



# Physical activity, anxiety, and depression in workers during the COVID-19 pandemic: systematic review and meta-analysis

Atividade física, ansiedade e depressão em trabalhadores durante a pandemia da covid-19: revisão sistemática e meta-análise

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## ABSTRACT

**Introduction:** Physical activity (PA) has been associated with lower symptoms of anxiety and depression, particularly during crises such as the COVID-19 pandemic. However, evidence regarding this association in working populations remains limited. **Objective:** We assessed the relationship between PA and symptoms of anxiety and depression during the COVID-19 pandemic in working populations. **Methods:** We searched the PubMed and EMBASE databases in April 2024. Eligible studies included observational designs evaluating PA and anxiety or depression symptoms using validated instruments. Risk of bias was assessed by the Newcastle-Ottawa Scale, and meta-analyses were performed using random-effects models to calculate odds ratios (ORs) with 95% confidence intervals (CIs). **Results:** Nine studies (8 cross-sectional and 1 cohort) involving 7,380 workers were included, with healthcare workers comprising 82.7% of participants. PA was significantly associated with reduced anxiety symptoms (OR = 0.69; 95% CI: 0.58 – 0.83;  $I^2 = 0\%$ ). In addition, a significant association was observed between PA and reduced depressive symptoms (OR = 0.56; 95% CI: 0.44 – 0.71;  $I^2 = 31.6\%$ ). **Conclusion:** PA practiced during the COVID-19 pandemic was associated with lower anxiety and depression symptoms in workers from different settings.

**Keywords:** SARS-CoV-2; Anxiety; Depression; Exercise; Occupational health.

## RESUMO

**Introdução:** A atividade física (AF) tem sido associada a menores sintomas de ansiedade e depressão, particularmente durante crises como a pandemia de covid-19. No entanto, as evidências sobre essa associação entre trabalhadores ainda são limitadas. **Objetivo:** Avaliamos a relação entre atividade física e sintomas de ansiedade e depressão durante a pandemia de covid-19 em populações trabalhadoras. **Métodos:** Realizamos buscas nas bases de dados PubMed e EMBASE em abril de 2024. Foram incluídos estudos observacionais que avaliaram atividade física e sintomas de ansiedade ou depressão utilizando instrumentos validados. O risco de viés foi avaliado pela Newcastle-Ottawa Scale, e as meta-análises foram conduzidas com modelos de efeitos aleatórios para calcular odds ratios (OR) com intervalos de confiança (IC) de 95%. **Resultados:** Nove estudos (8 transversais e 1 de coorte), envolvendo 7.380 trabalhadores, foram incluídos, sendo que profissionais da saúde representaram 82,7% dos participantes. A atividade física esteve significativamente associada à redução dos sintomas de ansiedade (OR = 0,69; IC 95%: 0,58 – 0,83;  $I^2 = 0\%$ ). Além disso, foi observada associação significativa entre atividade física e redução dos sintomas de depressão (OR = 0,56; IC 95%: 0,44 – 0,71;  $I^2 = 31,6\%$ ). **Conclusão:** A prática de atividade física durante a pandemia da covid-19 esteve associada a menores sintomas de ansiedade e depressão em trabalhadores de diferentes contextos.

**Palavras-chave:** SARS-CoV-2; Ansiedade; Depressão; Exercício Físico; Saúde Ocupacional.

## Introduction

In December 2019, an outbreak of SARS-CoV-2, the virus responsible for COVID-19, was first identified in Wuhan, China<sup>1</sup>. To control the spread of the virus, governments worldwide implemented measures such

as social isolation, quarantine, and changes in work routines. While these strategies were effective in reducing transmission, they also had negative effects on people's physical and mental well-being<sup>2,3</sup>.

The pandemic significantly disrupted work rou-

tines. Many employees had to transition suddenly to remote work, while essential sectors (e.g., healthcare) experienced increased workloads. Others faced job loss and economic uncertainty. These challenges contributed to higher levels of stress, anxiety, and depression<sup>4,5</sup>. The impact varied across different worker groups. For instance, systematic reviews with meta-analysis conducted during the COVID-19 pandemic reported anxiety rates exceeding 20% and depression rates over 30% among healthcare professionals<sup>4,5</sup>. A systematic review with meta-analysis conducted before the pandemic reported that the prevalence of anxiety was up to 85% and the prevalence of depression was up to 31%, respectively<sup>6</sup>. However, it is important to note that these values represent pooled prevalence estimates, which may vary depending on the confidence intervals and the level of heterogeneity across the included studies. Meanwhile, office workers experienced mixed effects, depending on factors such as the ability to work remotely and comply with social distancing measures<sup>7</sup>. These findings suggest that the nature of one's job played a key role in shaping both positive and negative consequences of the pandemic.

Regular physical activity (PA) has been associated with improved mental health and can help reduce symptoms of anxiety and depression<sup>8</sup>. During the social distancing caused by the COVID-19 pandemic, PA appeared to support workers well-being<sup>9,10</sup>. However, there is still a lack of consistent, systematic evidence confirming these benefits. Restrictions on movement and changes in daily routines made it harder for many people to stay physically active, which may have increased mental health risks during this time<sup>3</sup>. Studies show that health professionals reduced the time spent being physically active<sup>11</sup>, and office workers in particular reported sitting more and exercising less in 2020<sup>12</sup>.

Wu et al.<sup>13</sup> examined the relationship between PA and mental health during the COVID-19 pandemic across different population groups, including healthcare workers, students, and the general population. Their systematic review included 13 studies and concluded that the available evidence was insufficient to determine whether PA interventions improve anxiety, depression, and stress during the pandemic. To address this gap, the current study aims to provide quantitative evidence by conducting a systematic review and meta-analysis of observational studies that examined the effect of PA on anxiety and depression symptoms among different groups of workers during the

COVID-19 pandemic.

## Methods

### Data sources

We followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) recommendations for the report of this systematic review<sup>14</sup>. The protocol was retrospectively registered in the International Prospective Register for Systematic Reviews (PROSPERO) (CRD42024598699).

### Eligibility Criteria

We used the acronym PICOS to determine eligibility criteria before searches in electronic databases<sup>15</sup>). We included studies conducted with the adult working population (e.g., aged between 18 and 64), reporting on PA by either questionnaire or direct measures; that assessed symptoms of anxiety and depression by validated questionnaires (e.g., Patient Health Questionnaire-9 [PHQ-9] for depression and Generalized Anxiety Disorder 7-item scale [GAD-7] for anxiety), and with an observational design. Additionally, we included only studies conducted during the COVID-19 pandemic period, defined according to the World Health Organization as the period from March 11, 2020 (pandemic declaration) to May 5, 2023 (end of the Public Health Emergency of International Concern), and published in English, Portuguese, and Spanish.

### Sources of information and research

We searched PubMed and EMBASE in April 2024. We used English descriptors, following the Medical Subject Headings (MeSH), related to eligible participants (workers), exposure (PA), outcome (anxiety and depression symptoms), and timing (COVID-19 pandemic). The detailed search strategy (descriptors and combinations) can be found in Supplementary Material 1. We performed an additional search in the reference lists of similar systematic review studies.

### Selection of studies

After downloading the datasets and removing duplicates, we uploaded the final dataset to the Systematic Review Data Repository (SRDR) for data screening (<https://sdrplus.ahrq.gov/>). We conducted abstract screening in duplicate, with all team members reviewing 100 abstracts in two pilot rounds. Full text screening was conducted independently by two reviewers and conflicts were resolved by consensus.

## Data collection process

We used an Excel spreadsheet to extract data from the included studies. The extracted information included study characteristics (first author's name and year of publication), country (location of study participants), participant characteristics (gender, mean age, sample size, and work setting), and the instruments used to assess PA and symptoms of anxiety and depression.

## Risk of bias

We assessed the risk of bias using the Newcastle – Ottawa Scale, adapted for cross-sectional studies<sup>16,17</sup> and cohort studies<sup>17</sup>. The scale includes six items for cross-sectional studies and eight items for cohort studies, evaluating three domains: selection, comparability, and outcome. Each item is awarded one point, except for the comparability domain, which has two items and can receive up to two points. The maximum possible score, indicating the lowest risk of bias, is seven points for cross-sectional studies and nine points for cohort studies.

## Meta-analysis

We conducted a meta-analysis including studies that reported odds ratios (ORs) as the effect measure. Heterogeneity was assessed using the  $I^2$  statistic, considering values above 50% as evidence of substantial heterogeneity. We used the meta package in R, instead of Stata as specified in the protocol, for the computational implementation of the analyses, applying a random effects model. Results are presented as OR with 95% confidence intervals (CI). We also performed subgroup analyses to examine whether the relationship between PA and symptoms of anxiety and depression differed by occupational group.

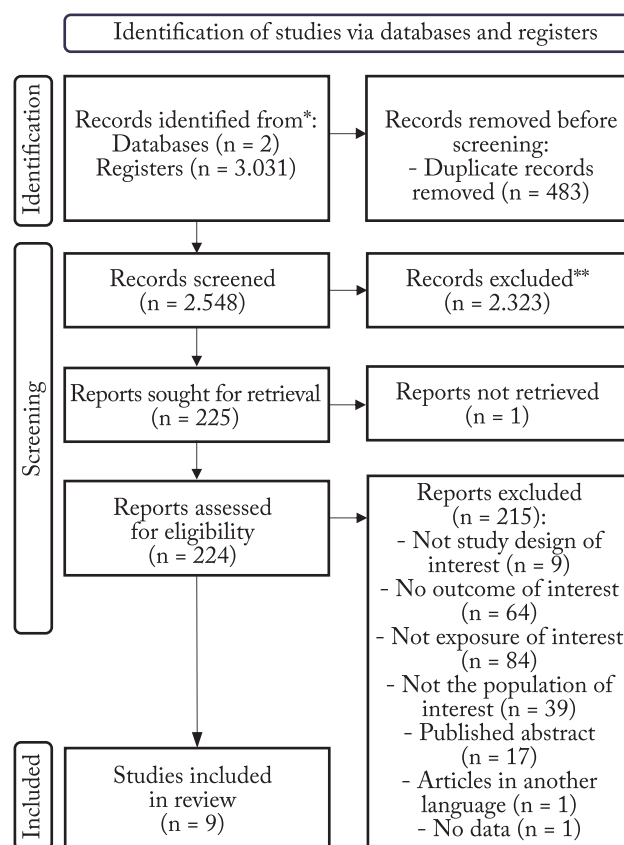
## Results

### Studies description

A total of 3,031 studies were retrieved (1,069 in PubMed and 1,962 in EMBASE), of which 2,548 records remained after removing duplicates. After screening, nine studies met the eligibility criteria and were included. The main reasons for exclusion were lack of exposure to interest (37.7%), lack of outcome of interest (28.3%) and not population of interest (17.9%), as shown in Figure 1.

### Studies characteristics

The characteristics of the studies included in this review are shown in Table 1. There were eight cross-sectional



**Figure 1** – PRISMA flowchart<sup>14</sup> of the selected studies.

tional studies<sup>18–25</sup> and one cohort<sup>26</sup>. The data collection periods of the included studies ranged from February 2020 to December 2021. The total sample of workers was 7,380 participants. The proportion of women varied between studies, ranging from 6.3% to 86.8%, while the average age of participants was between 31.1 and 48.8 years.

Five studies were conducted with healthcare workers<sup>18,21,23,25,26</sup>, two with education workers<sup>19,20</sup>, one with military<sup>24</sup>, and one with office workers<sup>22</sup>. The prevalence of participants engaging in the recommended levels of PA ranged from 16.9% to 89.6%. The prevalence of symptoms of depression and anxiety ranged from 10.8% to 71.0% and from 7.5% to 81.0%, respectively (Table 1).

### Assessment of PA, symptoms of anxiety, and depression

Four studies used the International Physical Activity Questionnaire - Short Form (IPAQ-SF)<sup>20,21,24,25</sup>, one study used the Godin-Shephard Leisure-time Physical Activity Scale (GSLTPAQ)<sup>26</sup>, and in four studies, the researchers developed questions to assess PA<sup>18,19,22,23</sup>. Cut-off criteria for defining physically ac-

**Table 1** – Characteristics of the included studies (n = 9)

| Author, year, design, country                                         | Data collection period (month/year)                    | Work setting | n                              | % Women | Age                        | % Active | % Depression          | % Anxiety             |
|-----------------------------------------------------------------------|--------------------------------------------------------|--------------|--------------------------------|---------|----------------------------|----------|-----------------------|-----------------------|
| Zhu et al. <sup>18</sup> , 2020, Cross-sectional, China               | February/2020                                          | Healthcare   | 5062                           | 85      | 30-49 (56.4%) <sup>1</sup> | 16.9     | 13.5                  | 24.1                  |
| Feter et al. <sup>19</sup> , 2020, Cross-sectional, Brazil            | May to June/2020                                       | Education    | 210                            | 47.1    | 32.7 (7.9) <sup>2</sup>    | 28.1     | 71                    | 81                    |
| García-Garro et al. <sup>20</sup> , 2022, Cross-sectional, Colombia   | May to June/2020                                       | Education    | 336                            | 44.4    | 48.8 (6.7) <sup>2</sup>    | 45.2     | 24.4                  | NA                    |
| Juliana et al. <sup>21</sup> , 2022, Cross-sectional, Malaysia        | February 2020 to August 2021                           | Healthcare   | 413                            | 81.1    | 31.7 (5.9) <sup>2</sup>    | 68.3     | 27.4                  | 34.6                  |
| Oliver et al. <sup>26</sup> , 2022, Cohort, United States of America  | M0: January/2021<br>M6: July/2021<br>M12: January/2022 | Healthcare   | M0: 234<br>M6: 148<br>M12: 124 | 86.8    | 38.69 (12.0) <sup>2</sup>  | M0: 53.7 | M0: 70.5<br>M12: 58.9 | M0: 70.5<br>M12: 53.2 |
| Žilinskas <sup>22</sup> , 2022, Cross-sectional, Lithuania            | February to April/2021                                 | Office       | 114                            | 41.1    | 56 (49.1) <sup>3</sup>     | 50       | NA                    | 25.4                  |
| Okour & Amarnah <sup>23</sup> , 2023, Cross-sectional, Jordan         | June to July/2021                                      | Healthcare   | 295                            | 50.2    | 33.1 <sup>4</sup>          | 61.4     | 59.3                  | NA                    |
| Valladares-Garrido et al. <sup>24</sup> , 2023, Cross-sectional, Peru | November/2021                                          | Military     | 615                            | 6.3     | 22 (19–32) <sup>5</sup>    | 89.6     | 10.8                  | 7.5                   |
| Bernhard et al. <sup>25</sup> , 2024, Cross-sectional, Brazil         | September to December/2021                             | Healthcare   | 101                            | 77.2    | 31.1 (6.3) <sup>2</sup>    | 56.4     | 41.6                  | 29.7                  |

1 Highest proportion range; 2 Mean (SD); 3 Median (range); 4 Mean; 5 Median (IQR); M0: baseline; M6: month 6; M12: month 12

tive participants ranged from weekly minutes to weekly MET-minutes of moderate or vigorous activity.

Three studies used the Patient Health Questionnaire-9 (PHQ-9)<sup>18,24,25</sup>, while each of the following instruments was used in one study: the Zung Self-Rating Depression Scale (ZSDS)<sup>20</sup>, the Hospital Anxiety and Depression Scale (HADS)<sup>19</sup> the Depression, Anxiety and Stress Scale - 21 items (DASS-21)<sup>21</sup>, the Patient Health Questionnaire-2 (PHQ-2)<sup>26</sup>, and the Center for Epidemiologic Studies Depression Scale – Revised (CESD-R1)<sup>23</sup>. Cutoff points used across these instruments varied, with thresholds for symptom classification including  $\geq 10$  points for the PHQ-9, DASS-21, and CESD-R1;  $\geq 50$  for the ZSDS; and  $\geq 1$  point for both the HADS and PHQ-2. Symptom classifications ranged from binary outcomes (e.g., yes/no for depression) to severity levels such as mild, moderate, severe, and extremely severe.

Anxiety symptoms were assessed using the Generalized Anxiety Disorder 7-item scale (GAD-7) in five studies<sup>18,22,24–26</sup>, and the Hospital Anxiety and Depression Scale (HADS)<sup>19</sup> and the Depression, Anxiety and Stress Scale - 21 items (DASS-21)<sup>21</sup> in one study each. The cut-off points used to define anxiety symptoms varied across studies: for the GAD-7, they ranged from  $\geq 5$  to  $\geq 10$ ; for the HADS, a cut-off of  $\geq 1$  was used; and for the DASS-21, the threshold was  $\geq 8$ . Anxiety symptoms were classified either by their presence or absence, or by severity levels (e.g., none, moder-

ate, severe).

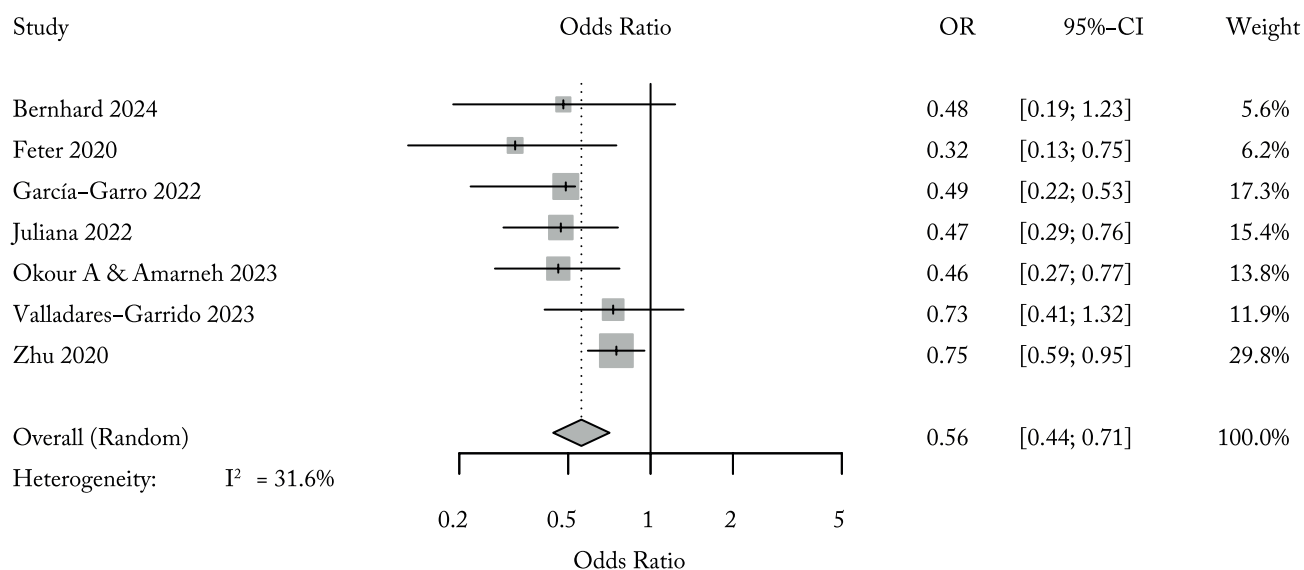
A detailed description of the instruments used to assess PA, symptoms of anxiety and depression, as well as the definitions of the variables and the classification criteria adopted, is available in Supplementary Material 2.

### Depression/Anxiety and PA

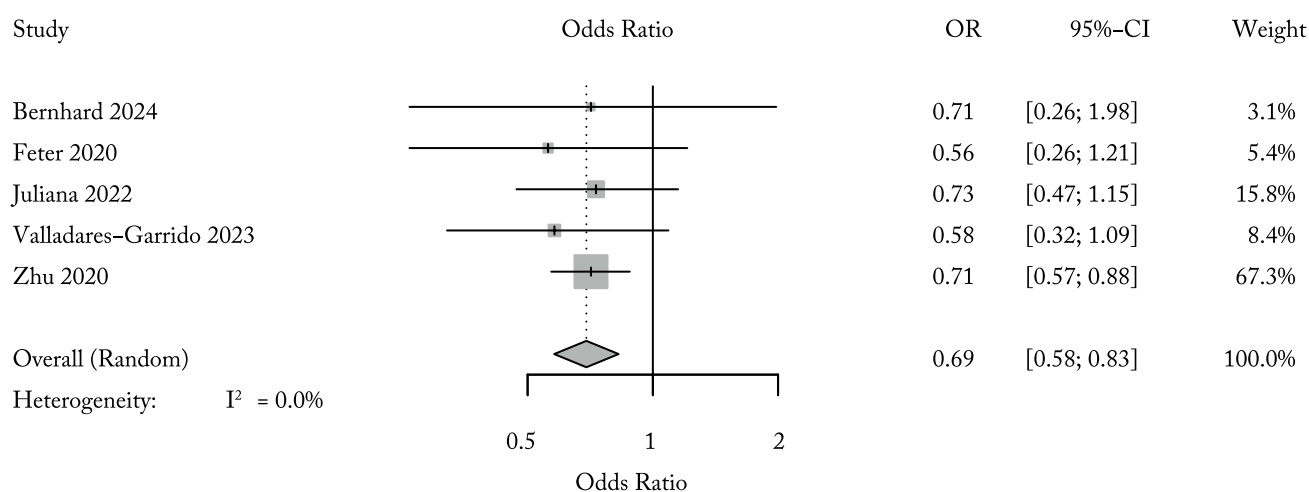
Figures 2 and 3 present the meta-analysis results for the association between PA and depression and anxiety, respectively. The pooled estimate indicated that PA was associated with lower odds of depression [OR: 0.56; 95% CI: 0.44 – 0.71;  $I^2 = 31.6\%$ ]. Workers who engaged in regular PA also reported lower levels of anxiety during the COVID-19 pandemic [OR: 0.69; 95% CI: 0.58 – 0.83;  $I^2 = 0\%$ ].

Two studies did not report OR for the associations between PA and depression/anxiety and were not included in the meta-analyses. Oliver et al.<sup>26</sup> found an inverse association between PA and symptoms of depression ( $p < 0.001$ ) among health professionals. However, they did not observe an association with symptoms of anxiety ( $p = 0.471$ ). Žilinskas et al.<sup>22</sup> reported a prevalence of anxiety symptoms of 25%, with a significant negative association between these symptoms and PA ( $p = 0.048$ ) in office workers.

Subgroup analyses were conducted to explore whether the association between PA and mental health differed by occupational group. For depression, PA was associated with a lower odds among healthcare work-



**Figure 2** – Combined results of the association between physical activity and symptoms of depression among workers.



**Figure 3** – Combined results of the association between physical activity and symptoms of anxiety among workers.

ers [OR: 0.57; 95% CI: 0.42 – 0.79;  $I^2 = 42\%$ ] and education workers [OR: 0.45; 95% CI: 0.30 – 0.67;  $I^2 = 0\%$ ] (Supplementary Material 3). For anxiety symptoms, the protective association of PA was observed only among healthcare workers [OR: 0.71; 95% CI: 0.59 – 0.86;  $I^2 = 0\%$ ] (Supplementary Material 3).

### Risk of bias

The risk of bias is presented in Table 2. For cross-sectional studies where the maximum score is 7 points, the score ranged from 3<sup>22,23</sup> to 6<sup>18</sup> points, and 4 studies<sup>19–21,24</sup> obtained 5 points. In the cohort study with a maximum score of 9 points, one study<sup>26</sup> scored 5 points.

### Discussion

We revealed that being physically active during the COVID-19 pandemic was associated with a lower

chance of experiencing depression and anxiety symptoms among workers from different occupational settings. Overall, physically active workers were 31% less likely to report anxiety symptoms and 44% less likely to present symptoms of depression. The diversity of occupational contexts included in the reviewed studies suggests that the associations of PA may vary according to job type, working conditions, and exposure to pandemic-related stressors. Moreover, work sector-specific factors may have influenced the strength of associations observed.

Most of the studies included focused on healthcare workers, a group under high physical and emotional pressure during the pandemic. For them, PA may have served as a way to care for themselves, reduce stress, and manage emotions<sup>27,28</sup>. However, healthcare workers also had higher rates of depression symptoms, which may have

**Table 2** – Newcastle–Ottawa Scale risk of bias tool results for included studies.

| Study                                           | Selection | Comparability | Outcome | Total |
|-------------------------------------------------|-----------|---------------|---------|-------|
| Zhu et al. <sup>18</sup> , 2020                 | ***       | **            | *       | 6     |
| Feter et al. <sup>19</sup> , 2021               | **        | **            | *       | 5     |
| García-Garro et al. <sup>20</sup> , 2022        | **        | **            | *       | 5     |
| Juliana et al. <sup>21</sup> , 2022             | **        | **            | *       | 5     |
| Oliver et al. <sup>26</sup> , 2022 <sup>a</sup> | **        | *             | **      | 5     |
| Žilinskas et al. <sup>22</sup> , 2022           | **        |               | *       | 3     |
| Okour & Amarnah, 2023                           | *         | *             | *       | 3     |
| Valladares-Garrido et al. <sup>24</sup> , 2023  | ***       | *             | *       | 5     |
| Bernhard et al. <sup>25</sup> , 2024            | *         | **            | *       | 4     |

a Cohort study.

made the association between PA and mental health less noticeable in this group. This pattern was also found in the studies by Zhu et al.<sup>18</sup> and Juliana et al.<sup>21</sup>, suggesting that the unique challenges faced by healthcare workers, likely heavy workloads and traumatic experiences, may have limited the mental health benefits of PA.

In contrast, education professionals faced different challenges, such as remote work, increased screen time, and overlapping personal and professional demands. These conditions may have led to more sedentary behavior and higher stress levels. The lower levels of PA reported among this group, along with high rates of anxiety and depression symptoms, highlight the vulnerability of education professionals<sup>29,30</sup>.

Evidence from studies conducted during the COVID-19 pandemic indicates that remote work was associated with increased psychological distress, including higher levels of anxiety and depression symptoms, partly due to social isolation, blurred boundaries between personal and professional life, and increased work demands<sup>31,32</sup>. At the same time, regular PA has been consistently associated with better mental health outcomes among remote workers, helping to reduce stress, improve mood, and alleviate symptoms of anxiety and depression<sup>33</sup>. Taken together, these findings suggest that promoting PA may be particularly important for workers performing remote tasks, including education professionals.

The heterogeneity observed in the depression analysis ( $I^2 = 31.6\%$ ) may be partially explained by methodological differences across the included studies and variability in occupational settings, PA assessment, and mental health measures.

It is important to note that the overall quality of the evidence is limited. Most included studies had a cross-sectional design, which limits causal inference

and the ability to establish temporality between PA and mental health outcomes. In addition, the reliance on self-reported measures of both PA and mental health may have introduced information bias, and residual confounding cannot be ruled out. Therefore, the certainty of the evidence should be considered low, and the findings should be interpreted with caution.

The limitations of our review must be acknowledged. Most of the included studies focused on healthcare workers, which may limit how well the findings apply to other types of jobs. More research is needed in other occupational groups, since the effects of public health crises can vary depending on the work context. Differences in the timing of data collection across studies may also partially explain the heterogeneity observed, as levels of restrictions and lockdown measures varied across countries and phases of the pandemic. Performing a meta-analysis is a strength of our study, since it provides a strong and reliable summary of the data and improves the accuracy of the results.

In conclusion, the results of this systematic review and meta-analysis suggest that PA was associated with lower symptoms of anxiety and depression in workers during the COVID-19 pandemic. These findings support the need for workplace policies that encourage PA, particularly during times of crisis that place extra strain on mental health. More studies with diverse worker samples are needed to better understand how PA can help protect mental health in future public health emergencies.

## Conflicts of interest

The authors declare no conflict of interest.

## Funding

The present study did not receive financial support.

## Authors' Contributions

Marins MF and Caputo EL: Conceptualization; Methodology; Software; Validation; Formal analysis; Investigation; Resources; Data curation; Supervision; Project administration; Visualization; Writing – original draft; Writing – review & editing; Approval of the final version. Pasqualinoto SRV, Vilarinho FRC, Jerônimo JS and Marins EF: Conceptualization; Methodology; Software; Validation; Formal analysis; Investigation; Writing – review & editing; Approval of the final version. Silva MC: Conceptualization; Methodology; Validation; Formal analysis; Investigation; Supervision; Project administration; Writing – review & editing; Approval of the final version.

## Declaration regarding the use of artificial intelligence tools in the article writing process

For the development of this manuscript, the artificial intelligence tool ChatGPT was used for the following activities: text organization and revision. The authors declare that all material derived from this process has been reviewed, and they assume full responsibility for the entire content of the manuscript.

## Availability of research data and other materials

The data of this study are available on demand from referees.

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## Supplementary materials

### Supplementary material 1 - Search strategy.

| Database | Search                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Results |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| PubMed   | <p>(((((("occupational groups"[MeSH Terms]) OR (work*) OR (employ*) OR (job)) OR (occupacio*) OR (job)) OR (professional)) AND (((exercise[MeSH Terms]) OR (physical activit*) OR (walk*) OR (sedentar*)) AND (((anxiety[MeSH Terms]) OR (depression[MeSH Terms])) OR (depressi*) OR ("social phobia") OR ("mental health")))) AND (((covid-19[MeSH Terms]) OR (covid*[Title/Abstract])) OR (sars*[Title/Abstract])) OR (coronavirus*[Title/Abstract])) OR (pandemic*[Title/Abstract]))</p> <p>No<br/>Query<br/>Results</p> <p>#1<br/>occupational AND groups<br/>59391</p> <p>#2<br/>occupatio*<br/>619047</p> <p>#3<br/>'work'<br/>1957672</p> <p>#4<br/>professional<br/>532979</p> <p>#5<br/>job<br/>149413</p> <p>#6<br/>employ*<br/>1087760</p> | 1069    |
| EMBASE   | <p>#7<br/>#1 OR #2 OR #3 OR #4 OR #5 OR #6<br/>3788702</p> <p>#8<br/>'exercise'<br/>717395</p> <p>#9<br/>physical AND activit*<br/>591830</p> <p>#10<br/>walk*<br/>442150</p> <p>#11<br/>sedentar*<br/>63630</p> <p>#12<br/>#8 OR #9 OR #10 OR #11<br/>1526821</p> <p>#13<br/>anxiety<br/>541420</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 1962    |

Continue...

Continue of **Supplementary material 1** - Search strategy.

| Database | Search                                      | Results |
|----------|---------------------------------------------|---------|
| EMBASE   | #14<br>depressi*<br>936154                  |         |
|          | #15<br>'mental health'<br>644124            |         |
|          | #16<br>'social phobia'<br>16732             |         |
|          | #17<br>#13 OR #14 OR #15 OR #16<br>1638569  |         |
|          | #18<br>'coronavirus disease 2019'<br>398840 |         |
|          | #19<br>'covid 19'<br>417539                 |         |
|          | #20<br>'sars-related coronavirus'<br>643    |         |
|          | #21<br>#18 OR #19 OR #20<br>476770          |         |
|          | #22<br>#7 AND #12 AND #17 AND #21<br>1962   |         |
|          | Obtained from<br>reference lists            | 3031    |
|          | After removal of<br>duplicates              | 2548    |

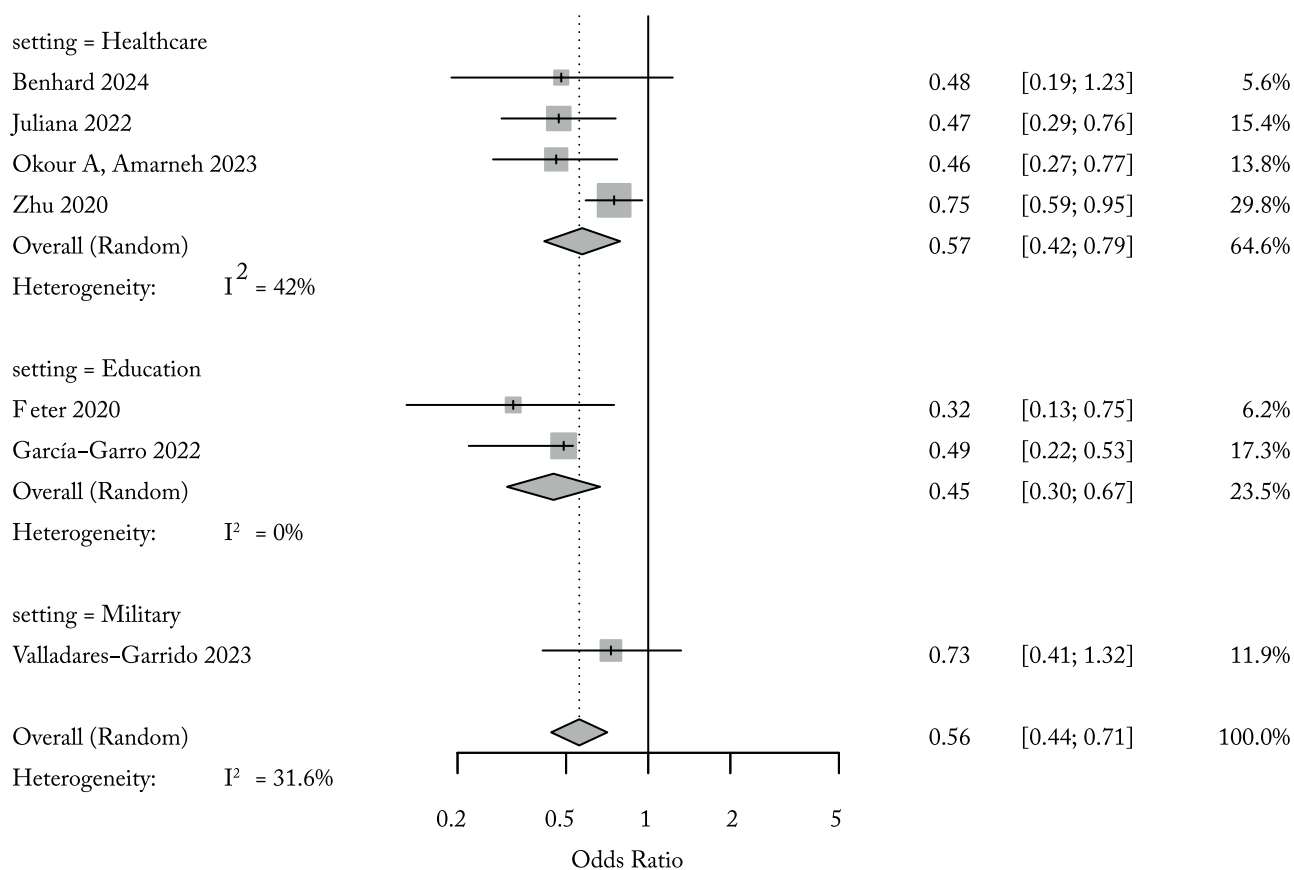
**Supplementary material 2** – Assessment instruments used in the selected studies.

| Author, year, design                                            | Instrument                                                                                             | Cut-off                                                                                                                                                                                                               | Classification                                                                           |
|-----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| Physical activity                                               |                                                                                                        |                                                                                                                                                                                                                       |                                                                                          |
| Zhu et al. <sup>18</sup> , 2020, Cross-sectional                | Developed by the author                                                                                | Active: ≥ 60 min of moderate to vigorous intensity physical activity daily, and most of the daily physical activity should be aerobic, at least 3 times per week                                                      | Active or inactive                                                                       |
| Feter et al. <sup>19</sup> , 2021, Cross-sectional              | Developed by the author                                                                                | Active: ≥ 150 minutes per week                                                                                                                                                                                        | Active or inactive                                                                       |
| García-Garro et al. <sup>20</sup> , 2022, Cross-sectional       | International Physical Activity Questionnaire - Short Form (IPAQ-SF)                                   | Active: ≥ 5 days of moderate activity (at least 600 Mets/min/week or 30 min/day), or ≥ 3 days of vigorous activity for at least 25 min/day                                                                            | Active or insufficiently active                                                          |
| Juliana et al. <sup>21</sup> , 2022, Cross-sectional            | International Physical Activity Questionnaire - Short Form (IPAQ-SF)                                   | Active: ≥ 600 MET-minutes per week with moderate or vigorous physical activity on at least 3 days per week.                                                                                                           | Active: High-Efficiency Particulate Air (HEPA)<br>Inactive: Inactive or minimally active |
| Oliver et al. <sup>26</sup> , 2022, Cohort                      | Total exercise sessions (counts) and the Godin-Shephard Leisure-time Physical Activity Scale (GSLTPAQ) | Active: ≥ 150 minutes per week of moderate-intensity, or ≥ 75 minutes per week of vigorous-intensity, or an equivalent combination of moderate- and vigorous-intensity aerobic activity                               | Active or insufficiently active                                                          |
| Žilinskas et al. <sup>22</sup> , 2022, Cross-sectional          | Developed by the author                                                                                | Active: ≥ 150 minutes of moderate-intensity physical activity or at least ≥ 75 minutes of vigorous-intensity physical activity                                                                                        | Sufficient active or insufficiently active                                               |
| Okour & Amarneh <sup>23</sup> , 2023, Cross-sectional           | Developed by the author                                                                                | Active: Daily to weekly for 30 min                                                                                                                                                                                    | Active or inactive                                                                       |
| Valladares-Garrido et al. <sup>24</sup> , 2023, Cross-sectional | International Physical Activity Questionnaire - Short Form (IPAQ-SF)                                   | Active: ≥ 3 days of vigorous activity for at least 20 min/day, or ≥ 5 days of moderate activity and/or walking for at least 30 min/day, or ≥ 600 METs from a combination of walking and moderate or vigorous activity | Active or inactive                                                                       |
| Bernhard et al. <sup>25</sup> , 2024, Cross-sectional           | International Physical Activity Questionnaire - Short Form (IPAQ-SF)                                   | Active: ≥ 150 minutes per week                                                                                                                                                                                        | Active or insufficiently active                                                          |
| Depression                                                      |                                                                                                        |                                                                                                                                                                                                                       |                                                                                          |
| Zhu et al. <sup>18</sup> , 2020, Cross-sectional                | Patient Health Questionnaire-9 (PHQ-9)                                                                 | Yes: PHQ-9 ≥ 10                                                                                                                                                                                                       | Yes or no                                                                                |
| Feter et al. <sup>19</sup> , 2021, Cross-sectional              | Hospital Anxiety and Depression Scale-Adapted (HADS)                                                   | Yes: HADS ≥ 1                                                                                                                                                                                                         | Depressive symptoms rated as more frequent: None, 1, 1-3, 4 or more                      |
| García-Garro et al. <sup>20</sup> , 2022, Cross-sectional       | Zung Self-Rating Depression Scale (ZSDS)                                                               | Yes: ZSDS ≥ 50                                                                                                                                                                                                        | With or Without                                                                          |
| Juliana et al. <sup>21</sup> , 2022, Cross-sectional            | Depression, Anxiety and Stress Scale - 21 items (DASS-21)                                              | Yes: DASS-21 ≥ 10                                                                                                                                                                                                     | Mild: 10-13<br>Moderate: 14-20<br>Severe: 21-27<br>Extremely Severe: 28 or more          |
| Oliver et al. <sup>26</sup> , 2022, Cohort                      | Patient Health Questionnaire-2 (PHQ-2)                                                                 | Yes: PHQ-2 ≥ 1                                                                                                                                                                                                        | Mild: 1<br>Moderate: 2<br>Severe: 3-6                                                    |
| Okour & Amarneh <sup>23</sup> , 2023, Cross-sectional           | Center for Epidemiologic Studies Depression Scale – Revised (CESD-R1)                                  | Yes: CESD-R1 ≥ 10                                                                                                                                                                                                     | Yes or no                                                                                |
| Valladares-Garrido et al. <sup>24</sup> , 2023, Cross-sectional | Patient Health Questionnaire-9 (PHQ-9)                                                                 | Yes: PHQ-9 ≥ 10                                                                                                                                                                                                       | None: 0-4<br>Mild: 5-9<br>Moderate: 10-14<br>Moderately severe: 15-19<br>Severe: 20-27   |
| Bernhard et al. <sup>24</sup> , 2024, Cross-sectional           | Patient Health Questionnaire-9 (PHQ-9)                                                                 | Yes: PHQ-9 ≥ 10                                                                                                                                                                                                       | None: 0-4<br>Mild: 5-9<br>Moderate: 10-14<br>Moderately severe: 15-19<br>Severe: 20-27   |

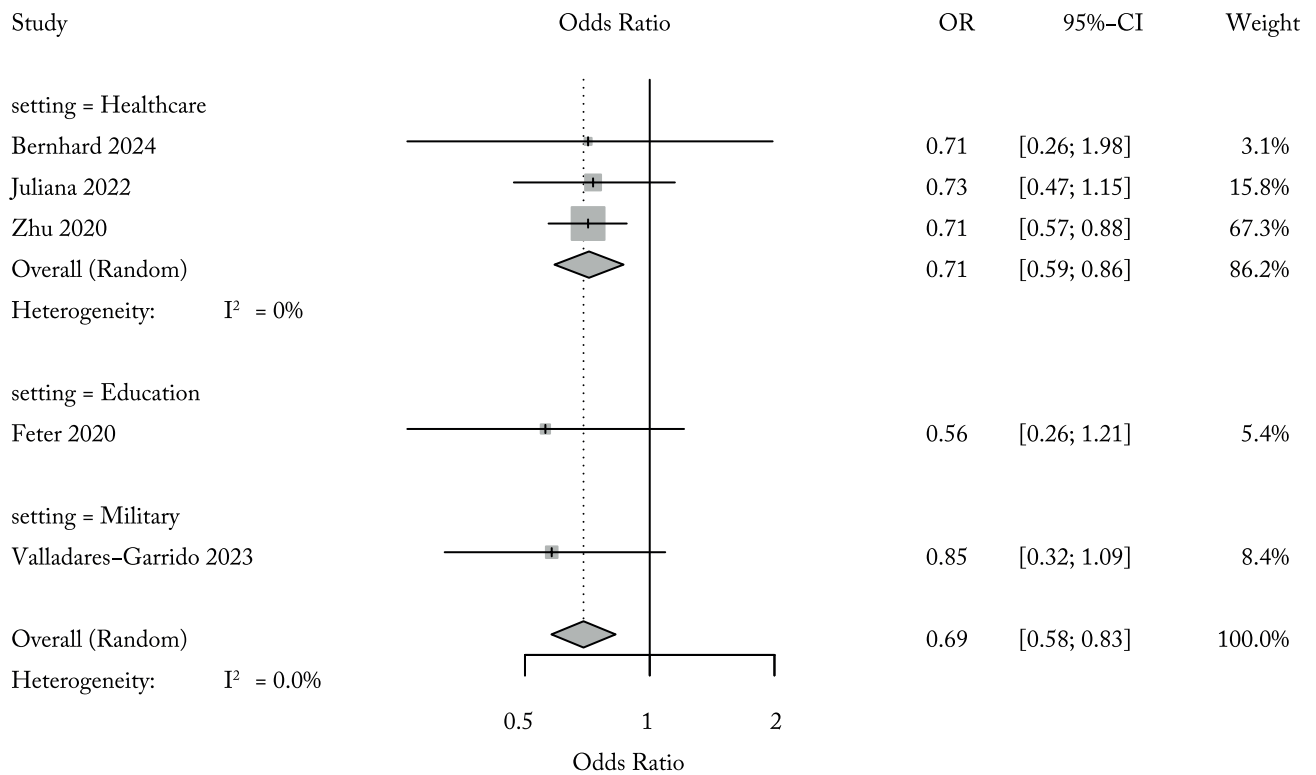
Continue of **Supplementary material 2** – Assessment instruments used in the selected studies.

| Author, year, design                                   | Instrument                                                | Cut-off               | Classification                                                                |
|--------------------------------------------------------|-----------------------------------------------------------|-----------------------|-------------------------------------------------------------------------------|
| Anxiety                                                |                                                           |                       |                                                                               |
| Zhu et al. <sup>18</sup> , 2020, Cross-sectional       | Generalized Anxiety Disorder 7-item scale (GAD-7)         | Yes: GAD-7 $\geq$ 8   | Yes or no                                                                     |
| Feter et al. <sup>19</sup> , 2021, Cross-sectional     | Hospital Anxiety and Depression Scale-Adapted (HADS)      | Yes: HADS $\geq$ 1    | Anxiety symptoms rated as more frequent: None, 1, 1-3, 4 or more              |
| Juliana et al. <sup>21</sup> , 2022, Cross-sectional   | Depression, Anxiety and Stress Scale - 21 items (DASS-21) | Yes: DASS-21 $\geq$ 8 | Mild: 8-9<br>Moderate: 10-14<br>Severe: 15-19<br>Extremely Severe: 20 or more |
| Oliver et al. <sup>26</sup> , 2022, Cohort             | Generalized Anxiety Disorder 7-item scale (GAD-7)         | Yes: GAD-7 $\geq$ 5   | Mild: 5-9<br>Moderate: 10-14<br>Severe: 15-21                                 |
| Žilinskas et al. <sup>22</sup> , 2022, Cross-sectional | Generalized Anxiety Disorder 7-item scale (GAD-7)         | Yes: GAD-7 $\geq$ 10  | Minimal: 0-4<br>Mild: 5-9<br>Moderate: 10-14<br>Severe: 15-21                 |
| Valladares-Garrido et al., 2023, Cross-sectional       | Generalized Anxiety Disorder 7-item scale (GAD-7)         | Yes: GAD-7 $\geq$ 10  | None: 0-4<br>Mild: 5-9<br>Moderate: 10-14<br>Severe: 15-21                    |
| Bernhard et al. <sup>24</sup> , 2024, Cross-sectional  | Generalized Anxiety Disorder 7-item scale (GAD-7)         | Yes: GAD-7 $\geq$ 10  | None: 0-4<br>Mild: 5-9<br>Moderate: 10-14<br>Severe: 15-21                    |

**Supplementary Material 3** – Subgroup analysis of the association between physical activity and anxiety and depression symptoms among workers by occupational setting



**Figure 4** – Combined results of the association between physical activity and symptoms of anxiety among workers, stratified by occupational setting.



**Figure 5** – Combined results of the association between physical activity and symptoms of depression among workers, stratified by occupational setting.

# Reviewers' assessment

The reviews of this article were originally conducted in Portuguese. This version has been translated using ChatGPT and subsequently reviewed by the Chief Editors.

## Reviewer A

Anonymous

To the author and editor

This systematic review and meta-analysis investigated the relationship between physical activity, anxiety, and depression among workers across various sectors during the COVID-19 pandemic.

The methodology employed was appropriate, adhering to international guidelines for the standardization of systematic reviews and meta-analyses. The protocol was registered in advance.

The presentation of results was appropriate, and their interpretation fell within the scope of the review.

The authors adequately addressed the study's limitations, and the conclusion highlights how the findings advance the literature (e.g., by including workers from diverse fields), suggests how the collected information can be used to improve workers' mental health conditions, and proposes directions for future research.

In light of this, I recommend the study for publication.

## Final Decision

- Accept submission

## Reviewer B

José Rodolfo Obando Monge 

University of Costa Rica, Department of Physiology, School of Medicine, San Pedro, Costa Rica.

## Reviewer Comments

For author and editor

The study addresses an important topic regarding the relationship between physical activity and mental health outcomes among workers during the COVID-19 pandemic, and the overall structure of the manuscript is clear.

Most of the comments concern minor language and wording revisions that can be easily addressed. In addition, I suggest improving methodological clarity by specifying the time frame in which the included studies were conducted, considering that pandemic restrictions differed across countries.

From a scientific perspective, the discussion could be strengthened by incorporating evidence related to teleworking contexts, particularly for education workers, to better support the interpretation of the findings.

Importantly, I recommend carefully verifying the direction of the effect reported for the Okour (2023) study in the depression meta-analysis (Figure 2). The odds ratio appears to be expressed relative to physical inactivity rather than physical activity, which may affect the pooled estimate and contribute to the observed heterogeneity.

Overall, the manuscript is relevant and can be improved with minor revisions and clarification of the meta-analytic data.

## Comments on the manuscript

### Introduction

- Page 3, line 11: The sentence currently reads "Other faced job loss...". This should be corrected to "Others faced job loss..."
- Page 3, line 13: The manuscript reports percentages of anxiety and depression among healthcare professionals during the pandemic. It would strengthen the contextualization of these findings to indicate whether similar prevalence rates were observed before the COVID-19 pandemic, or to briefly compare them with pre-pandemic estimates.
- Page 4, line 5: It may be important to clarify the specific time periods during which the included studies were conducted, since COVID-19 containment measures and lockdown durations varied substantially between countries. Providing this information could improve methodological transparency and interpretation of heterogeneity across studies.

### Methods

- Page 4, line 17: replace "We prospectively register the protocol" with "The protocol was prospectively registered"
- Page 4, line 21: replace the verb tense in "to determined eligibility criteria" to "to determine eligibility criteria."

### Results

- Page 7, line 2: The phrasing may need revision to clearly refer to "studies included."

## Discussion

- Page 9, line 18: The discussion could be strengthened by including evidence or references regarding depression and anxiety among teleworkers and the potential role of physical activity in remote work contexts. This may particularly help support the interpretation of findings related to education workers.
- Page 10, line 8: Replace phrasing to “Most of the studies included...”

## Figure 2

- Page 17: There appears to be a possible inconsistency in the direction of the effect reported for Okour (2023) in the forest plot. The reported OR

of 2.18 seems to represent the risk associated with physical inactivity, whereas the remaining studies appear to evaluate the protective effect of physical activity ( $OR < 1$ ).

- This lack of standardization in the reference category may bias the pooled estimate, shifting the overall effect toward the right side of the plot and potentially inflating heterogeneity ( $I^2 \approx 78\%$ ).
- It is recommended to carefully recheck the data extraction and effect direction for the Okour study.

## Final Decision

- Substantial revisions required