anxiety and Stress Scale-21 – DASS-21; Beck Anxiety Inventory – BAI; Brief Symptom Inventory - BSI; Self-Rating Anxiety Scale – SAS; International Physical Activity Questionnaire – IPAQ; Godin Leisure Questionnaire – GLQ; Moderate to vigorous physical activity – MVPA; Vigorous physical activity – VPA; Sedentary behavior – SB; Telephone risk factor surveillance survey – VIGITEL; University of Washington Twin Registry - WSTR; Patient Health Questionnaire-4 (PHQ-4); State-Trait Anxiety Inventory – STAI; Confidence interval - CI.

Chart 2. Continued...

Author	Objective	Sample	Instruments of screening		Main findings
			Physical Activity	Anxiety symptoms assessment	
Peterson et al.[43]	To examine changes in psychological health and PA over an 8-week period under social distancing policies during the COVID-19 pandemic.	90 participants, of which 73.3% are women. The age ranged from 18 to over 40 years. 18 to 29 years old represent 57.7%, 30 to 39 years old represent 26.7%, and over 40 years old 15.6%. Mean anxiety score 45.92 ± 4.38.	IPAQ - low, moderate, and high intensity.	STAI	Vigorous PA had a negative and significant correlation (r= -0.25, p <0.05) with trait anxiety. In contrast, low-intensity PA (walking) was positively correlated with state anxiety (r=0.22, p<0.05).
Lewis et al.[44]	I. Reduced PA and increased sedentary behavior will be directly associated with more depressive and anxiety-related symptoms, and this association will be stronger during lockdown than before lockdown. II. Reduced PA and increased sedentary behavior will be indirectly associated with more depressive and anxiety-related symptoms through their influence on sleep health and this association will be stronger during lockdown than before lockdown.	1,048 South African adults (age: 32.76 ± 14.43 years; female: n = 767; male: n = 261; non-binary: n = 15; prefer not to say: n= 5). Of the sample, 473 were university students (age: 22.6 ± 6.39 years) and 575 non-students (workers, retirees, and volunteers; age: 41.1 ± 13.8 years)	IPAQ - low, moderate, and high intensity.	GAD-7	During confinement, less PA was directly associated with less sleep regularity and more severe insomnia symptoms. The effects of exercise on anxiety symptoms did not exist before the blockade. In addition, there was a significant indirect effect between PA and anxiety symptoms during the block, so that less PA was associated with more severe insomnia symptoms and, therefore, greater anxiety symptoms.
Haider et al.[45]	To explore associations between PA and mental health in Austria during COVID-19 social restrictions.	652 adults with a mean age of 36.0 (±14.4) years. 481 (72.4) were women and 513 (77.3) had no diagnosed mental illness. In addition, 424 (66.7) had no anxiety and 212 (33.3) had anxiety.	IPAQ - low, moderate, and high intensity.	BAI	Individuals who spent ≥ 60 min/day outdoors were more likely to have high mental well-being compared with individuals who spent <60 min/day outdoors. They were also more likely to not have depression compared to people who were outside <60 min/day. Individuals who managed to maintain their MVPA level during self-isolation were more likely to have high mental well-being, no depression, no anxiety symptoms, and no loneliness compared to those individuals who reduced their MVPA behavior.

Note. Physical Activity - PA; World Health Organization – WHO; Depression, Anxiety and Stress Scale-21 – DASS-21; Beck Anxiety Inventory – BAI; Brief Symptom Inventory - BSI; Self-Rating Anxiety Scale – SAS; International Physical Activity Questionnaire – IPAQ; Godin Leisure Questionnaire – GLQ; Moderate to vigorous physical activity – MVPA; Vigorous physical activity – VPA; Sedentary behavior – SB; Telephone risk factor surveillance survey – VIGITEL; University of Washington Twin Registry - WSTR; Patient Health Questionnaire-4 (PHQ-4); State-Trait Anxiety Inventory – STAI; Confidence interval - CI.

Chart 2. Continued...

Author	Objective	Sample	Instruments of screening		Main findings
			Physical Activity	Anxiety symptoms assessment	
Meira et al.[27]	To examine the relationships between state anxiety and levels of PA in the leisure domain during the COVID-19 pandemic.	571 adult volunteers, 200 men, and 371 women. The mean age was 39 (± 14) years.	VIGITEL - PA section that contains 5 items. Practice once a week; 40 min a day; 40 min/day in 3 days or more.	STAI-S-6	The tests showed significantly lower levels of anxiety for participants who practiced PA for (1) 40 minutes or more per session compared to those who practiced less than 40 minutes per session (U = 14607.5; p = 0.005), (2)) three or more days a week in relation to those who practiced less than 3 days a week (U = 12,760.5; p<0.0001), and (3) at least 40 min per session on three or more days of the week in comparison with those who practiced less than that and also those who did not practice (U = 14616.5; p < 0.0001). No differences were detected between practitioners of moderate PA compared to practitioners of vigorous or vigorous and moderate PA (U = 18714; p = 0.119).
Schuch et al.[46]	To explore the associations between MVPA, VPA, MPA, and SB with depressive, anxious, and comorbid depressive and anxious (D&A) symptoms in isolated Brazilians.	937 adults, women (72.3%). Age ranged from 18 to 65 years or older. 52.6% of the sample were between 18 and 34 years old. The mean anxiety score was 6.00 (± 11.00).	1) "How much time in a normal day do you spend in vigorous PA since self-isolation?"; and 2) "How much time in a typical day do you spend in moderate PA since self-isolation?" MVPA and MPA were dichotomized at 1 = <30 min/day, or 2 = ≥30 min/day, and VPA was dichotomized at 1 = <15 min/day, or 2 = ≥15 min VPA/day. These cutoffs are in line with the public health recommendations of 150 min of MVPA, or 75 min of VPA per week.	BAI	Those who reported ≥30 min in MVPA/day had a decreased chance of anxiety (OR = 0.72, 95% CI = 0.54-0.96) and those who spent ≥15 min in VPA/day had a lower chance. of having anxiety symptoms (OR = 0.70, 95% CI = 0.51-0.96).

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Chart 2. Continued...

Author	Objective	Sample	Instruments of screening		Main findings
			Physical Activity	Anxiety symptoms assessment	
Rogowska et al.[47]	Association between PA, anxiety and depression in the study sample?	1512 students aged 18-51 (20.06 ±3.05). The GAD-7 scores identified that 23.81% of the sample had moderate to severe anxiety.	PA during the coronavirus lockdown was assessed using the following question: "How many days per week have you physically exercised or engaged in sports activities at home or away from home, at university, at clubs, or at the gym, in the last month?", "How many minutes a day (on average) do you practice?". "How many days a week did you practice physical exercises or sports activities at home or away from home, at the university, in clubs or at the gym, until a month before the general quarantine of the coronavirus?" Students who performed 150 min per week or more were included in the Active group (A), while the Inactive sample (I) was composed of those individuals who dedicated less than 150 min per week to PA, according to the WHO recommendation.	GAD-7	Undergraduate students who met clinical criteria for anxiety (GAD-7 scores $\geq$ 10) were 1.7 times less likely to exercise than their peers without clinically significant anxiety disorders, χ 2(1) = 17.98, OR = 1.69, 95% CI (1.32, 2.17), B = 0.53, SE B = 0.13, t (1510) = 4.18, p <0.001, χ of Wald2 = 17 .47. Anxiety levels were similar in physically active and inactive students. Physically active and inactive male college students did not differ in their anxiety levels. The effect of the interaction between gender and PA was also not statistically significant.
Xiang et al.[48]	To assess the prevalence of inadequate PA, anxiety, and depression and explore the relationship of PA with symptoms of anxiety and depression among Chinese university students during quarantine.	1,396 participants were used in the analysis, including 881 (63.1%) men and 515 (36.9%) women. The mean age was 20.68 (1.84) years. 31% of the sample had symptoms of anxiety.	IPAQ-SF - Low, moderate, high according to the protocol that stipulates the questionnaire.	SAS	Linear regression analyzes showed that participants with a high level (β = –0.121, P < 0.001) of PA were significantly associated with low anxiety.

Note. Physical Activity - PA; World Health Organization – WHO; Depression, Anxiety and Stress Scale-21 – DASS-21; Beck Anxiety Inventory – BAI; Brief Symptom Inventory - BSI; Self-Rating Anxiety Scale – SAS; International Physical Activity Questionnaire – IPAQ; Godin Leisure Questionnaire – GLQ; Moderate to vigorous physical activity – MVPA; Vigorous physical activity – VPA; Sedentary behavior – SB; Telephone risk factor surveillance survey – VIGITEL; University of Washington Twin Registry - WSTR; Patient Health Questionnaire-4 (PHQ-4); State-Trait Anxiety Inventory – STAI; Confidence interval - CI.

Chart 2. Continued...

Author	Objective	Sample	Instruments of screening: Physical Activity	Instruments of screening: Anxiety symptoms assessment	Main findings
Lesser & Nienhuis[49]	To understand the impact of the global pandemic and public health restrictions on Canadians. Specifically, we aim to report changes since the beginning of COVID-19 in barriers and enablers of PA and engagement, as well as well-being (anxiety, general mental health), in both active and inactive individuals.	1098 adult participants of both sexes, of which 79.3% were women. The mean age was 42 (± 15).	GLQ - The cut-off for active was >150 min of moderate-vigorous PA per week, while the related cut-off for inactive was <149.9 min of moderate-vigorous PA per week based on standard guidelines for related health benefits the health.	GAD-7	There was a significant difference in the amount of PA performed with other people among those who did more 9.87 ± 4.26, the same PA 8.83 ± 4.71 or less activity 11.24 ± 4.66 in the population inactive (F (2, 693) = 5.98, p = 0.003), but this was not found in the active population (F (2, 398) = 1.25, p = 0.287).
Jacob et al.[50]	To investigate the cross-sectional association between PA levels with depressive symptoms, anxiety symptoms, and positive mental well-being in a sample of UK public social distancing due to COVID-19.	902 adults of both sexes, of which 63.8% are women. Age ranged from 18 to 64 years or older, 50.1% of people were aged 35–64 years. 30.7% of the sample had moderate to severe anxiety symptoms.	Participants were asked: 1) "How much time in a normal day do you spend in vigorous activities since social distancing?"; and 2) "How much time in a typical day do you spend in moderate activities since social distancing?" Following the WHO recommendations on PA levels per week (i.e., at least 150 min of moderate PA and/or 75 min of vigorous PA in adults aged ≥18 years), sufficient PA per day was defined. as approximately 21 min of moderate PA and/or 11 min of vigorous PA per day.	BAI	The prevalence of moderate to severe anxiety symptoms was 30.7% and this number decreased significantly with increasing PA. 0-30 minutes was 41.2%, 30-90 minutes 27.4%, more than 90 minutes 22.0% the prevalence of moderate to severe anxiety symptoms. The effect size was 0.18.
Ozdemir et al.[51]	To assess individuals' PA levels and assess the effects of PA on quality of life, depression, and anxiety levels during the COVID-19 outbreak	2,301 individuals of both genders, of which 61.1% are women. The mean age was 36.2 ± 10.9 years. 569 (24.7%) participants had moderate and severe levels of anxiety	IPAQ - classified into Inactive, Minimum Active and Active.	BAI	It was found that there was a significant relationship (<0.001) between the participants' level of PA and mean anxiety scores. 11.23 (± 10.91), 9.67 (± 9.87), and 9.24 (± 10.58) for the inactive, minimally active, and active groups, respectively.

Note. Physical Activity - PA; World Health Organization – WHO; Depression, Anxiety and Stress Scale-21 – DASS-21; Beck Anxiety Inventory – BAI; Brief Symptom Inventory - BSI; Self-Rating Anxiety Scale – SAS; International Physical Activity Questionnaire – IPAQ; Godin Leisure Questionnaire – GLQ; Moderate to vigorous physical activity – MVPA; Vigorous physical activity – VPA; Sedentary behavior – SB; Telephone risk factor surveillance survey – VIGITEL; University of Washington Twin Registry - WSTR; Patient Health Questionnaire-4 (PHQ-4); State-Trait Anxiety Inventory – STAI; Confidence interval - CI.

Chart 2. Continued...

Author	Objective	Sample	Instruments of screening: Physical Activity	Instruments of screening: Anxiety symptoms assessment	Main findings
Duncan et al.[52]	To investigate associations between changes in PA and mental health outcomes during the COVID-19 pandemic, after the implementation of mitigation strategies, in a sample of adult twins. A cohort studies.	The final analytical sample included N = 757, N = 563, and N = 547 pairs of twins for Waves 1, 2, and 3, respectively. The mean follow-up time was 88.4 ± 4.8 days between Waves 1 and 2 and 63.3 ± 5.8 days between Waves 2 and 3 (Wave 1, April 20 to May 3; Wave 2, July 16 to August 2; Wave 3, September 16 to October 1). The average age of participants was around 52 years, ranging from 20 to 93 years.	PA was operationalized as weekly MVPA and walking in the neighborhood. Participants reported, in the last two weeks, the number of days per week they engaged in moderate PA for at least 30 minutes and vigorous PA for at least 20 minutes. The amount of MVPA (minutes per week) was created by adding the days of moderate and vigorous PA by their respective durations. This measure was validated with objective PA data measured using accelerometers and GPS data loggers within a subsample of the WSTR.	BSI	Mean MVPA levels remained similar between S1 and S2, with a slight decrease of about 7 minutes per week at S3. Mean walking levels showed a slight decline from S1 to S2, with a further decrease of about 25 minutes at S3. The cross-sectional associations between MVPA and anxiety (p = 0.002) and between walking and anxiety (p = 0.038) were statistically significant, meaning that individuals with more PA presented less anxiety.
Rees-Punia et al.[53]	To explore differences in the association between PA and sedentary time with symptoms of anxiety and depression by sex and pre-pandemic history of anxiety and depression.	2,240 individuals of both genders older than 50 (mean 57.5 (SD = 9.7) years, 65% of which are women.	The items "walking 3 or more mph or faster than 20 min per mile", "moderate activities" and "strenuous activities" were used to capture total moderate to vigorous intensity aerobic PA (MVPA). Response options were "0, <1, 1–2, 3–4, 5–6, 7–8, 9–10, 11+ hours per day" to obtain daily mean MVPA and sedentary time before and during the COVID-19 pandemic.The continuous time in MVPA at both moments was summarized in the categories 'active' or 'inactive'. Based on these categories, the change in the 2018 MVPA for the pandemic was categorized as: remained active, became active, became inactive, and remained inactive.	PHQ-4	Compared with participants who remained active, participants who became inactive or remained inactive were more likely to have worse psychological distress. Participants who became active did not differ in psychological distress compared to those who remained active. Changes in PA were not associated with anxiety symptoms; however, participants who remained inactive were twice as likely to have worse depressive symptoms (OR = 2.07, 1.34–3.22) compared with those who remained active.

Note. Physical Activity - PA; World Health Organization – WHO; Depression, Anxiety and Stress Scale-21 – DASS-21; Beck Anxiety Inventory – BAI; Brief Symptom Inventory - BSI; Self-Rating Anxiety Scale – SAS; International Physical Activity Questionnaire – IPAQ; Godin Leisure Questionnaire – GLQ; Moderate to vigorous physical activity – MVPA; Vigorous physical activity – VPA; Sedentary behavior – SB; Telephone risk factor surveillance survey – VIGITEL; University of Washington Twin Registry - WSTR; Patient Health Questionnaire-4 (PHQ-4); State-Trait Anxiety Inventory – STAI; Confidence interval - CI.

Characteristics of the studies

The included studies were published between 2020 and 2022. A total of sixteen studies collected data between February and June 2020. In the study by Duncan et al., data were collected from April to October, while in the study by Coakley et al., data were collected from October to November 2020, with both studies collecting data in the second half of the year. In only one study, the date of data collection was not specified[39,52].

The number of participants ranged from 43 to 2,301, aged between 18 and 65 years or older. Several instruments were used to analyze the practice of PA: i) International Physical Activity Questionnaire (IPAQ), ii) Physical Activity and Sedentary Behavior Questionnaire (PASB-Q), iii) Telephone risk factor surveillance survey (Surveillance of Risk and Protective Factors for Chronic Diseases by Telephone Survey - VIGITEL) - physical activity section containing 5 items, iv) Physical Activity Vital Sign (PAVS), v) Godin Leisure Questionnaire (GLQ). Three studies did not use a questionnaire, but a model of questions about physical activity during the period of social isolation.

Anxiety was assessed using different scales, namely: i) General Anxiety Disorder (GAD-7 and GAD-2), ii) Depression, Anxiety and Stress Scale – Short Form (DASS-21), iii) Beck Anxiety Inventory (BAI), iv) State-Trait Anxiety Inventory (STAI), v) Self-Rating Anxiety Scale, vi) Brief Symptom Inventory (BSI) and vii) Hospital Anxiety and Depression Scale (HADS).

Risk of bias

Most observational/cross-sectional studies met the main methodological quality criteria. Some studies have demonstrated confusion in inclusion and exclusion criteria[37,38,40,47,51]. The cohort studies met all JBI criteria[52,53]. More details in Supplementary file 1. No studies were excluded after individual assessments, more information can be seen in the Supplementary file 1.

Main findings

Observational studies

Marashi et al.[38] and Coakley et al.[39] in their respective studies, found that people who reported decreased PA practice or increased sitting time experienced higher levels of anxiety symptoms[38,39]. PA has an association on reducing state and trait anxiety[42,43]. Indeed, it was found that vigorous PA[48] had a negative and significant correlation with trait anxiety[43], whereas low-intensity PA was not associated to reducing anxiety symptoms.

In addition, some studies have shown that the duration and frequency of PA practice are important for reducing anxiety levels[27,30,46,50]. The minimum duration of activity and weekly frequency with some effectiveness were 30 min and 3 times a week, respectively[27,45]. Schuch et al.[46] found that practicing 15 minutes or more of vigorous PA/day provides a lower chance of presenting anxiety symptoms when compared to those who perform 30 minutes or more of moderate PA/day[46]. Reduced PA practice may have indirect effects on anxiety, as demonstrated in the study by Lewis et al, in which the decrease in PA increased the symptoms of insomnia and, consequently, anxiety[44]. Haider et al.[45] demonstrated that individuals who spend more than 60 min/day outdoors and who managed to maintain a moderate to vigorous level of PA were more likely to have high mental well-being, without depression and anxiety symptoms[45].

Recommendations for Physical Activity

When the practice of PA was analyzed according to the WHO and ACSM recommendations as parameters, we found that most of the populations studied did not meet the minimum recommendations for health benefits. Still, for those who were active, with the beginning of the pandemic and social restrictions, there was a decrease in PA levels. Al-Ajlouni et al.[30] found that participants who did not meet the WHO guidelines had a higher prevalence of moderate to severe anxiety symptoms.

Among the studies analyzed, only the study by Duncan et al, did not meet any of the minimum recommendations of physical Activity[52]. There were variations in compliance with the recommendations in the studies before and during social isolation. The studies by Haider et al.[45], Meira et al.[27] and Wood et al.[37] obtained the highest percentages of the sample meeting the recommendations before social isolation, being 89%, 86.9% and 82.58%, respectively. These percentages were reduced to 76.3%, 65.6% and 51.6% during social isolation, respectively. Even with the efforts of the WHO and ACSM with illustrative publications for people to remain physically active, many individuals decreased the level of physical activity over the period of social isolation and other restrictions, as can be seen in more detail in the Chart 3.

Chart 3. Changes in Physical Activity during the COVID-19 pandemic

STUDIES	Physical Activity Recommendations - Adults and Older Adults	
	WHO	ACSM
Al-Ajlouni et al.[30]	31.5% of participants met the PA guidelines	
Duncan et al.[52]	Did not meet the recommendations.	
Rees-Punia et al.[53]	38.21% of the participants met the recommendations.	
Wood et al.[37]	82.58% of the participants met the recommendations. However, only 51.6% met the recommendations during the lockdown.	
Marashi et al.[38]	The participants met the recommendations. However, the data is unclear.	
Coakley et al.[39]	51% of university students met the recommendations.	
Kua et al.[40]	56.5% of participants met the recommendations before the lockdown. After the lockdown, only 39.8% met the recommendations.	
Pears et al.[41]	56% of the participants met the recommendations.	
Antunes et al.[42]	68.1% of the participants met the recommendations.	
Peterson et al.[43]	Moment 1 (2 to 4 weeks of lockdown), 59% of participants met the recommendations; moment 2 (4 to 6 weeks of lockdown), 53% met the recommendations; moment 3 (6 to 8 weeks of lockdown), 49% met the recommendations.	
Lewis et al.[44]	Participants met the recommendations before the lockdown.	
Haider et al.[45]	89.0% of participants met the recommendations before and 76.3% during the lockdown.	

Note. World Health Organization (WHO) – Adults and older adults should perform 150 to 300 minutes/week of moderate and 75 to 150 minutes/week of vigorous-intensity PA. Strength training for at least two days for large muscle groups. For older people, training in multicomponent activities at least 3 days a week is recommended26. American College of Sports Medicine (ACSM) – Adults should perform 150 minutes/week of moderate and 60 minutes/week of vigorous-intensity aerobic PA. For strength and endurance improvement, train large muscle groups at least two days a week. Older adults should perform 150 minutes/week of moderate-intensity and 75 minutes/week of vigorous-intensity PA, or a combination of both. Perform strength training at least two days a week and other types of training such as balance[54].

Chart 3. Continued...

STUDIES	Physical Activity Recommendations - Adults and Older Adults	
	WHO	ACSM
Meira et al.[27]	86.9% of participants met the recommendations before the pandemic, during the pandemic, only 65.6% met the recommendations.	
Schuch et al.[46]	53.4% of the participants met the recommendations.	
Rogowska et al.[47]	46.49% of participants met the recommendations before the pandemic. During the pandemic, only 43.19% met the recommendations.	
Xiang et al.[48]	University students met the recommendations - the mean (SD) of time spent in vigorous activity, moderate activity, and walking were 90.09 (78.53), 133.34 (79.70), and 157.45 (95. 31) min/week, respectively.	
Lesser & Nienhuis[49]	36,6% of the participants met the recommendations.	
Jacob et al.[50]	63,41% of the participants met the recommendations.	
Ozdemir et al.[51]	37.5% of the participants met the recommendations, with a mean consumption of 875 ± 1588 MET-min.	

Note. World Health Organization (WHO) – Adults and older adults should perform 150 to 300 minutes/week of moderate and 75 to 150 minutes/week of vigorous-intensity PA. Strength training for at least two days for large muscle groups. For older people, training in multicomponent activities at least 3 days a week is recommended26. American College of Sports Medicine (ACSM) – Adults should perform 150 minutes/week of moderate and 60 minutes/week of vigorous-intensity aerobic PA. For strength and endurance improvement, train large muscle groups at least two days a week. Older adults should perform 150 minutes/week of moderate-intensity and 75 minutes/week of vigorous-intensity PA, or a combination of both. Perform strength training at least two days a week and other types of training such as balance[54].

DISCUSSION

The present systematic review investigated the effect of exercise and PA on anxiety symptoms during the COVID-19 pandemic. Main findings revealed that exercise and PA are important factors for reducing anxiety levels, and that greater intensity, duration, and frequency were related to greater effects. Vigorous-intensity activities[46] or longer duration[50] were more effective for this result than moderate-intensity activities.

Disarrangements resulting from the COVID-19 pandemic have had a negative impact on individuals mental health, such as, increasing the incidence of symptoms of anxiety and depression[12,55]. Because of locomotion restrictions, an increase in sitting time and sedentary behavior[56] were major reasons for the reduction of exercise and physical Activity[57] in a large portion of the population, even in those who were already physically active. Time spent using screens and general sedentary behavior[58,59] are risk factors associated with increased anxiety[53].

Physical activity is considered a positive mediator of anxiety[60,61] and even an individual with generalized anxiety disorder can sustain high levels of PA, for example by activating compensatory mechanisms[62] and regulatory systems of the sympathetic and parasympathetic systems, regulating the stress response through the hypothalamic-pituitary-adrenal (HPA) axis[63], in addition stimulating the brain-derived neurotrophic factor (BDNF), which can balance the neurobiological responses to stress[64] in cortical and limbic regions of the brain, such as in the hippocampus, where in the BDNF Val66Met polymorphism (which decreased BDNF expression and signaling) has been associated with reduced hippocampal volume and executive function, increased susceptibility to anxiety, and depressive behaviors[65]. In addition, the positive effect of physical activity includes increased blood flow to the hippocampus and an increase in size, as well as decreased neuro-inflammation[66], an increase in neuroprotection, and overpowering the negative effects of anxiety[67,68].

The lowest engagement in PA was seen in the study by Lesser and Nienhuis, with 36.6% [49] of participants meeting the recommendations proposed by the WHO or ACSM, while the highest engagement was observed in the study by Haider et al.[45], with 76.3%, both during the lockdown[45]. Such a discrepancy shows how much people diverged in the ways to keep themselves active according to the location. The non-commitment of all participants to the minimum PA recommendations may be one of the factors related to some divergent results, in studies that did not show differences in the anxiety profile in individuals who performed PA[19,51,69,70]. Overall, participants who meet recommended PA guidelines are less likely to experience greater anxiety than those who do not[53,71].

Evidence from a systematic review conducted by Wolf et al.[72] suggests that people who regularly perform PA with greater volume and frequency and maintain a stable PA routine have fewer symptoms of depression and anxiety. For example, those who reported the most total time spent in moderate to vigorous PA were 12 to 32% less likely to experience depressive symptoms and 15 to 34% less likely to experience anxiety[72].

The study conducted by Kim et al.[73] found that compared to the sedentary group (0-600 METs-min/week), individuals who achieved 600-6000 METs-min/week had a significantly lower risk of anxiety. After stratifying the data by sex, optimal PA ranges were 600 to 9,000 METs-min/week for men, but 1,200 to 3,000 METs-min/week for women. Furthermore, engagement in more than 6,000 METs-min/week was found to be not associated with higher risk of anxiety symptoms, suggesting a specific PA dose-response regardless of the type of activity practiced. In this sense, a cross-sectional study, which reported that people who were not practicing PA during COVID-19 confinement presented a higher level of stress, anxiety, and depression, highlighting the importance of home physical training to reduce the impacts of physical inactivity due to confinement measures, due to the pandemic situation on mental health[74].

As identified by the self-reports of participants in the studies addressed, the specifications of PA in terms of frequency and duration were crucial to reduce anxiety during the COVID-19 pandemic. In fact, other studies and institutions advocate the practice of frequent and prolonged PA. Both WHO and ACSM have recommended at least 150 minutes per week of moderate to vigorous PA and, during the COVID-19 pandemic, have suggested people to maintain their usual levels of PA. As observed in Chart 3, there was a reduction in the practice of PA due to social restrictions. Evidence supports the importance of regular PA practice in the prevention and treatment of chronic diseases, cognitive decline, improvement of the immune system and increased longevity[75]. The COVID-19 pandemic reinforced the relevance of PA for physical and mental health, mainly because of PA reduction and increased sedentary behavior, especially due to social isolation protocols[76]. Physical inactivity and sedentary behavior were related to the most severe outcomes of COVID-19[77], especially for the elderly who presented themselves as a risk group[78]. The low-cost and low-risk nature of PA shows that it should be implemented in public policies during pandemics.

According to a study conducted with Australians who underwent three data collection periods (April, July, and August 2020), people participating in at least 150 minutes of moderate or vigorous physical activity per week had significantly higher resilience scores than those not participating in PA. As resilience is a response to persistent stressors, like the COVID-19 pandemic[79], it can vary based on what individuals are capable of coping with[80]. Interventions that aim to minimize psychological distress can be designed with an understanding of resilience and its changes over time[81,82].

Mental health and well-being are associated with the behaviors we adopt throughout life, so PA has been a positive way to maintain mental health during periods of social isolation[33]. A study comparing the effects of isolation in New Zealand and the United Kingdom found that the as more PA practiced and the less sedentary behavior, the better the perception of well-being and the lower the DASS-9 score[32,33].

It is worth mentioning that the prevalence of anxiety and depression may vary in these surveys, due to the methodological heterogeneity between the studies. Wu et al.[83] found that the prevalence of anxiety ranged from 6.3% to 87.5% in 53 studies with seven populations (I^2 = 99.6%), and the point prevalence of depression ranged from 3.1% to 87.3% among 48 studies and seven populations (I^2 = 99.6%)[83]. The I^2 values presented in both studies, above 99%, show the degree of heterogeneity that exists.

These are the main limitations of this systematic review which, in addition to the disparity in the data of the analyzed studies, could not provide sufficient quantitative information to conduct a meta-analysis. Finally, the absence of experimental studies limits us to cautious statements about the level of PA and anxiety. If, on the one hand, vigorous and moderate intensity as well as continuous frequency of at least three times weekly can mitigate anxiety, on the other hand, light exercise may not have the same effect. Nevertheless, the observational nature of the analyzed studies, which were the majority in this systematic review, makes it impossible to establish cause-and-effect relationship.

CONCLUSION

Despite the positive consequence of physical activity for the reduction of anxiety symptoms during the COVID-19 pandemic, the results of the present systematic review are still inconclusive. However, it is worth mentioning the importance of intensity, session duration and weekly frequency, which, in some studies, showed better effects in more active individuals, suggesting a proportional dose-response relationship of physical activity on anxiety. The higher the intensity and frequency of PA, the lower the risk of developing anxiety symptoms. Taking part in vigorous physical activity for at least 15 minutes per day may relieve anxiety symptoms.

COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

This research is in accordance with the standards set by the Declaration of Helsinki

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conceived and designed the experiments: IRD; EOB; LFFF; LLL; EHES; AMBP; FOS; FSMM; RSMJ. Performed the experiments: IRD; EOB; LFFF; LLL; EHES; AMBP; FOS; FSMM; RSMJ. Analyzed the data: IRD; EOB; LFFF; LLL; EHES; AMBP; FOS; FSMM; RSMJ. Contributed reagents/ materials/analysis tools: IRD; EOB; LFFF; LLL; EHES; AMBP; FOS; FSMM; RSMJ. Wrote the paper: IRD; EOB; LFFF; LLL; EHES; AMBP; FOS; FSMM; RSMJ.

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SUPPLEMENTARY MATERIAL

Supplementary material accompanies this paper.

Supplementary File 1: Free access in https://osf.io/ykz6v/

This material is available as part of the online article from http://www.scielo.br/rbcdh