Iran J Public Health, Vol. 53, No.2, Feb 2024, pp.293-304

Review Article

Sedentary Behavior and Risk of Depression in Older Adults: A Systematic Meta-Analysis

*#Qiusha Li [1], #Zixuan Zhao [1], Chunxiao Yang [1], *Zhongming Chen [2], *Wenqiang Yin [2]*

1. *School of Public Health, Shandong Second Medical University, Shandong, China*
2. *School of Management, Shandong Second Medical University, Shandong, China*

***Corresponding Authors:** Emails: yinwq1969@126.com, czm3306196@163.com

#These authors contributed equally to this work

(Received 10 May 2023; accepted 23 Jul 2023)

Abstract

Background: The elderly represents the population group with the highest rate of sedentary behavior. Sedentary behavior has an adverse impact on the elderly, which might be related to depression.

Methods: We queried PubMed, EMBASE, Web of Science, and MEDLINE to collect literature data. The odds ratio (*OR*) and corresponding 95% confidence interval (*CI*) were adopted for the pooled measurements. Sub-group analyses were conducted through stratified meta-analyses based on study design, depression indicator, adjustment for physical activity, sedentary behavior indicator, and type. Sensitivity analyses were performed to test the robustness of the results, and publication bias was assessed through a funnel plot.

Results: Seven cross-sectional studies and five cohort studies were included in our meta-analysis. The overall pooled *OR* was 1.38 (95%*CI*: 1.16–1.65; $P < 0.01$), which indicated that sedentary behavior was positively associated with depression in older adults. Sub-group analysis showed that different study designs, depression indicators, sedentary behavior indicators, adjustment for physical activity, sedentary behavior indicator, and type produced different results. In the cross-sectional studies (*OR* = 1.45, 95%*CI*: 1.15–1.84), CES-D scale (*OR* = 1.54, 95%*CI*: 1.13–2.10), self-reported (*OR* = 1.39, 95%*CI*: 1.04–1.87), watching TV (*OR* = 1.75, 95%*CI*: 1.02–3.02), and not adjusted for physical activity (*OR* = 1.37, 95%*CI*: 1.14–1.65) groups, there was a strong correlation between sedentary behavior and depression in the elderly.

Conclusion: Sedentary behavior is associated with depression in the elderly. As a preventive strategy, we should consider reducing their sedentary time and appropriately increasing physical activity.

Keywords: Sedentary behavior; Depression; Elderly; Meta-analysis; Mental health

Introduction

Sedentary behavior is defined as "any waking behavior characterized by low energy consumption", whether sitting or lying, and usually denotes activities of less than 1.5 metabolic equivalent units, such as watching TV, reading, or using a computer (1). It is pervasive in the daily lives of people and is highly prevalent worldwide. As many studies have demonstrated, sedentary behavior has already developed into a new risk factor for physical health, potentially having adverse

effects on chronic disease (2), diabetes (3), cardiovascular disease (4), cancer mortality (5, 6), sleep disturbance (7), stress (8), mental health (9), and so on. This problem is particularly serious for the elderly, as evidence has indicated that older adults are the age group with the longest sedentary time (10, 11). Research has shown that older people spend 79% of their waking hours in sedentary behaviors (12), typically sitting for 8–11h/d (13). As the elderly generally have poor heart and lung function, sedentary behavior has a greater severe impact on their health, especially in terms of mental health.

At present, mental disorders are also one of the key global disease burdens, where depression is one of the most common mental diseases, defined as a series of specific symptoms with associated damages (14). According to a report released by the WHO, the total number of patients with depression exceeded 300 million worldwide (15). The WHO lists major depression as one of the world's most burdensome diseases, and the incidence rate of depression is frequent in older people, affecting about 7% of the elderly worldwide (16, 17). At present, the pathogenesis of depression remains unclear; even though many studies have examined the relationship between sedentary behavior and depression in the elderly, the results of these studies were inconsistent. Most studies have reported a positive correlation between sedentary behavior and depression (18, 19), while, after separating out the types of sedentary behavior, this relationship may turn out to be opposite or invalid (20, 21). These conflicting results may be caused by the use of different objects, designs, and methods.

With the increase in the global aging population, we should pay more attention to the elderly in this aspect. In particular, COVID-19 has swept the world, and epidemic prevention and control measures have forced the elderly to stay at home, further increasing their sedentary time. Although several meta-analyses have studied the relationship between sedentary behavior and depression, focus has been placed on the whole population (9), or children and adolescents (22). There is a lack of specific research on elderly people. To address this gap in the literature, we summarize evidence on the relationship between sedentary behavior and depression in the elderly in this paper. We conducted a systematic meta-analysis of many empirical studies with the aim to: Discuss the correlation between sedentary behavior and depression among the elderly; and determine the source of heterogeneity among different studies through sub-group analysis.

Methods

Search strategy

Our study conformed to the PRISMA guidelines. We systematically searched the publications up to 12 November, 2022, without limitations on language, study population, or publication type. The queried databases included PubMed, WOS (Web of Science), Cochrane Library, Embase, EBSCO, Medline, CNKI, and WanFang Data. The search words and their combinations included: (sedentary behavior OR watching TV OR physical activity) AND (depression OR depressive OR mental health) AND (older adults OR elderly OR old people) (Supplementary Table 1). The original languages of the studies retrieved included English and Chinese. In addition, we supplemented the references cited in the original published studies with a manual search, in order to ensure that there were no omissions in the database. The detailed search and screening steps are depicted in Fig. 1.

Formulate inclusion and exclusion criteria

The inclusion criteria were as follows: 1) Research design including cohort and cross-sectional studies; 2) independent variable of sedentary behavior, determined by a scale or wearing an accelerometer; 3) dependent variable of depression, with diagnosis confirmed by a physician or determined by a depression scale; 4) study population of older adults, defined as those aged 60 years and older; and 5) included *OR* and 95%*CI* (or data to calculate these). The exclusion criteria were as follows: 1) Lack of specific effect quantity; 2) general mental health problems ra-

ther than depression, such as negative emotions or anxiety; 3) studies that mixed sedentary and physical activity; 4) studies that used "lower physical activity" to describe sedentary behavior; and 5) literature with only graphs and no numerical results.

Data collection and quality evaluation

Two researchers independently extracted the data included in the study using the Excel software. The extracted characteristics included the author names, published year, country, research design, number of participants, their age range, depression indicator, sedentary behavior indicator, *OR*, and 95%*CI*.

Furthermore, two researchers independently estimated the study quality using a revised edition of the Newcastle–Ottawa quality assessment scale, which evaluates sample type and capacity, comparability between respondents and others, identification of depression, and integrity of the descriptive analysis. The total score was between 0 and 5. If the score was < 3 points, we consider it to have high deviation; meanwhile, if the score was ≥ 3 points, the study was judged to have a low bias. Any discrepancies were resolved by discussion.

Statistical analyses

We used the odds ratio (*OR*) and corresponding 95% confidence interval (*CI*) as summary effect indicators to assess the relationship between sedentary behavior and depression. Every effect quantity was taken directly from the included studies. Four original papers reported β values and one paper reported *RR* values, for the studies that did not report *OR* and/or 95%*CI*, we used standard formulae to convert the data (23). Adjusted effect sizes were used, if possible. The literature included in our study was heterogeneous in many aspects. We used the DerSimonian and Laird random-effects model to obtain an overall *OR* and 95%*CI,* regarding both within- and between-study differentiation(24). The Higgins and Thompson I^2 was used to test statistical heterogeneity between studies (25), where an I^2 value < 25% represents low heterogeneity level, 25–50% represents moderate heterogeneity, and > 50% represents high heterogeneity.

In addition, we performed sub-group analysis to determine the source of heterogeneity. Based on the research, we selected study design (cross-sectional and cohort study), depression indicator (GDS, PHQ-9, CES-D, and HADS scales), adjustment for physical activity (adjusted and not adjusted), sedentary behavior indicator (self-reported and accelerator), and types for the assessment. Based on existing studies, we classified sedentary behaviors into passive sedentary behaviors (e.g., watching TV) and active sedentary behaviors (e.g., reading, using computers) (20, 21).We conducted a sensitivity analysis to test the robustness of the conclusions. We referred to the measurement methods of Begg and Egger, and evaluated the publication bias using a funnel diagram (26, 27). All statistical analyses were performed using Stata software. Two-tailed *P*-values <0.05 were considered statistically significant.

Results

Literature selection

We identified 1258 relevant studies in our comprehensive literature search. After deleting duplicate articles and review abstracts, 1102 literature were excluded. After further screening of full papers, we excluded 144 articles, according to the exclusion criteria. Thus, our study eventually included seven cross-sectional studies (18-20, 28-31) and five cohort studies (21, 32-35). The 12 studies included 23,811 participants (Fig. 1).

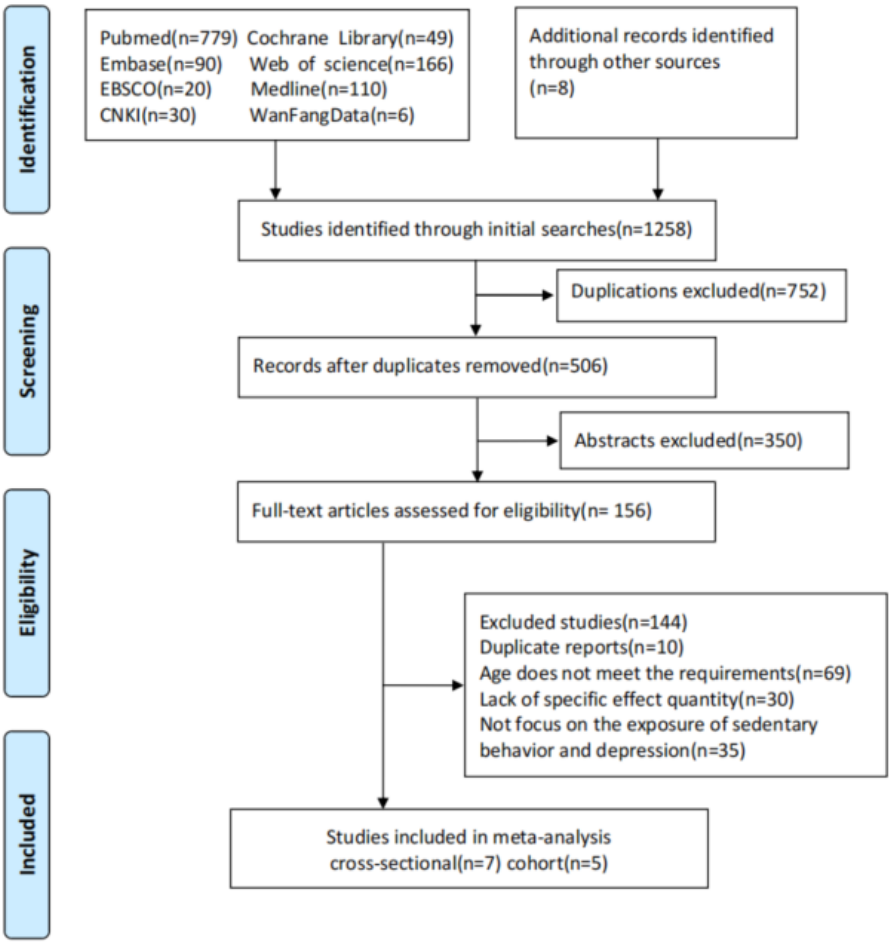

Fig. 1: Literature review screening steps

Characteristics of selected literature

The characteristics of the selected research are summarized in Table 1. Including the author names, year of publication, study region, research design, sample capacity, age of participants, depression and sedentary behavior indicators, effect value (*OR* and 95% *CI*), and NOS score. Among these 12 studies, 3 were performed in the United Kingdom, 3 in China, 2 in Japan, and 1 study in each of Mediterranean, Chile, Spain, and Sweden. The total number of participants was 23,811. The sample capacity of cross-sectional studies (which ranged from 349 to 3633) and cohort studies (which ranged from 271 to 6090) varied widely. The age of all participants was ≥60 years; only two cohort studies reported mean age, while the rest did not. Two studies differentiated between types of sedentary behavior and reported *OR* values for each. Other studies did not distinguish between types of sedentary behavior. The scales in all studies measured depression. Seven of the studies used the GDS, two used the PHQ-9, two used the HADS, and one used the CES-D scale. Concerning the measurement of sedentary behavior, seven studies used self-reporting, while five used an accelerator worn on the person. In the included studies, the average quality score was 3.64, with eight studies obtaining a quality score >3. (Supplementary Table 2)

Table 1: Characteristics of selected literature

Author	*Year*	*Country*	*Study design*	*Sample Size*	*Age(yr)*	*Depression Indicator*	*Sedentary behavior Indicator*	*OR*	*95%CI*
Mamplekou	2010	Mediterranean	Cross-sectional	1190	65-100	GDS	Self-reported	1.53	1.00-2.35
Arredondo	2013	Chile	Cross-sectional	397	>60	PHQ-9	Self-reported	1.2	1.00-1.50
Gardner	2014	UK	Cohort	6090	64.9±8.9	CES-D	Self-reported	1.54	1.13-2.10
Tsutsumimoto	2016	Japan	Cohort	5104	≥65	GDS	Self-reported	1.63	1.02-2.64
Ku	2017	China	Cohort	285	≥65	GDS	Accelerometer	2.45	1.16-5.15
Elena-active	2018	Spain	Cohort	1821	≥60	GDS	Self-reported	0.87	0.71-1.05
Elena-passive	2018	Spain	Cohort	1821	≥60	GDS	Self-reported	1.12	0.50-1.35
Yasunaga	2018	Japan	Cross-sectional	349	65-85	GDS	Accelerometer	1.14	1.02-1.28
Okely	2019	UK	Cohort	271	78.97±0.44	HADS	Accelerometer	1.15	1.02-1.30
Eriksson	2020	Sweden	Cross-sectional	3633	70	GDS	Accelerometer	1.11	1.00-1.24
Tully	2020	UK	Cross-sectional	1360	≥65	HADS	Accelerometer	1.80	1.68-1.92
Jiang	2021	China	Cross-sectional	632	≥60	PHQ-9	Self-reported	2.02	1.68-2.43
Wang-active	2022	China	Cross-sectional	2679	≥60	GDS	Self-reported	0.26	0.06-0.71
Wang-passive	2022	China	Cross-sectional	2679	≥60	GDS	Self-reported	3.59	1.93-6.68

Sedentary behavior and depression

Among the 12 studies, most studies reported a significant positive correlation between sedentary behavior and depression, while two studies showed a negative correlation. As presented in Fig. 2, the results of the random-effect model indicated that the combined *OR* was 1.38 (95%*CI*: 1.16–1.65). The results showed that sedentary behavior was positively associated with depression in older adults, and the study heterogeneity was 91.6%, as shown in Fig. 2.

Subgroup analyses

In order to explore the potential reasons for the observed heterogeneity, we performed sub-group analyses considering study design, depression indicator, adjustment for physical activity, type of sedentary behavior, and indicator, respectively. The overall pooled *OR* was 1.45 (95%*CI*: 1.15–1.84; $P < 0.05$) for cross-sectional studies and 1.25 (95%*CI*: 1.00–1.57; $P = 0.05$) for cohort studies. The heterogeneity was higher in cross-sectional studies ($I^2 = 93.6\%$) than in cohort studies ($I^2 = 71.0\%$). When stratified by different depression indicators, the effect size between depression and sedentary behavior as measured by the PHQ-9 and HADS scales was not statistically significant. In the HADS group, the combined *OR* was 1.44 (95%*CI*: 0.93–2.24) with high heterogeneity ($I^2 = 97.5\%$). In the PHQ-9 group, the combined OR was 1.56 (95%*CI*: 0.93–2.62) with high heterogeneity ($I^2 = 93.0\%$). Depression was positively associated with sedentary behavior when assessed using the CES-D and GDS scales.

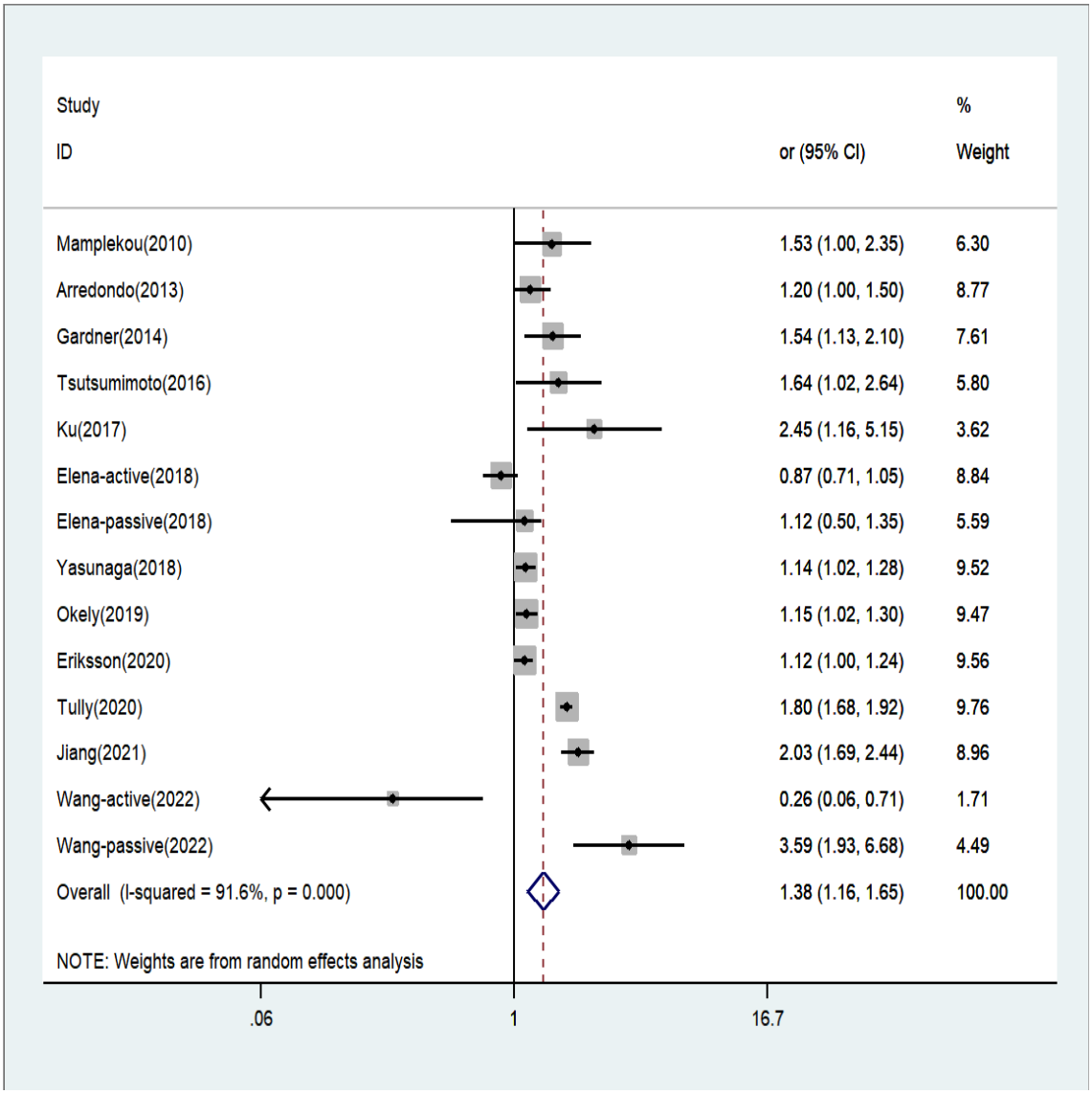

Fig. 2: Forest plot of the retrieved studies

The combined OR of the CES-D group was 1.54 (95%*CI*: 1.13–2.10), and the combined *OR* of the GDS group was 1.26 (95%*CI*: 1.03–1.53), with high heterogeneity (I^2 = 76.5%). When the sedentary behavior was separated into two groups (self-reported or wearing accelerator), the results showed that sedentary behavior measured with an accelerator was positively correlated with depression (*OR* = 1.35, 95%*CI*: 1.03–1.76); while, in the self-reported group, the combined *OR* was 1.39 (95%*CI*: 1.04–1.87), with high heterogeneity (I^2 = 86.2%). When stratified by adjustment for physical activity, we found that the sedentary behavior when adjusted for physical activity was not associated with depression (*OR* = 1.33, 95%*CI*: 0.99–1.78), with relatively low heterogeneity (I^2 = 79.7%). Meanwhile, sedentary behavior without physical activity adjustment was positively correlated with depression 1.37, 95%*CI*: 1.14–1.65), with high heterogeneity (I^2 = 93.5%).We divided sedentary behavior into watching TV (passive sedentary) and other sedentary behaviors (active

sedentary), and the results indicated that active sedentary behaviors were positively associated with depression (*OR* = 1.75, 95%*CI:* 1.02–3.02), while passive sedentary behaviors were not significantly associated with depression and had lower heterogeneity (I^2 = 55.5%); (Table 2). (Supplementary Figures 1-5).

Table 2: Subgroup analysis results

Factor	*N*	*OR (95% CI)*	*P-value*	*I² (%)*
Study design				
Cross-sectional	8	1.45(1.15,1.84)	<0.05	93.6
Cohort	6	1.25(1.00,1.57)	0.05	71.0
Depression indicator				
GDS	9	1.26(1.03,1.53)	<0.05	76.5
PHQ-9	2	1.56(0.93,2.62)	0.09	93.0
CES-D	1	1.54(1.13,2.10)	<0.05	/
HADS	2	1.44(0.93,2.24)	0.10	97.5
Sedentary Behavior indicator				
Self-reported	9	1.39(1.04,1.87)	<0.05	86.2
Accelerator	5	1.35(1.03,1.76)	<0.05	95.8
Adjusted for physical activity				
Adjusted	9	1.33(0.99,1.78)	0.06	79.7
Not adjusted	12	1.37(1.14,1.65)	<0.05	93.5
Types of sedentary behavior				
Watching TV	3	1.75(1.02,3.02)	<0.05	75.7
Other SB	2	0.72(0.40,1.27)	0.26	55.5

Analysis of sensitivity

We performed sensitivity analysis by omitting each study in turn, with the combined *OR* ranging from 1.32 (95%*CI*: 1.10–1.58) to 1.44 (95%*CI*: 1.21–1.72), which proved the stability of our study (Fig. 3).

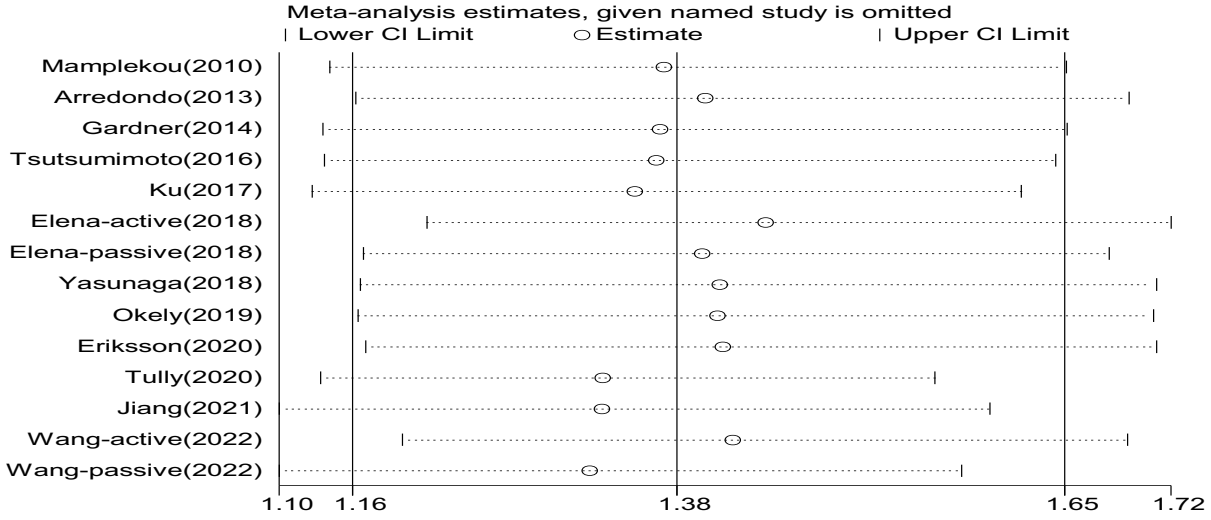

Fig. 3: Sensitivity analysis result

Publication bias

We drew funnel plots to examine the evidence of publication bias (Fig. 4). In addition, Begg's rank correlation test (P = 0.381) and Egger's linear regression test (P = 0.576) were also performed for publication bias assessment. The findings suggested no significant publication bias for all included studies.

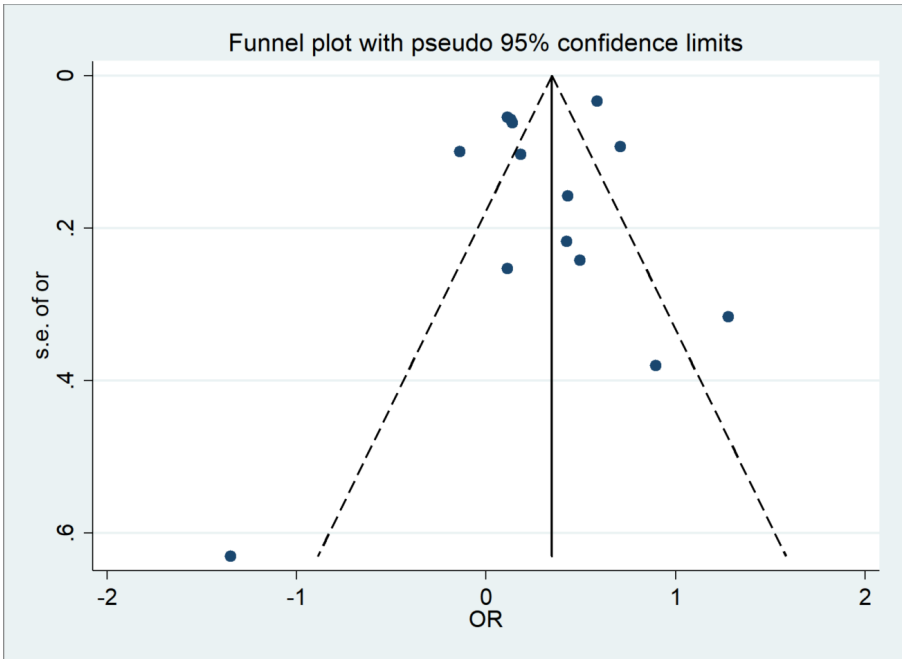

Fig. 4: Funnel diagram

Discussion

Previous comprehensive research has measured the relationship between sedentary behavior and depression, including studies on sedentary behavior and depression based on screen time (36), sedentary behavior and depression risk (9, 37), and the correlation between screen time-based sedentary behavior and depression in children and teenagers (22). Our study focused on the older adults: the particular population with the longest sedentary time. To assess the correlation between sedentary behavior and depression among the elderly, we systematically analyzed 12 previous studies. Our meta-analysis showed that the pooled *OR* of the included studies was 1.38 (95%*CI*: 1.16–1.65), which indicates that sedentary behavior was positively correlated with depression in the elderly. This is consistent with previous studies, as prolonged sedentary behavior is associated with adverse health outcomes, such as cardiovascular diseases, chronic disease, stress, and the risk of depression. Nevertheless, the effect observed in our meta-analysis was slightly higher than the combined *OR* in previous similar research. Compared with other age groups, the study results showed a stronger correlation between sedentary behavior and depression among the elderly. Several mechanisms can explain the adverse effects of sedentary behavior on depression. The daily physical activities of the elderly gradually decrease with increasing age. Thus, they lack exercise and remain sedentary for most of the day. Most studies have proved that physical activity can effectively prevent and treat depressive symptoms (38, 39). Lessened physical activity is one of the reasons why sedentary behavior leads to depression. Prolonged sedentary behavior reduces the social participation of the elderly, resulting in social segregation, which is a significant hazard factor for depression among the el-

derly. Many studies have shown that social isolation places a burden on the health of the elderly (40), reduces their subjective well-being (41), and increases their risk of depression (41).

The sub-group analysis showed a consistent correlation between cross-sectional studies and cohort studies; however, the *OR* of cross-sectional studies was more significant than that of cohort studies, while the heterogeneity of the cohort studies was minor. According to the results of the sub-group analysis by depression indicator, there were significant differences between the different scales. When using the PHQ-9 and HADS scales, sedentary behavior was non-significantly associated with depression, while it was significant when using the CES-D and GDS scales. The scores of many depression measurement scales cannot be directly transformed into clinical diagnoses; as such, semi-structured interviews may be more accurate in defining the existence of depression. Some related studies have used the CES-D or GDS scale to judge whether the elderly suffer from depression. The diagnostic results showed good effectiveness. The limited number of original studies using the PHQ-9 and HADS scales may be the reason why the effect of sub-group analysis was not significant. We also conducted sub-group analysis according to different sedentary behavior measurement methods.

The result indicated both the measurement of sedentary behavior through self-reporting or the use of an accelerator was associated with depression, where the effect value obtained by self-reporting was higher. Self-reported measurements are more often used in observational epidemiological studies that explore physical activity and health outcomes; however, using this measurement alone may cause older people to overestimate their sedentary time (42). Further, to provide objective evidence related to depression, many studies have used accelerometer-based activity measurement, rather than self-reported measurements, in order to measure sedentary behavior. Therefore, the bias caused by self-reported physical activity measurement methods can be eliminated, such as recall bias, which limits the accuracy of self-reporting in the elderly. In addition, we recommend using objective measurement methods, such as accelerometer data, such that researchers can draw more effective conclusions about sedentary behavior. After categorizing sedentary behaviors, the results showed no significant association between passive sedentary behavior and depression, while sedentary time spent watching television had a greater impact on depression. Hallgren et al. considered that the mental stimulation provided by different sedentary behavior patterns might have different correlations with depression. They suggested that negative sedentary behavior (e.g., watching TV) may be related to depression, while positive sedentary behavior (e.g., reading) may be beneficial. In research in the elderly, depression has been related to certain sedentary behaviors (watching TV or sitting), but not to other behaviors (using a computer or reading). A study of 6359 older adults in the U.K. obtained similar results; sedentary TV watching was associated with higher depression rates, while sedentary use of the Internet was related to minor depression (43).

Excluding the included studies that adjusted for physical activity led to different findings in our research. When not adjusting for physical activity, sedentary behavior was associated with depression, while it was not significant when adjusting for physical activity. Non-adjustment for physical activity contributed to the positive association between sedentary behaviors and depression, as lacking physical activity is independent risk factors for depression (37). Statistical heterogeneity may be related to differences in adjustment variables. The conclusions drawn from our current research were confirmed furthermore by accelerometer data and adjustment for physical activity. The elderly are sedentary most of the time, and sedentary behavior is pervasive in their daily life. Therefore, minor changes may be pivotal. To decrease and prevent depression in the elderly, we should consider controlling their sedentary time and increasing physical activity appropriately.

Strengths and limitations

We focused on older adults, who have the highest rates of sedentary behavior. Our study has a large sample size, which makes the correlation between sedentary behavior and depression detection rate reliable in older adults. Some limitations to this study should also be acknowledged. First, we did not specifically classify sedentary times. Small changes in sedentary time may significantly affect the prevalence of depression, such as an increase in daily standing time. Second, there were few studies specifically focusing on sedentary behavior and depression in the elderly, the limited information provided in the included studies and the number of original studies in some groups was small at the time of subgroup analysis, which may have had a certain influence on the analysis results. Third, there are many factors associated with depression, such as changes in socioeconomic status and suffering from other mental illnesses, which should be considered in future studies. Last, this meta-analysis was not registered, so the results should be considered as exploratory finding and interpreted with caution.

Conclusion

Sedentary behavior is a risk factor for depression. However, the symptoms of depression are complex, this mechanism of action is difficult to judge. Symptoms such as decreased mood, slow movement, and mental fatigue can be regarded as the reason for sedentary behavior. Therefore, future studies should explore how sedentary behavior leads to depression. Meanwhile, we should combine the objective measurement of sedentary behavior with studying the correlation between depression and different sedentary behavior types at different times. Physical activity may play an essential role in improving depressive symptoms in the elderly and preventing subsequent adverse health consequences; we can consider searching for the association between physical activity and depression in the elderly.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Conflict of Interest

The authors have no conflicts of interest to declare.

Funding

This study was funded by the National Natural Science Foundation of China (72274140) the Humanities and Social Science Fund Ministry of Education of China (22YJAZH137).

Data availability

The datasets used, supplementary tables and/or analyzed during the present study are available from the corresponding author on reasonable request.

References

1. Tremblay MS, Aubert S, Barnes JD, et al (2017). Sedentary Behavior Research Network (SBRN) – Terminology Consensus Project process and outcome. *Int J Behav Nutr Phys Act,* 14(1):75.
2. Dempsey PC, Matthews CE, Dashti SG, et al (2020). Sedentary Behavior and Chronic Disease: Mechanisms and Future Directions. *J Phys Act Health,* 17 (1):52-61.
3. Hills AP, Arena R, Khunti K, et al (2018). Epidemiology and determinants of type 2 diabetes in south Asia. *Lancet Diabetes Endocrinol,* 6 (12):966-978.
4. Wilmot EG, Edwardson CL, Achana FA, et al (2012). Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. *Diabetologia,* 55(11):2895-905.

5. Patterson R, Mcnamara E, Tainio M, et al (2018). Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. *Eur J Epidemiol,* 33 (9):811-829.
6. Gilchrist SC, Howard VJ, Akinyemiju T, et al (2020). Association of Sedentary Behavior With Cancer Mortality in Middle-aged and Older US Adults. *JAMA Oncol,* 6 (8):1210-1217.
7. Yan Y, Shin JC, Li D, An R (2017). Sedentary Behavior and Sleep Problems: a Systematic Review and Meta-Analysis. *Int J Behav Med,* 24 (4): 481-492..
8. Eunmi L, Yujeong K (2019). Effect of university students' sedentary behavior on stress, anxiety, and depression. *Perspect Psychiatr Care,* 55 (2):164-169.
9. Zhai L, Zhang Y, Zhang D (2015). Sedentary behaviour and the risk of depression: A meta-analysis. *Br J Sports Med,* 49 (11):705-709.
10. Charles E. Matthews KYC, Patty S. et al (2008). Amount of Time Spent in Sedentary Behaviors in the United States, 2003–2004. *Am J Epidemiol,* 167 (7):875-881.
11. Schl Aff RA, Baruth M, Boggs A, Hutto B (2017). Patterns of Sedentary Behavior in Older Adults. *Am J Health Behav,* 41 (4):411-418.
12. Maria GG, Oriol SN, Tully MA, et al (2020). Accelerometer-Measured Sedentary and Physical Activity Time and Their Correlates in European Older Adults: The SITLESS Study. *J Gerontol A Biol Sci Med Sci,* 75 (9):1754-1762.
13. Biswas A, Oh PI, Faulkner GE, et al (2015). Sedentary Time and Its Association With Risk for Disease Incidence, Mortality, and Hospitalization in Adults: A Systematic Review and Meta-analysis. *Ann Intern Med,* 162 (2):123-32.
14. Thapar A, Collishaw S, Pine DS, Thapar AK (2012). Depression in adolescence. *Lancet,* 379 (9820):1056-67.
15. WHO (2017). Depression and Other Common Mental Disorders: Global Health Estimates. https://www.who.int/publications-detail-redirect/depression-global-health-estimates
16. Organization WH (2003). The world health report 2002 - reducing risks, promoting healthy life. *Educ Health (Abingdon),* 16 (2):230.
17. Feng Z, Li Q, Zhou L, et al (2021). The relationship between depressive symptoms and activity of daily living disability among the elderly: results from the China Health and Retirement Longitudinal Study (CHARLS). *Public Health,* 198:75-81.
18. Eriksson M, Naas S, Berginstrom N, et al (2020). Sedentary behavior as a potential risk factor for depression among 70-year-olds. *J Affect Disord,* 263:605-608.
19. Jiang Yan CA, Zhang Hailing, Wu Xiaoting (2021). The relationship between sedentary behavior, social participation and depression in community — dwelling elderly. *Modern Preventive Medicine,* 48 (17):3141-3144.
20. Wang JQ, Li RQ, Zhang LM, et al (2022). Associations between sedentary behaviour patterns and depression among people aged 60 and older in Hebei Province of China. *BMC Public Health,* 22 (1):283.
21. Andrade-Gomez E, Martinez-Gomez D, Rodriguez-Artalejo F, Garcia-Esquinas E (2018). Sedentary behaviors, physical activity, and changes in depression and psychological distress symptoms in older adults. *Depress Anxiety,* 35 (9):884-897.
22. Mingli, Liu, Lang, Wu, Shuqiao, Yao (2016). Dose–response association of screen time-based sedentary behaviour in children and adolescents and depression: a meta-analysis of observational studies. *Br J Sports Med,* 50 (20):1252-1258.
23. Allen MS, Walter EE, Swann C (2019). Sedentary Behaviour and Risk of Anxiety: A Systematic Review and Meta-analysis. *J Affect Disord,* 242:5-13.
24. Higgins J, Thompson SG, Decks JJ, Altman DG (2003). Measuring inconsistency in meta-analyses. *BMJ,* 327 (7414):557-560.
25. Higgins J, Thompson SG (2002). Quantifying heterogeneity in a meta-analysis. *Stat Med,* 21 (11):1539-1558.
26. Begg C, Mazumdar M (1994). Operating Characteristics of a Rank Correlation Test for Publication Bias. *Biometrics,* 50 (4):1088-1101.
27. Lewis SJ, Zammit S, Gunnell D, Smith GD (1997). Bias in Meta-Analysis Detected by a Simple, Graphical Test. *BMJ,* 315 (7109):629-634.
28. Mamplekou E, Bountziouka V, Psaltopoulou T, et al (2010). Urban environment, physical

inactivity and unhealthy dietary habits correlate to depression among elderly living in eastern Mediterranean islands: the MEDIS (MEDiterranean ISlands Elderly) study. *J Nutr Health Aging,* 14 (6):449-55.
29. Arredondo EM, Lemus H, Elder JP, et al (2013). The relationship between sedentary behavior and depression among Latinos. *Mental Health and Physical Activity,* 6 (1):3-9.
30. Yasunaga A, Shibata A, Ishii K, Koohsari MJ, Oka K (2018). Cross-sectional associations of sedentary behaviour and physical activity on depression in Japanese older adults: an isotemporal substitution approach. *BMJ Open,* 8 (9):e022282.
31. Tully MA, McMullan I, Blackburn NE, et al (2020). Sedentary behavior, physical activity, and mental health in older adults: An isotemporal substitution model. *Scand J Med Sci Sports,* 30 (10):1957-1965.
32. Gardner B, Iliffe S, Fox KR, Jefferis BJ, Hamer M (2014). Sociodemographic, behavioural and health factors associated with changes in older adults' TV viewing over 2 years. *Int J Behav Nutr Phys Act,* 11:102.
33. Tsutsumimoto K, Makizako H, Doi T, et al (2017). Prospective associations between sedentary behaviour and incident depressive symptoms in older people: a 15-month longitudinal cohort study. *Int J Geriatr Psychiatry,* 32 (2):193-200.
34. Ku PW, Steptoe A, Liao Y, et al (2018). Prospective relationship between objectively measured light physical activity and depressive symptoms in later life. *Int J Geriatr Psychiatry,* 33 (1):58-65.
35. Okely JA, Cukic I, Shaw RJ, et al (2019). Positive and negative well-being and objectively measured sedentary behaviour in older adults: evidence from three cohorts. *BMC Geriatr,* 19 (1):28.
36. Xiao, Wang, Yuexuan, Haoliang, Fan (2019). The associations between screen time-based sedentary behavior and depression: a systematic review and meta-analysis. *BMC Public Health,* 19 (1):1524.
37. Huang Y, Li L, Gan Y, Wang C, Lu Z (2020). Sedentary behaviors and risk of depression: a meta-analysis of prospective studies. *Transl Psychiatry,* 10 (1):26.
38. Kandola A, Ashdown-Franks G, Hendrikse J, et al (2019). Physical activity and depression: Towards understanding the antidepressant mechanisms of physical activity. *Neurosci Biobehav Rev,* 107:525-539.
39. Sun-Young Kim, Jae-Hyun Park, Mi Yeon Lee, et al (2019). Physical activity and the prevention of depression: A cohort study - ScienceDirect. *Gen Hosp Psychiatry,* 60:90-97.
40. Hawton A, Green C, Dickens AP, et al (2011). The impact of social isolation on the health status and health-related quality of life of older people. *Qual Life Res,* 20 (1):57-67.
41. Shankar A, Rafnsson SB, Steptoe A (2015). Longitudinal associations between social connections and subjective wellbeing in the English Longitudinal Study of Ageing. *Psychol Health,* 30 (6):686-698.
42. Urda JL, Larouere B, Verba SD, Lynn JS (2017). Comparison of subjective and objective measures of office workers' sedentary time. *Prev Med Rep,* 8:163-168.
43. Hamer M, Chida Y (2011). Life satisfaction and inflammatory biomarkers: The 2008 Scottish Health Survey. *Japanese Psychological Research,* 53 (2):133-139.