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Review Article

MENTAL HEALTH AND PHYSICAL ACTIVITY DURING THE OUTBREAK OF COVID-19: ANALYSIS OF RAPID RESPONSE RESEARCH USING A SYSTEMATIC REVIEW

SAÚDE MENTAL E ATIVIDADE FÍSICA DURANTE O SURTO DE COVID-19: ANÁLISE DA PESQUISA DE RESPOSTA IMEDIATA USANDO REVISÃO SISTEMÁTICA

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RESUMO

A rápida resposta à pandemia da COVID-19 mudou a vida das pessoas de forma abrupta, com a diminuição da atividade física (AF). Essa situação levou a uma série de estudos que exploraram o impacto das restrições na saúde mental (MH) e os possíveis benefícios da AF. Nosso objetivo foi avaliar como a resposta rápida da pesquisa gerou evidências adequadas para orientar a resposta às restrições da COVID-19, a fim de informar respostas geradoras de evidências em futuras emergências de saúde. Para isso, foi realizada uma revisão sistemática, abrangendo 17 artigos publicados durante os primeiros seis meses da pandemia (março a agosto de 2020), com foco predominante na saúde mental e sua associação com a AF. Foi observada na literatura uma associação positiva entre AF e saúde mental, particularmente em relação à depressão, estresse e bem-estar. No entanto, a variação nos resultados e a influência de fatores contextuais ressaltaram a necessidade de consenso metodológico em pesquisas de emergência. Um atraso notável na publicação de pesquisas de determinadas regiões gerou preocupações sobre a representação equitativa. Esse atraso poderia introduzir um viés, devido a uma proporção substancial de pesquisas disponíveis provenientes de países desenvolvidos. É importante ressaltar que as pesquisas publicadas durante os primeiros seis meses enfatizaram predominantemente a morbidade na avaliação da saúde mental, embora as evidências defendam uma abordagem mais holística. Como o mundo continua a enfrentar crises imprevistas, essas descobertas sugerem que a pesquisa de emergência deve levar em conta a diversidade do contexto e promover uma compreensão mais abrangente da saúde mental além dos sintomas psicopatológicos. Essa abordagem é essencial para maximizar o impacto dos recursos de pesquisa na resposta a emergências e garantir uma representação científica equitativa.
Palavras-chave: Psicologia; Bem-estar; Depressão, Ansiedade, Coronavírus, Qualidade de vida

ABSTRACT

The rapid response to the COVID-19 pandemic changed people's lives abruptly, causing decreased physical activity (PA). This situation led to an array of studies exploring the impact of restrictions on mental health (MH) and the potential benefits of PA. We aimed to evaluate how the rapid research response generated adequate evidence for guiding the response to COVID-19 restrictions, in order to inform evidence-generating responses in future health emergencies. For this, a systematic review was conducted, encompassing 17 articles published during the first six months of the pandemic (March to August 2020), with a predominant focus on MH and its association with PA. A positive association between PA and MH, particularly regarding depression, stress, and well-being, was observed in the literature. However, the variation in outcomes and the influence of contextual factors underscored the need for better methodological consensus in emergency research. A noticeable gap in published research from certain regions highlighted concerns about equitable representation. This disparity could introduce bias, due to a substantial proportion of available research originated from industrialized and developed nations. Importantly, the published research during the first six months predominantly emphasized morbidity in the assessment of MH, though evidence advocates for a more holistic approach. As the world continues to face unforeseen crises, these findings suggest that emergency research must account for context diversity and promote a more comprehensive understanding of MH beyond psychopathological symptoms. This approach is essential for maximizing the impact of research resources in emergency response and ensuring equitable scientific representation.
Keywords: Psychology; Well-Being; Depression, Anxiety, Coronavirus, Quality Life

Introduction

In January 2020, the World Health Organization (WHO) declared COVID-19 a Public Health Emergency of global concern, subsequently giving it the status of pandemic in March of the same year [1]. Governments worldwide responded with a variety of measures, including

lockdowns, to curb the virus's spread. The early months of the pandemic were marked by significant restrictions on social interactions. Understanding the impact of these restrictions on public health, including mental and physical well-being, remains a vital research focus. This was particularly pertinent during the critical initial phase of the pandemic, from March to October 2020, when the WHO recommended a range of restrictive measures [2].

These restrictions transformed daily routines and behaviors across age groups. Increased screen time and sedentary behavior became common [3.] Adverse effects on nutritional health and reduced physical activity (PA) were observed [4]. Additionally, stress-related symptoms, including fear, insomnia, and anxiety, became prevalent [5]. The fear of contagion and uncertainty about the future led to feelings of loneliness and financial concerns [6]. Even athletes, though less affected, reported some psychological symptoms [7].

Physical Activity (PA) has been associated with reduced depressive symptoms in the general population [8]. Recent studies reveal positive correlations between PA and mental well-being [9], especially when the activity is of moderate-vigorous intensity [10]. Engaging in outdoor exercise and limiting screen time also positively influences self-perception of MH [8]. In older adults, PA contributes to emotional well-being and supports healthy aging [11]. In children and adolescents, for example during social restriction, some results showed that when physical activity decreases, there is an increase in time spent on screen [12,13]; previous works have indicated that PA strengthens cognitive functioning in children[14].

However, while there's a growing body of evidence suggesting the benefits of PA on MH, there is a lack of consensus on the research methods to evaluate both PA (modality, intensity, and dosage of PA) and mental health (MH). This brings us to the central focus of our paper. The use of systematic reviews to identify knowledge gaps and the need for further research. While existing evidence points toward the beneficial effects of PA on MH, the field still lacks a standard convention to make studies comparable and to achieve internal and external validity (i.e., study conclusions represent the truth status of the population) [15.]

To illustrate this issue, we conducted a systematic review of studies that aimed to associate PA and MH during the initial months of the Covid-19 outbreak. Our principal aim was to evaluate how the swift research response generated adequate evidence for guiding future responses to COVID-19 restrictions. Our goal is to pinpoint areas of improvement in preparation for potential new emergencies.

Method

The present study is a systematic review conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol [16,17]

Databases and Search Strategy

To gather relevant literature, we conducted searches in electronic databases, including SCOPUS, PubMed, Web of Science (WOS), PsyNet, and Scielo. We used August 27, 2020, as the reference date, corresponding to the initial assessment conducted by the WHO [1]. We restricted our search to full-text articles in English or Spanish published between 2019 and 2020.

Our search strategy employed MeSH terms, combining ("physical activity" OR "physical exercise" OR "acute exercise" OR "isometric exercise" OR "aerobic exercise" OR "training exercise" OR "active living" OR "physical fitness" OR "exercise") AND ("health" OR "physical health" OR "health status" OR "health behavior" OR "well-being" OR "mental health" OR "emotions") AND ("pandemic" OR "COVID-19" OR "SARS-CoV-2" OR "coronavirus infections" OR "coronavirus diagnosis" OR "disease transmission").

Selection of relevant literature

Inclusion criteria encompassed observational studies, both cross-sectional and longitudinal, conducted during the COVID-19 outbreak with human populations, irrespective of age or country. These studies were required to include measures of PA and report an association between PA and MH. A comprehensive search was conducted to identify potential studies, and databases used included SCOPUS, PubMed, Web of Science, PsyNet, and Scielo. Detailed keywords used for each database are available in Supplementary Material (Supplementary 1).

A team of three researchers (AJM, SO, and JO) conducted the database search, following which titles and abstracts were independently reviewed to assess articles according to eligibility criteria. This process considered the risk of bias in the included studies, aligning with the tool established by the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) initiative [18]. Potentially eligible studies were examined in their entirety, and disagreements were resolved by an independent advisor in the presence of all three reviewers. Given the novelty of the study, no search of gray or non-indexed literature was conducted, and no additional searches were performed using a snowball strategy.

Quality assessment and data extraction

Quality assessment and data extraction were carried out by three researchers (AJM, SO, and JO) independently. The quality assessment was based on the STROBE guidelines for observational methodological designs [18]. The evaluation form included 31 variables to assess the adherence of manuscripts to the STROBE guidelines across various sections: (a) title and abstract: the title, objective, method, and main result were indicated; (b) introduction: reasons, theoretical foundations, background, and objectives of the study were evaluated; (c) method: criteria such as design, data collection information, description, sampling strategy, sample size, loss of participants, identification and operationalization of variables (response, predictors, confounders, modifiers, methods of valuation of variables, e.g., mean), treatment of quantitative variables in the analyses, techniques for analyzing groups and interactions, and specification of missing data were evaluated; (d) results: characteristics of participants (e.g., sociodemographic, clinical, and social variables), description of summary measures, and reports of measures of unadjusted estimates and their precision (e.g., 95% CI); (e) discussion: summary of main results, discussion of limitations and possible sources of bias, interpretation of results based on objectives, limitations, analyses, and similar studies, and generalizability of results; and (f) funding information. These variables were dichotomously categorized as 'yes' or 'no' depending on whether the articles met the quality attribute, such as the presence of each section. Data extraction encompassed general information about the article (e.g., title, author, year, article type, nationality), population characteristics (sample size, demographic features, comorbidities, alcohol or cigarette consumption), PA intervention details (instrument, PA modalities, intensity and duration classification, sample size), and MH outcomes along with their statistical associations with PA (construct instrument, sample size, mean, standard deviation, p-value, and Odds Ratio [OR]). This data extraction was conducted by the same researchers (AJM, SO, and JO) (see, Supplementary 2).

Results and Discussion

The selection process for articles in this systematic review is illustrated in Figure 1. Our initial database search yielded a total of 357 articles. After removing 77 duplicate records and excluding 280 articles that did not meet our inclusion criteria, 56 articles were selected for a full-text assessment. Subsequently, 40 articles that either did not report or failed to

establish an association between the PA intervention and MH outcome variables were excluded. Additionally, two articles that have not yet produced conclusive results as of the present date were omitted (Supplementary 2). As a result, 17 articles met the criteria for inclusion in the qualitative analysis (Table 1).

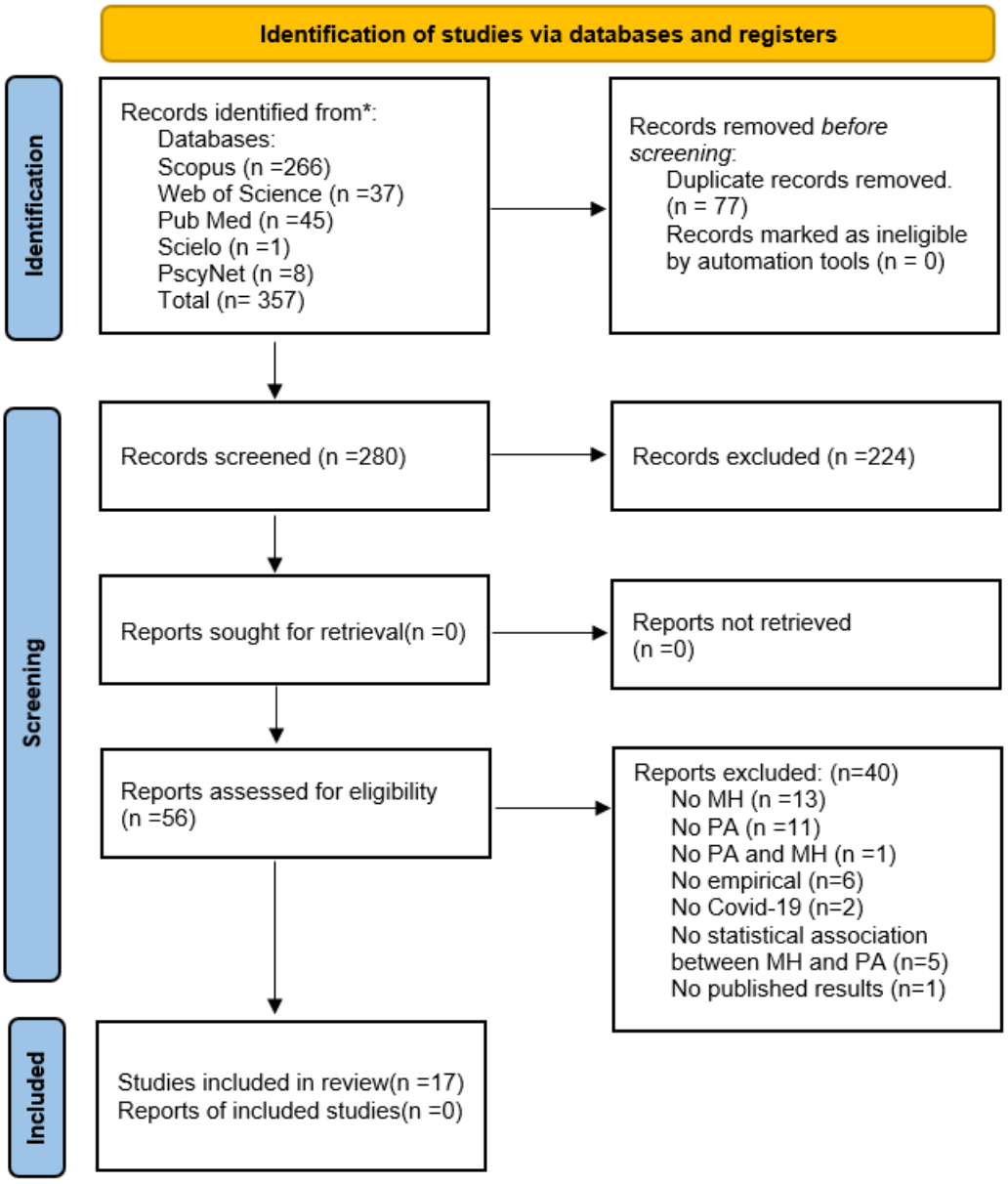

Figure 1. Flowchart of articles on the association of Physical Activity and Mental Health during Covid-19.
Source: Authors

Table 1. *Sociodemographic data and quality assessment of the included articles*

	Sample included in analysis			**Sociodemographic data**						**Quality assessment (STROBE)**	
Authors	***Total***	***Women***	***Men***	***National ity***	***Sample of alcohol and tobacco use***	***Ethnicity***	***n rural population***	***n urban population***	***Occupation of participants***	***%***	***Score***
García, et al [19]	150	88	62	Spain	*	*	*		*	56.6	5.6
Lesser & Nienhuis [20]	1098	871	215	Canada	*	Natives, Caucasian	146	502	*	76,6	7.6
Choi, et al. [21]	229	131	98	South Korea	*	*	*	*	*	76,6	7.6
Qin, et al [10]	12107	6474	5636	China	*	*	8407	3700	Students	70.0	7
Zhou, et al [22]	4805	4805	*	China	*	*	*	*	Students	86,6	8.6
Wang, et al [23]	2289	1113	1176	China	Alcohol: 478 Tobacco: 237	*	*	*	*	86,6	8.6
Schuch, et al. [24]	937	677	260	Brazil	*	*	*	*	*	66,6	6.6
Jacob L. et al [25]	902	575	327	U. Kingdom	Alcohol:670 Tobacco: 106	*	*	*	*	63,3	6.3
López-Bueno, et al. [26]	2250	1232	1018	Spain	Alcohol:1616 Tobacco: 322	*	*	*	*	90.0	9
Hu, et al. [27]	1033	498	535	China	*	*	303	730	*	96,6	9.6
Şenışık et al. [7]	571	199	372	Turkey	*	*	*	*	Athletes	60.0	6
Duncan, et al. [28]	3971	2746	1125	USA	*	*	*	*	*	80%	8
Zhang, et al. [5]	66	41	25	China	*	Han, Minority	15	51	Students	93.3	9.3
Stanton, et al. [29]	1483	999	484	Australia	Alcohol: 1090 Tobacco: 172	*	*	*	*	80.0	8
Maugeri, et al. [9]	2524	1426	1098	Italy	*	*	*	*	*	73.3	7.3
Ellis, et al. [30]	1054	805	230, other: 19	Canada	*	Asian, African, American, Africans, Latinos	*	*	Students	80	8
Callow, et al [8]	1046	834	212	Canada	*	Whites, African American, Hispanics, Asian, American indian, Alaska, native Hawaiian, Pacific Islander	*	*	Elderly	96.6	9

Note: All studies are published in 2020. * = They do not present sociodemographic data. STROBE score: ≤6 (n = 4); 7-8 (n = 9); 9-10 (n = 4). Total items = 30; Total mean% 78.4
Source: authors.

The geographic distribution of the included studies was as follows: North America accounted for five studies (29.4%), Asia for six (35.3%), Europe for three (17.6%), Oceania for one (5.89%), the Middle East for one (5.6%), and South America for one (5.6%). This result suggests a publication bias toward high-income countries or late publication of research findings for developing countries. Publication bias is a major concern in health care as biased evidence available to decision makers may lead to suboptimal decisions that can negatively impact global public health [31].

Quality assessment of selected articles

To assess the quality and potential risk of bias in the selected articles, we employed 31 variables adapted from the STROBE guidelines [(18)]. These variables, detailed in Supplementary 2, were used to evaluate each article's level of compliance with the STROBE guidelines. The compliance percentage was calculated, enabling us to rate and rank the articles based on seven criteria (see Figure 2). The highest achievable score for each article was 10, and the classification intervals were as follows: Low (≤6 points), High (7-8 points), and Excellent (≥9 points). In summary, our assessment revealed the following distribution among the selected articles:

- *Low Quality (n=4):* Articles by García-Fernández et al. [19], Jacob et al. [25], Schuch et al. [24], and Şenışık et al. [(7)] fell into this category.
- *High Quality (n=9):* Articles authored by Choi & Bum [21], Duncan et al., [28], Ellis et al., [30], Lesser & Nienhuis [20], Maugeri et al., [9], Qin et al. [10], Stanton et al. [29], Wang et al. [23], and Zhou et al. [32] met the criteria for this classification.
- *Excellent Quality (n=4):* Articles by Callow et al. [8], Hu et al. [2], López-Bueno et al. [26], and Zhang et al. [5] exhibited the highest quality in terms of adherence to the STROBE guidelines.

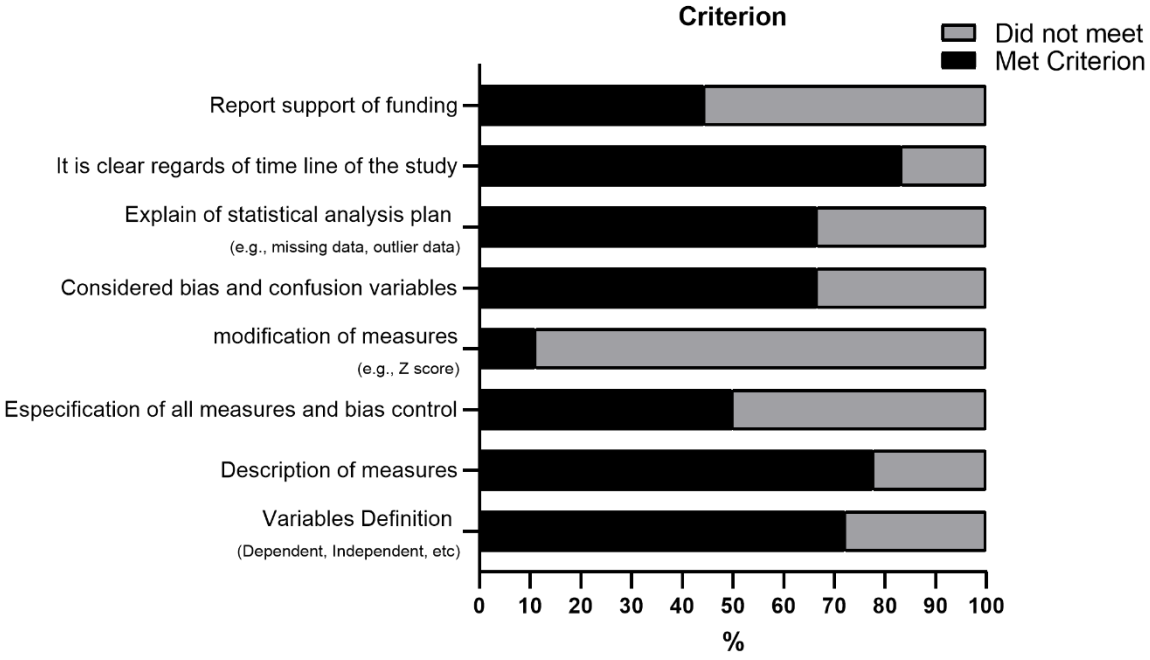

Figure 2. STROBE compliance level of included articles in the systematic review.
Source: Authors

The score heterogeneity underscored the need for improved standardization and transparency in reporting, especially in these critical aspects of research methodology. Achieving greater consistency in the following areas would enhance the overall quality and

comparability of studies in the field. The greatest heterogeneity in scoring for quality attributes was observed in several key areas:

- *Modifications of Measures (88.9%):* This category constituted the most significant variation in scoring, reflecting diverse approaches and alterations made to the measurement methods employed in the included articles.
- *Specification of All PA and MH Measures and Possible Confounding Variables (50%):* A notable level of diversity was observed in specifying all measures related to physical activity (PA), mental health (MH), and potential confounding variables. Variability in the comprehensiveness of reporting in these areas was apparent.
- *Explanation of the Analysis Plan, Including Handling Missing and/or Outlier Data (33.3%):* There was considerable disparity in how the articles explained their analysis plans, particularly in addressing missing or outlier data. The level of detail and transparency in these aspects varied among the selected articles.

The majority of (*n*=16) the studies employed a cross-sectional design and only one study adopted a longitudinal design. While cross sectional studies are valuable in the search for rapid evidence and hypothesis generation, there are some problems inherent to the design, such as reverse causation-(i.e., not knowing what the cause is and what the effect is) that limits the value of evidence provided by the study [15]. The sample sizes across the studies varied widely, ranging from 66 to 12,107 participants encompassing all age groups. The cumulative sample size across all included studies totalled 36,515 individuals.

In terms of demographic data reporting, 5 of the studies did not provide any information about the characteristics of the studied populations (Table 1). The lack of demographic information is a barrier to establishing effective interventions. It has been reported that the impact of decreased PA could be greater for children and adolescents [33]. Likewise, the literature points out that factors such as gender, education, and socioeconomic position are strong determinants of MH outcomes. It is necessary to include these factors when evaluating the impact of PA on MH [34].

All articles in this systematic review indicated that PA was assessed from self-reports. The restrictions of the countries as a preventive measure against COVID-19 limited the researchers' data collection strategies. The use of electronic resources was the main means to obtain the data. The information collected through PA self-reports is subjective and fails to clearly discriminate the possible scales of intensity. It was clear that there is no consensus on the domain of PA, nor the context in which PA is performed (e.g.in transport, at home, school sports, PA in free time, etc.) [35].

For the measurement of PA, 29.4% of the studies employed ad-hoc questionnaires, 35.29% used the International Physical Activity Questionnaire (IPAQ), and the remaining 35.3% utilized other validated questionnaires. Although the IPAQ instrument has well-defined psychometric properties [36]. A dose-response discrimination including duration, modality, and type of PA is also desirable. The reviewed studies had variabilities from walking and gardening to physical exercises with weight (Table 1). Knowing PA intensities is necessary to determine its effects on MH. From the collected data, it may not be possible to provide a consensus regarding the PA intensity necessary to observe the impact on MH. Currently, available evidence indicates that moderate-vigorous intensities seem to be the most favorable for MH outcomes as well as cognitive and emotional processes [37,38]. Only one study established that 2500 METs (Metabolic Equivalent of Task) are required to achieve a positive impact on the symptoms of stress, depression, anxiety, quality of sleep, and aggressiveness [5].

The diverse representation and varying methodologies to evaluate PA and MH within the included articles highlight the need for standardized reporting and measurement techniques, enhancing the comparability of research findings in this domain.

Evaluation of Mental Health

Mental health from a psychopathological perspective is the primary focus of the studies examined in this systematic review, with a strong emphasis on constructs like anxiety, depression, and stress. This resulted in a morbi-centric approach in the context of the COVID-19 outbreak, where psychopathological symptoms took center stage. Nonetheless, MH should also be considered and studied from a promotional health perspective. Additional constructs of MH related to PA could include cognitive processes through the body as embodied cognition frameworks [39,40]. Evidence indicates that PA may reduce the perception of a state of mind [26] and favor the perception of well-being [9,25,27.]

Mixed results regarding the associations between PA and MH were found in the included studies. The heterogeneity of these results might be explained by limitations in study design, such as the use of non-validated instruments to assess PA and mental health, as well as the challenges of conducting in-person research during a pandemic. Additionally, the heterogeneity of the study samples, which included older adults, athletes, students, and others, may also contribute to the variations in results. The favorable effect of PA on MH in the context of the COVID-19 pandemic has been confirmed in more recent research [33,41.]

Our analysis focused on four groups of constructs: Stress, Anxiety, Depression, and Well-being, Quality of Life, and Quality of Sleep.

Stress

One of the five studies that included stress measurements adopted a longitudinal observational design with the student population [5], while the remaining four studies employed cross-sectional designs. The study by Şenışık et al. [7], specifically focused on athletes, while the rest examined general populations (see Table 2). Interestingly, the population aged over 60 years tended to exhibit lower levels of stress and depression when compared to younger age groups [19,29]. Participants who reported a negative change in PA were more likely to experience higher stress symptoms [29]. Moreover, PA was identified as a reliever of negative feelings in one of the studies [5]. Notably, one of the studies reported a significant association between stress scores and decreased PA levels [28].

Table 2. *Stress - Physical Activity (PA) and Mental health*

Author	Instrument for PA assessment	Intensity and duration of PA	Type of PA	Instrument Stress	Statistical Association	*Value p*	*Value OR*	Outcomes
García, et al. [19]	Ad-hoc			ASDI	ANOVA	0.490		PA was not associated with stress.
Şenışık et al. [7]	IPAQ	MET's per week	Individual sports, Group sports	DASS-21	Rho Spearman	0.021		Negative correlation between the level of PA and symptoms of stress.

Author	Instrument for PA assessment	Intensity and duration of PA	Type of PA	Instrument Stress	Statistical Association	*Value p*	*Value OR*	Outcomes
Zhang, et al. [5]	IPAQ	MET's PA-V		DASS-21	Mixed–effect model with random effect	.090		PA showed no effects on stress.
Stanton, et al. [29]	AAS	Physically active (M-V) Physically inactive (L)	Gardening, Walk, General PA	PSS	Linear regression	<.001	1.08	A negative change in the PA, was associated with greater stress levels.
Duncan, et al. [28]	Ad-hoc			DASS-21	Multiple linear regression	<.001		An association between decreased PA and stress.

Note: MH= Mental Health. PA= Physical Activity. METs= Metabolic Equivalent of Task. Intensities PA: L=low, M=Moderate, V=Vigorous.
Instruments: HARS= Hamilton Anxiety Rating Scale. IPAQ= International Physical Activity Questionnaire. AAS= Active Australia Survey. ASDI= Acute Stress Disorder Scale, DASS-21= Depression Anxiety Stress Scale. PSS= Perceived Stress Scale.
Source: authors.

Anxiety

Seven studies within our selection reported a significant impact of physical activity (PA) on reducing anxiety [7,20,24–26,28,29] (see Table 3), indicating a negative association between moderate-vigorous PA and anxiety levels, assessed with IPAQ or self-report [25,28.] Additionally, outdoor PA was highlighted as having an even more favorable impact on reducing anxiety [20]. However, two studies reported a non-significant association between PA and MH related to anxiety [8,19]. Moreover, Lesser & Nienhuis [20] found no significant differences when comparing active and inactive groups in terms of anxiety levels and time (minutes) dedicated to moderate-vigorous PA.

Table 3. Anxiety - Physical activity and mental health

Author	Instrument for PA assesment	Intensity and duration of the PA	Type of PA	Instrument Anxiety	Statistical Association	*Value p*	*Value OR*	Outcomes
García et al. [19]	Ad-hoc			HARS	ANOVA	< .250		Regular exercise had no significant impact on anxiety.
Şenışık et al. [7]	IPA	MET's	Group sports, individual sports	DASS-21	Spearman	< .006		Negative correlation between PA levels and anxiety symptoms.

Author	Instrument for PA assesment	Intensity and duration of the PA	Type of PA	Instrument Anxiety	Statistical Association	*Value p*	*Value OR*	Outcomes
Zhang, et al. [5].	IPAQ	MET's PA (V)		DASS-21	Mixed model with random effects control		-0.03 (Every 100 MET Increase in AF)	PA was inversely associated with negative emotions. The effect of PA was not significant on anxiety.
Stanton, et al. [29]	AAS	Physically active (M-V) Physically inactive (L)	Gardening Walk General PA	DASS-21	Logistic regression	< .001	1.09	A negative change in PA, and increased consumption of alcohol and cigarettes, were associated to have greater levels of anxiety.
Duncan, et al. [28]	Ad-hoc			DASS-21	Multiple linear regression	< .001		A significant association between decreased PA and anxiety.
Lesser & Nienhuis [20]	GLQ	Physically active (M-V) Physically inactive (L)	Walking, Biking, Running Weight Training, Videos or Online Classes, Yoga, Workout at Home. Others.	GAD-7	t student n Independent	0.45		There was no difference in anxiety scores between active and inactive participants.
Zhang, et al. [5]	IPAQ	PA (V)		DASS-21	Mixed model with random effects control	-0.03 (Every 100 MET Increase in PA)		Although PA was inversely associated with negative emotions, there was no effect on anxiety.
Schuch et al. [24]	MVPA	M		BAI	Linear regression	.026	0.72 (> 30 min x day)	Performing PA with a moderate to vigorous intensity and duration was found to be a protective factor against anxiety.
		M-V		BAI		0.27	0.70 (>15 min x day)	
		V		BAI		0.57	-	

Author	Instrument for PA assesment	Intensity and duration of the PA	Type of PA	Instrument Anxiety	Statistical Association	*Value p*	*Value OR*	Outcomes
Jacob, et al. [25]	Ad-hoc	Physically active (M-V)		BAI	Chi-square	< .001	0.88	PA was found as a protective factor against anxiety.
López-Bueno, et al. [26]	PAVS	Physically active (M-V Physically inactive (L)		Ad-hoc	Logistic regression		0.66	150 minutes of physical activity a week was a protective factor against anxiety.
Callow, et al. [8]	PASE	Physically active (M-V) Physically inactive (L)	Walking outdoors, recreational aerobics, strength training, gardening, others.	GAS	Multiple linear regression	.629		PA was not a significant predictor of anxiety.
Jacob, et al. [25]	Ad-hoc	Physically active (M-V) Physically inactive (L)	.	BAI	Chi-square	< .001	0.88	PA was a protective factor for anxiety.

Note: MH= Mental Health. PA= Physical Activity. METs= Metabolic Equivalent of Task. Intensities PA: L=low, M=Moderate, V=Vigorous. Instruments: HARS= Hamilton Anxiety Rating Scale. IPAQ= International Physical Activity Questionnaire. AAS= Active Australia Survey, DASS-21= Depression Anxiety Stress Scale, GAD-7= Generalized Anxiety Disorder, BAI= Beck Anxiety Inventory, GAS= Geriatric Anxiety Scale.
Source: authors.

Depression

Regarding depressive symptoms, 9 articles were found (see table 4). Our analyses revealed that participants who engaged in more than 30 minutes of PA with moderate or vigorous intensities were less likely to experience depressive symptoms [25]. Furthermore, it was observed that for every 10 minutes of vigorous PA, there was a corresponding decrease of 0.18 points on the Beck Depression Inventory (BDI) [24]. Notably, individuals who reduced their PA levels during the isolation period were at a heightened risk of exhibiting depressive symptoms [24]. A distinction between athletes and non-athletes indicated that non-athletes tended to report higher depression scores [7]. Negative correlations were also evident between PA levels and depression [5,7]. In addition, reports suggested that both light and vigorous PA were associated with a reduction in depression, accounting for covariates like sex, age, and education [8]. Furthermore, PA emerged as a protective factor against depression in a separate study [30].

Table 4. Depression - Physical Activity (PA) And Mental health

Author	Instrument PA	Intensity and duration PA	Type of PA	Instrument Depression	Statistical Association	*Value p*	*Value OR*	Outcomes
García et al. [19]	Ad-hoc			BDI	ANOVA	0.23		Regular exercise had no significant impact on depression
Zhou, et al. [22]	Ad-hoc	< 30min, 30-60min, >60min		CES-D	Logistic regression	0.01	1.64	Less PA was associated with a higher risk of developing depression.
Jacob, et al. [25]	Ad-hoc	V-M		BDI	Chi-square	0.001	0.85	PA was a protective factor for depression.
Şenışık et al. [7]	IPAQ	MET's	Individual sports, Group sports	DASS-21	Spearman	0.037		Negative correlation between the level of PA and depressive symptoms.
Zhang, et al [5].	IPAQ	PA vigorous		DASS-21	Mixed model with random effects control	.,05		PA was significantly associated with depression. The dose-response to reduce negative emotions was given with a physical quantity of 2,500 METs per week
Stanton, et al. [29]	AAS	Physically active (M-V) Physically inactive (L)	Gardening, Walk, General PA	DASS-21	Linear regression	<0.001	1.08	A negative change in PA, and increased consumption of alcohol and cigarettes, were associated with anxiety levels.
Ellis, et al. [30]	IPAQ	V M L	Running, brisk walking, etc.	BSI	Hierarchical regression	0.12		There was not a correlation between PA nd depression.
Callow, et al [8]	PASE	Physically active (M-V) Physically inactive (L)	Outdoor walking, strength exercise, etc	GDS	Multiple linear regression	0.01		Low and vigorous physical activity was a significant predictor of depression.
Schuch, et al. [24]	MVPA	M		BDI	Linear regression	. 025	0.71(15 min/day)	Performing PA with an intensity of moderate to vigorous or vigorous was a protective factor against depression.
		M-V				0.70	0.60 (>15 min/day)	
		V				.002		

Note:MH= Mental Health. PA= Physical Activity. METs= Metabolic Equivalent of Task. Intensities PA: L=low, M=Moderate, V=Vigorous. Instruments: IPAQ= International Physical Activity Questionnaire. AAS= Australia Active Survey. PASE= Physical Activity Scale for the Elderly. BDI= Beck's Depression Inventory. CES-D= Center for Epidemiological Studies-depression Scale. DASS-21= Scale of stress, anxiety and depression.
Source: authors.

Well-being, quality of life, and quality of sleep

In addition to stress, anxiety, and depression, this systematic review also encompassed other MH variables, including positive constructs such as psychological well-being, quality of life, sleep quality, and positive and negative affect (see Table 5). Psychological well-being emerged as the most frequently examined construct. Results indicated that physically inactive participants tended to report lower well-being scores compared to their physically active counterparts [20]. Additionally, moderate, and vigorous intensities of physical activity were associated with enhanced well-being [25,] while individuals with low levels of physical activity correlated with lower well-being scores [9,27]. Furthermore, quality of life and sleep quality were positively linked to PA[23]. Several other variables were

also examined regarding physical activity. Key findings revealed that performing physical activity led to a reduction in hypochondriasis [21]. Moreover, physical activity was associated with a decreased perception of loneliness [30]. The mood appeared to be affected by confinement [26], but, significantly, it was improved with physical activity.

Table 5. Other constructs (Well Being, Quality of life, Sleep quality, etc.) related to physical Activity and Mental health

Author	Instrument to assess PA	Intensity and duration PA	Type of PA	Other constructs MH (test)	Statistical Association	*Value p*	Outcomes
Şenışık et al. [7]	IPAQ	MET's	Individual Sports, Group Sports	Post-traumatic stress (IES-R)	Spearman	.021	Correlation between PA and Post-traumatic stress level
Zhang, et al [5].	IPAQ	V		Sleep Quality (PSQI)	Mixed model with random effects control	> .05	Association between Sleep quality and PA was not significant.
	IPAQ	V		Aggressiveness (BPAQ)	Mixed model with random effects control	> .05	PA and aggressiveness didn't have a significant association
Lesser & Nienhuis [20]	GLQ	Physically active (M-V) Physically inactive (L)	Walking, Biking, Running, etc.	Well Being (MHC-SF)	t-test	.031	The inactive participants had lowered scores on well-being. However, the inactive participants that increased their PA levels had higher levels of Mental Health
Choi, et al. [21]	Ad-hoc	Play frequency (Rarely, sometimes, often, very often, always)	Home training, walking, running, etc.	Worry about Illness (IAS)	ANOVA	<.001	There was a significant association between the hypochondriasis categories and the type of sport. The people that participated in group sports displayed higher scores than the ones in individual sports on worry about illness, disease phobia, and symptom preoccupation
				Disease Phobia (IAS)	ANOVA	.004	
				Thanatophobia (IAS)	ANOVA	.690	
				Symptom Preoccupation (IAS)	ANOVA	1.000	
Qin, et al [10]	IPAQ	L-M-V		Positive Affect-Negative Affect (PANAS)	ANOVA	.001	There were differences between the positive and negative emotional states and the PA
Wang, et al [23]	IPAQ	L-M-V	V= rope jumping and weight training M= jogging, tai chi, dancing L=walkin, baduanjin, yoga	Quality of life (WHOQOL-BREF)	Linear Regression	.212	PA had a significant impact on the quality of life.
				Sleep quality (PSQI)	Linear Regression	<.001	PA had a significant impact on the quality of life and sleep quality.

Author	Instrument to assess PA	Intensity and duration PA	Type of PA	Other constructs MH (test)	Statistical Association	*Value p*	Outcomes
Jacob L. et al [25]	Ad-hoc	Physically active (M-V)		Well-being (WEMWBS)	Chi -square	<.001	PA had a significant association with Well-being and was a protective factor.
Jacob L. et al [25]	PAVS	Physically active (M-V) Physically inactive (L)		Mood (Ad-hoc /MOOD)	Logistic regression	V group <001	150 minutes of PA/week can reduce the probabilities of having a worst mood.
Hu, et al. [27]	IPAQ	Physically active (M-V) Physically inactive (L)		Well-being (SWB)	Mixed model with random effects control	M group: .020	Insufficient PA was associated with a higher risk of having a worst Well-being.
Maugeri, et al. [9]	IPAQ	L-M High-Active	V= weight lifting, intense aerobic exercise, etc. M= ride bike on a regular rate, doing exercise on the garden	Well-being (PGWBI)	Spearman	L group .054	Positive correlation between vigorous and moderate PA and a positive Well-being.
Ellis, et al. [30]	GLQ	L-M-V	Run, walk fast, walk slow	Loneliness UCLA	Hierarchical regression	0.01	Negative correlation between PA and Loneliness. The model indicates that PA can predict fewer loneliness symptoms.

Note: MH= Mental Health. PA= Physical Activity. METs= Metabolic Equivalent of Task. Intensities PA: L=low, M=Moderate, V=Vigorous. Instruments: IPAQ= International Physical Activity Questionnaire. AAS= Active Australia Survey. DASS-21= Depression Anxiety Stress Scale. PAVS= Physical Activity Vital Sign (PAVS) short version. IES-R= Impact of Events Scale-Revised (Post-traumatic stress symptoms). PSIQ= Pittsburgh Sleep Quality Index. BPAQ= Buss-Perry Aggressive Questionnaire. MHC-SF= Mental Health Continuum-Short Form. IAS= Illness Attitude Scale PANAS= Positive and Negative Affect Schedule. WHOQOL-BREF= The World Organization Quality of Life. WEMWBS= The Short Warwick Edinburgh Mental Wellbeing Scale. SWB= Subjective Well-Being Assessment. PGWBI= Psychological General Well-Being Index. UCLA=Loneliness Scale
Source: authors.

Implications and trends

The initial studies examining the impact of COVID-19 outbreak restrictions on mental health (MH) have yielded generally positive findings regarding the role of physical activity in mitigating depression, stress, and enhancing well-being. Reviewed studies show a strong tendency to consider mental health from a psychopathological perspective and a medical model. The studies focus on investigating the relationship between physical activity and depression, anxiety, and stress. Few studies considered variables such as psychological well-being, emotional well-being, and quality of life. Moreover, there is a compelling need to broaden the perspective of mental health research beyond morbidity and consider a more holistic approach that accounts for overall well-being. This approach would be more in line with the principles of a just and equitable scientific response. Perspectives on health promotion and prevention through physical activity are promising for future work and its potential implications in public policy

According to this review, there is variation in sample sizes among studies, with a predominance of cross-sectional studies, thus precluding causal inferences. In the first year of the pandemic, the possibility of conducting experimental studies was limited due to restrictions implemented by most governments. Another aspect to consider is the

heterogeneity of measures; for some studies, standardized instruments with evidence of validity were used, while others were developed through self-reports. However, it is important to acknowledge the variations in study outcomes and contextual factors that need careful analysis. While researchers responded swiftly to the emergency, the lack of consensus in methodology and the limitations inherent to obtaining data under these unprecedented circumstances have hampered the validity of the conclusions. This, in turn, affects their potential role in informing decision-making processes by governments and other entities.

The COVID-19 pandemic has had a significant impact on the mental health of the global population, and physical activity has been favorably proposed as a possible intervention to mitigate these negative effects on mental health [42]. Nevertheless, assessments of the intensity, duration, volume, and modality of physical activity are not clarified in this review. There seems to be a favorable trend toward aerobic study modalities, yet these results should be taken with caution. Another trend that appears to favor mental health involves moderate-to-vigorous intensities. However, future studies aim to elucidate the effect of intensities on multiple mental health variables. There has been an increase in interest in the relationship between physical activity and mental health during and post-pandemic. Consequently, interdisciplinary and professional approaches are required, involving fields such as psychology, psychiatry, medicine, nutrition, and areas of physical activity and sport. Additionally, complementary methodological designs are needed to better understand the relationship between physical activity and mental health.

Importantly, there was a noticeable delay in the publication of research from countries in Latin America and Africa, raising concerns about the equitable representation of populations in scientific studies. This delay could potentially introduce bias, as a significant portion of the available research is based on populations from more developed countries. Additionally, the prevailing focus on morbidity when assessing mental health is a noteworthy observation. These factors should serve as important considerations for researchers, government agencies, and funding bodies when preparing to respond to future emergencies. Recognizing the limitations and contextual variations is crucial for optimizing the impact of research resources in emergency response efforts and ensuring that scientific knowledge is not only comprehensive but also representative of diverse populations.

Conclusion

In summary, there is increasing evidence that physical activity appears to have a beneficial effect on mental health. Specifically, this review describes results indicating that physical activity reduced symptoms of depression, anxiety, and stress during the first year of the COVID-19 pandemic. However, further research is needed to understand physical activity as a potential tool to promote mental health. The evidence suggests that MH should encompass more than just the absence of disease, much of the research conducted during the COVID-19 pandemic has primarily on psychopathological symptoms.

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