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Journal of Sports Sciences

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rjsp20

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To cite this article: Yujia Liu, Zhenjia Sun, Xingqi Wang, Tong Chen & Chen Yang (2022): Dose-response association between the daily step count and all-cause mortality: A systematic review and meta-analysis, Journal of Sports Sciences, DOI: 10.1080/02640414.2022.2099186

To link to this article: https://doi.org/10.1080/02640414.2022.2099186

JOURNAL OF SPORTS SCIENCES
https://doi.org/10.1080/02640414.2022.2099186

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PHYSICAL ACTIVITY, HEALTH AND EXERCISE

Dose-response association between the daily step count and all-cause mortality: A systematic review and meta-analysis

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ABSTRACT

This review aims to investigate the dose-response relationship between the daily step count and all-cause mortality. PubMed, the Cochrane Library, Embase, and Web of Science were searched for all articles of cohort studies investigating the association between the daily step count and all-cause mortality. Cohort research articles were included if they reported mortality with no less than 3 categories of the daily step count, and hazard ratio (HR) with a 95% Confidence Interval (CI) was reported. Dose-response association meta-analysis and subsequent sex subgroup analysis were performed. The final analysis included a total of nine studies. Compared with the low-step count population, the high-step count population had a 62% lower risk of all-cause death (HR = 0.38, 95% CI 0.27–0.49). There was a non-linear dose-response relationship between the daily step count and all-cause mortality. Compared with the least (1895 steps), the first quartile (4000 steps/day) had a 37% lower risk for all causes of death (HR = 0.63, 0.57–0.71), the second quartile (6388 steps/day) had a 60% lower risk for all causes of death (HR = 0.40, 0.32–0.49), the third quartile (9994.3 steps/day) had a 75% lower risk of all-cause death than the first quartile (HR = 0.25, 0.19–0.33).

ARTICLE HISTORY
Received 11 October 2021
Revised 1 June 2022
Accepted 3 July 2022

KEYWORDS
Daily step count; all-cause mortality; dose-response association; meta-analysis

Introduction

Physical activity is associated with lower risks of all-cause mortality(I.-M. Lee et al., 2012). A linear dose-response relationship was shown between physical activity and all-cause mortality (Hupin et al., 2015). Physical activity has profound benefits in lowering all-cause mortality (Ekelund et al., 2019; Kraus et al., 2019). Thus, the current guidelines for healthy people and patients in different countries emphasize the importance of increasing the physical activity level (Chaput et al., 2020; Du et al., 2019; Piercy et al., 2018).

Walking represents the simplest physical activity, which is well accepted due to the lower intensity and higher safety compared with other physical activities, especially for the elderly (Hanson & Jones, 2015). Walking can significantly reduce all-cause mortality, independent of other physical activity (Hamer & Chida, 2008; Kelly et al., 2014). Besides, previous studies have shown that the largest reduction in all-cause mortality is evident among those who move from no walking to some regular walking (Hamer & Chida, 2008; Kelly et al., 2014). To ease the recording of the daily step count, there has been an expansion of wearable activity monitors and smartphones with activity-tracking capabilities. Achieving 10,000 steps per day has been a common goal that is widely spread by the lay press and often used as the default by software programs on wearables and smartphones. Since the results of cohort research studies from America, Great Britain, Australia, Japan, Spain and Norway widely varied, there is still no consensus on the dose-response association between the daily step count and mortality. In addition, corresponding prospective studies are still insufficient. The study by Dwyer et al. (Dwyer et al., 2015) on 10-year follow-up data found that all-cause mortality risk linearly decreased as the daily step count increased. Yamamoto et al. (Yamamoto et al., 2018) argued that a high daily step count is associated with a lower risk of all-cause mortality in the elderly, but the reported relationship between the daily step count and all-cause mortality was non-linear. According to Lee et al. (I. M. Lee et al., 2019), a daily step count of 4400 could reduce all-cause mortality compared with the reference women after a 4-year follow-up of elder American women. Self-rated walking pace was also used to assess all-cause and cardiovascular mortality (Stamatakis et al., 2018; Yates et al., 2017). Globally, the average daily step count (measured by smartphones) is about 5000; in America, it is 4800 (Althoff et al., 2017). Overall, there is insufficient information on how many daily steps are required for public health, so the goal of 10,000 steps per day still has some limitations.

Sex would contribute to the difference in the relationship between the daily step count and health. Tudor-Locke et al. (Tudor-Locke & Bassett, 2004) revealed a strong linear relationship between the step-based movement and cardiometabolic risk factors in women, while they found this relationship to be insignificant in men. A cohort research study of 16,741 participants showed no correlation between the step intensity and lower mortality after adjusting the total daily step count (Althoff et al.,

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Supplemental data for this article can be accessed online https://doi.org/10.1080/02640414.2022.2099186

2017). The relationship between the daily step count and mortality would be different. Age would also act as an influencing factor that affected the relationship. Defined as light physical activity may be equivalent to moderate-vigorous physical activity (in relative terms) in the elderly (Ekelund et al., 2019). Thus, the relationship between the daily step count and mortality in different aged populations needed to be clarified as well.

The dose-response relationship of the daily step count is needed to be clarified. Although a previous systematic review discussed the relationship between the daily step count and all-cause mortality, the included research works were too few to quantify (Hall et al., 2020). Longitudinal studies using accelerometers would help to establish dose-response relationships between step counts and all-cause mortality (Bassett et al., 2017). Therefore, in the present study, we aim to examine the dose-response relationship between the daily step count and all-cause mortality risk, providing evidence for formulating physical activity intervention plans.

Methods

Literature search strategy

We searched PubMed, the Cochrane Library, Embase, and Web of Science for all articles of cohort studies investigating the association between the daily step count and all-cause mortality from their inception until June 5th, 2021. The used search terms were "daily step*", "step count", "step volume", "pedometer*", "accelerometer*", "actigraph*" and "mortality". Research works were restricted to the English language. The reference lists of the included studies were also searched as an additional check for further studies that could be included in the review.

Inclusion criteria

The studies were selected for the review if they met the following criteria: (1) cohort research; (2) adult participants; (3) reported device-based measure of daily step counts; (4) all-cause mortality risk is the outcome or can be calculated; (5) the hazard ratio (HR) with 95% confidence interval (95% CI) is reported or can be calculated.

Study selection and data extraction

Two authors extracted the data independently using a standardized Microsoft Excel template. Disagreements were resolved through discussion, with a third author stepping in case of disagreement. The extracted data included the first author, publication year, cohort size, location, participants' characteristics (age, sex), follow-up period, method of daily step assessment, reduction of mortality risk, case number and median per category of the daily step count, reported level of the daily step count category, case number per category of the daily step count category, total persons or person-years per daily step count, HR for mortality with 95% CIs for each daily step count category and covariates on which the analyses were adjusted. If any given study did not provide relevant information, the corresponding author was contacted and asked to provide the data by email. If the median of the category was missed, then the mean of the interval of the daily step count was used instead. If the category for the daily step count was open-ended, then the width of the interval was obtained by referring to other studies. The Engauge Digitizer 4.1 software was used to extract the data if only the survival curve was reported. The HR and 95% CI values were calculated according to the method of Tierney et al. using the observed events, expected events, events of each category and total cases (Tierney et al., 2007). If the relevance was not the lowest category, we used the Microsoft Excel file made by Hamling et al. (Hamling et al., 2008) was used to convert it according to the theory of Greenland and Longnecker (Greenland & Longnecker, 1992).

Study quality and reporting

Two reviewers independently assessed the individual studies using the "Newcastle-Ottawa scale (NOS)", which allows for a total score of ≤9 points summarizing 8 aspects of each study (Stang, 2010). The higher the score, the higher the quality. Any disagreements were discussed until an agreement was reached.

Statistical analysis

Statistical analyses were carried out using the Stata software v.16.0. The between-study heterogeneity was investigated using the Cochran's Q test and the I^2 statistic. In terms of the statistical significance for I^2, we considered values ≥ 25 and ≤ 50% indicate low heterogeneity, those ≥ 50 and ≤ 75% to indicate moderate heterogeneity and those >75% to indicate high heterogeneity. The publication bias was assessed using Egger's test and funnel plot. A meta-analysis of HR with 95% CI was analysed using a fixed-effects model when the heterogeneity was low; otherwise, a randomized effects model was used. HR and 95% CI of the daily step count category with the highest level in all research works were pooled compared with those with the lowest level. The publication bias was assessed by examining the asymmetry of funnel plots using Egger's test. To test the robustness of the overall weighted effect sizes, a sensitivity analysis was conducted. For the further analysis of linear or nonlinear associations, spline analysis and dose-response generalized least-square trend (GLST) meta-analysis were applied. Finally, subgroup analysis was carried out based on the participants' sex, age and the instrument used to assess steps.

Results

Study selection

The literature search strategy is outlined in Figure 1. Our initial database search identified 5569 potentially eligible articles, with a further three identified through manual search. After screening of titles and abstracts and based on the inclusion criteria, 5501 articles were excluded. The remaining 68 papers underwent full-text screening, among which 59 were excluded. The final analysis included a total of 9 studies (Dwyer et al., 2015; Fox et al., 2015; Hansen et al., 2020; Jefferis et al., 2019; I. M. Lee et al., 2019; Mañas et al., 2021; Oftedal et al., 2020; Saint-Maurice et al., 2020; Yamamoto et al., 2018).

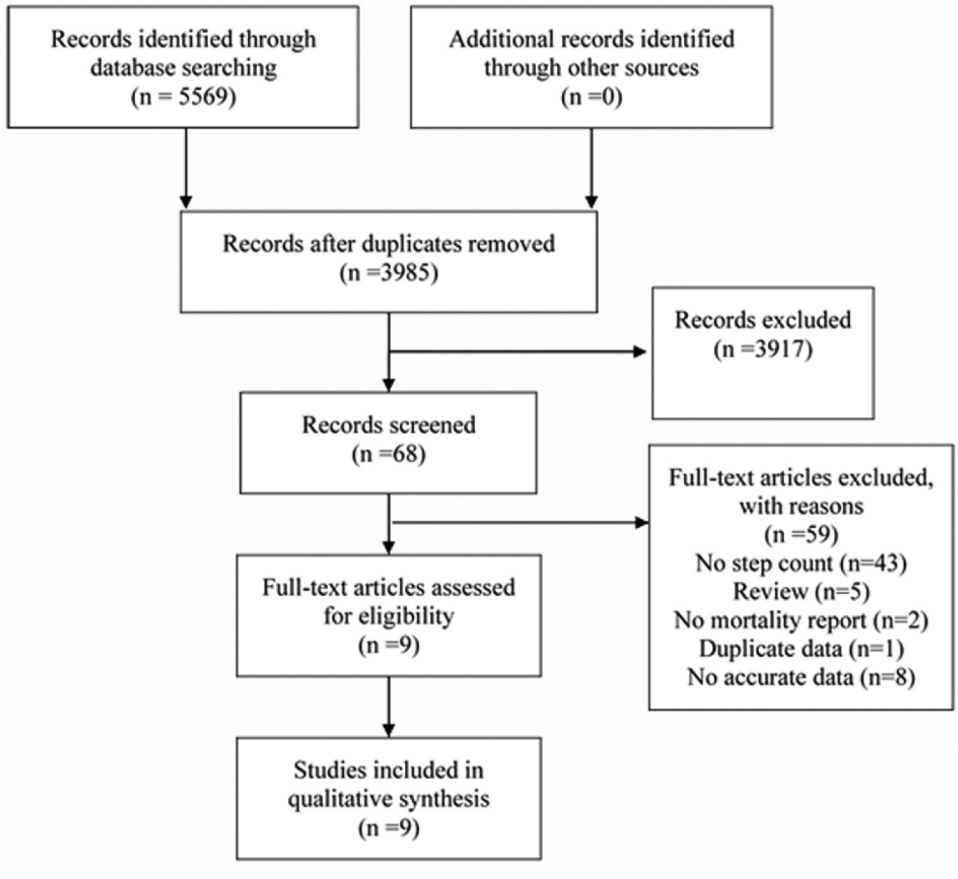

Figure 1. PRISMA flow diagram of the study selection process.

Characteristics of the included studies

The included studies evaluated a total of 30,645 participants, including 15,294 males and 15,351 females. The participants' mean age ranged from 56.8 years to 78.8 years. The year of follow-up ranged from 4 to 13.1 years. The mortality rate reported ranged from 3% to 18.1%. Of these 9 publications, most were conducted in the United Kingdom (n = 2), the United States (n = 2) and Australia (n = 2), with the rest from Norway (n = 1), Japan (n = 1), and Spain (n = 1). In the studies, pedometer (n = 3) or accelerometer (n = 6) was used to measure the number of steps per day. The characteristics are shown in Table 1

Table 1. Characteristics of research included.

ID	Study	Country	Cohort size	Sex	Age (years)	Follow-up (years)	Mortality reported	Wearable monitors	Daily step count unit	Risk Reduction (%)	NOS
1	Dwyer 2015	Australia	2576	M = 1226 W = 1350	58.8 ± 13.2	10	8.5	Pedometer	1000	6	9
2	Fox 2015	England	240	M = 125 W = 115	≥70	4–5	16.4	Actigraph GT1Ms Accelerometer	1000	36	6
3	Yamamoto 2018	Japan	419	M = 228 W = 191	70 ± 0	10	18.1	Pedometer	1000	7	9
4	Jefferis 2019	British	1181	M	78.4 ± 4.6	5	16.4	ActiGraph GT3X Accelerometer	1000	14	8
5	Lee 2019	US	16,741	W	72.0 ± 5.7	4	3	ActiGraph GT3X Accelerometer	1000	18	8
6	Saint-Maurice 2020	US	4840	M = 2435 W = 1732	mean age of 56.8	10.1	16.1	ActiGraph 7164	4000	23.9	9
7	Oftedal 2020	Australia	1697	M = 858 W = 873	65.4 ± 7.1	13.1	12	Pedometer	1000	7	8
8	Hansen 2020	Norway	2183	M = 1157 W = 1026	57 ± 10.9	median of 9.1	5.5	ActiGraph GT1M	1000	48	8
9	Mañas 2021	Spain	768	M = 354 W = 414	78.8 ± 4.9	5.7	11.6	ActiGraph wGT3X-BT	1000	13	8

M = men, W = women. Age was reported by Mean ± SD. Mortality reported was calculated by using total death cases divided by total cohort size. Risk Reduction was reported by their daily step count unit. NOS represented the quality assessment of the studies.

Study quality

The analyses of the study quality according to the NOS were shown in Table 2. Out of 9 studies, 8 studies were of high quality and 1 was of medium quality.

Highest vs. lowest daily step count analysis

The all-cause mortality risk of the highest category daily step count was reduced by 62% (HR = 0.38, 95% CI 0.27–0.49) compared with the lowest category (As shown in Figure 2). Value of I^2 = 70.6% and P < 0.001 meant that high heterogeneity was detected. When the estimated effect size was plotted against the standard errors, the funnel plot was asymmetrical (See supplemental Figure S1). This means that a publication bias risk was detected. Nonparametric trim-and-fill analysis of the publication bias was further conducted. There was no significant difference between the adjusted and unadjusted results. The result of sensitivity analysis suggested that there was no change when just one study was excluded (Supplemental figure S2.).

Dose-response association between the daily step count and all-cause mortality

We included nine studies to analyse the dose-response association between the daily step count and all-cause mortality. The results suggested a nonlinear dose-response relationship between the daily step count and all-cause mortality (χ^2 = 16.8, $P_{nonlinearity}$ < 0.001, Figure 3). Compared with the least (1895 steps), the first quartile (4000 steps/day) had a 37% lower risk for all causes of death (HR = 0.63, 0.57–0.71), the second quartile (6388 steps/day) had a 60% lower risk for all causes of death (HR = 0.40, 0.32–0.49), the third quartile (9994.3 steps/day) had a 75% lower risk of all-cause death than the first quartile (HR = 0.25, 0.19–0.33). In summary, all-cause mortality was reduced and the percentage change of HR per 1000 steps was lower with the increase of the daily step count.

Subgroup analysis

Sex

According to the sex of the cohort population, three studies were included in each of the male and female studies. Subgroup meta-analysis revealed that when comparing the highest vs. lowest daily step count level, the pooled HR of the males was 0.29 (95% CI 0.21–0.37, Supplemental Figure S3A), with a low heterogeneity (I^2 = 0%). On the other hand, all-cause mortality risk was reduced by 65% in females (HR = 0.35, 95% CI 0.27–0.43. Supplemental Figure S3B), with low heterogeneity.

A non-linear dose-response relationship between the daily step count and all-cause mortality was detected both in male and female subgroup analyses. Compared with the first quartile (3734.5 steps/day) in males, the second quartile (5701 steps/day) had a 21.66% lower risk for all causes of death. The third quartile (9600 steps/day) had a 38.46% lower risk of all-cause death than the first quartile (Figure 4a). Compared with the first quartile (4272.25 steps/day) in females, the second quartile (5952.5 steps/day) had a 16.95% lower risk for all causes of death. The third quartile (8831.5 steps/day) had a 31.83% lower risk of all-cause death than the first quartile (Figure 4b).

Age

We conducted a subgroup analysis by participants' age (<40 years vs. >40 years) to interpret the difference in the association between step counts and all-cause mortality. Subgroup meta-analysis revealed that when comparing the highest vs. lowest daily step count level, the pooled HR of the participants younger than 65 years was 0.43 (95% CI 0.20–0.65, Supplemental Figure S4), with high heterogeneity (I^2 = 85.69%). On the other hand, all-cause mortality risk was reduced by 66% in participants older than 65 years (HR = 0.34, 95% CI 0.27–0.41. Supplemental Figure S4), with low heterogeneity.

A non-linear dose-response relationship between the daily step count and all-cause mortality was detected in participants younger than 65 years. Compared with the first quartile (4500 steps/day) in males, the second quartile (7495.25 steps/day) had a 22.77% lower risk for all causes of death. The third quartile (11,372 steps/day) had a 46.91% lower risk of all-cause death than the first quartile (Figure 5a). A linear dose-response relationship was found in participants older than 65 years. Compared with people with the lowest daily step count (1895 steps/day), for each increase of 1000 steps increase, the relative all-cause mortality decreased by 15.3% (Figure 5b).

Wearable devices

To check if risk estimates differ by type of instrument used, subgroup analysis was performed by the wearable devices (pedometers and accelerometers). Subgroup meta-analysis revealed that when comparing the highest vs. lowest daily step count level, the pooled HR of the pedometers was 0.35 (95% CI 0.29–0.41, Supplemental Figure S5), with a low heterogeneity. On the other hand, all-cause mortality risk was reduced by 58% assessed by accelerometers (HR = 0.42, 95% CI 0.12–0.72. Supplemental Figure S5), with high heterogeneity (I^2 = 86.62%).

A non-linear dose-response relationship between the daily step count and all-cause mortality was detected both in pedometers and accelerometers subgroup analyses. Compared with the first quartile (3873 steps/day) assessed by pedometers, the second quartile (6849.75 steps/day) had a 20.71% lower risk for all causes of death. The third quartile (11,293.25 steps/day) had a 44.27% lower risk of all-cause death than the first quartile (Figure 6a). Compared with the first quartile (3646 steps/day) assessed by accelerometers, the second quartile (5952.5 steps/day) had a 28.42% lower risk for all causes of death. The third quartile (8421.5 steps/day) had a 49.41% lower risk of all-cause death than the first quartile (Figure 6a).

Discussion

Our dose-response meta-analysis was performed to quantitatively evaluate the relationship between the effect size and exposure dose by searching for and including relevant literature. Compared to Hall et al. (Hall et al., 2020), we included more researches in the present study that assessed the dose-response association between the daily step count and all-

Table 2. Quality assessment of included cohort studies.

		Selection				Comparability		Outcome				
ID	Study	Representativeness of the exposed cohort	Selection of the non exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at the start of the study	Comparability of cohorts based on the design or analysis	study controls for any additional factor	Assessment of outcome	Was follow-up long enough for outcomes to occur	Adequacy of follow up of cohorts	Score	quality
1	Dwyer 2015	☆	☆	☆	☆	☆	☆	☆	☆	☆	9	high
2	Fox 2015	☆	☆	☆	☆	☆		☆			6	medium
3	Yamamoto 2018	☆	☆	☆	☆	☆	☆	☆	☆	☆	9	high
4	Jefferis 2019	☆	☆	☆	☆	☆		☆	☆	☆	8	high
5	Lee 2019	☆	☆	☆	☆	☆	☆	☆		☆	8	high
6	Saint-Maurice 2020	☆	☆	☆	☆	☆	☆	☆	☆	☆	9	high
7	Oftedal 2020	☆	☆	☆	☆	☆		☆	☆	☆	8	high
8	Hansen 2020	☆	☆	☆	☆	☆	☆	☆		☆	8	high
9	Mañas 2021	☆	☆	☆	☆	☆		☆	☆	☆	8	high

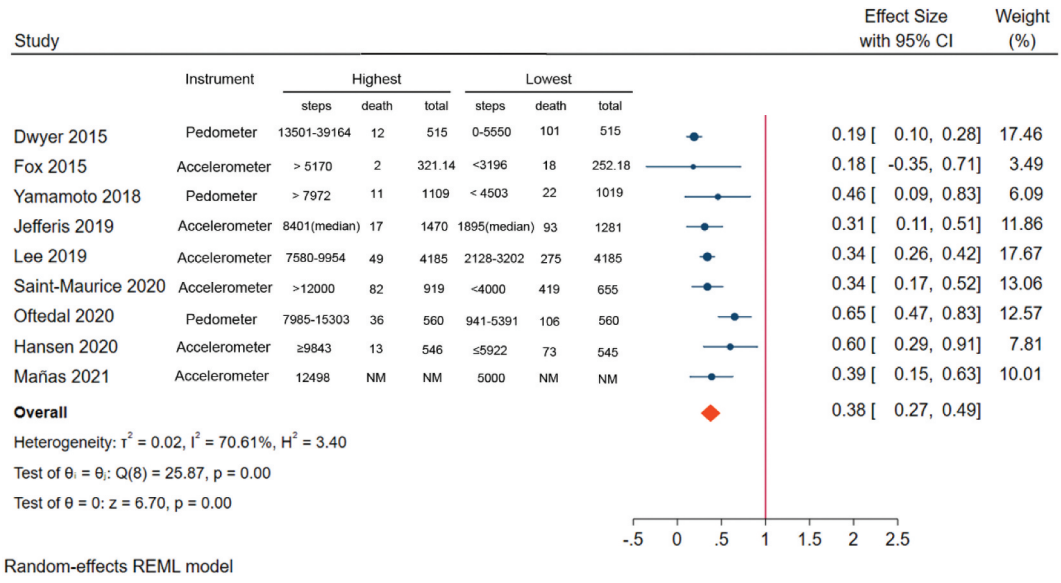

Figure 2. HR of the daily step count and all-cause mortality (Highest vs. Lowest). A randomized effects model was conducted. Each circle represents the estimated effect and 95% confidence interval of the study. The diamond represents the overall HR and 95% confidence interval (CI). The diamond went left of x = 1 represented HR of the highest category was lower than the lowest category.

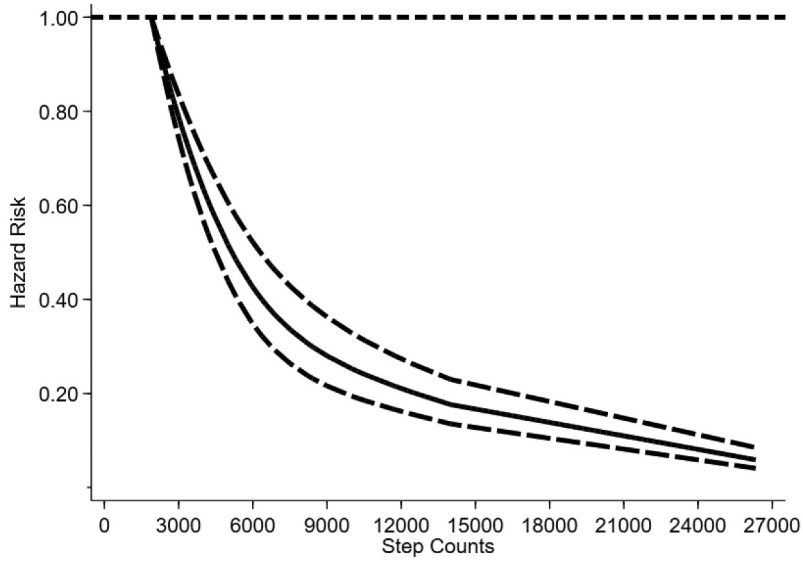

Figure 3. Dose-response association of the daily step count and all-cause mortality. The Wald test calculated a p-value for curve nonlinearity. The generalized least squares method was used to estimate the trend of the combined dose-response data.

cause mortality for the first time using meta-analysis. We found that people who had a high daily step count were associated with lower all-cause mortality. There is a non-linear relationship between daily step count and all-cause mortality.

A non-linear relationship between the daily step count and all-cause mortality would be a reference to evaluate the all-cause death risk for people. Mañas et al. (Mañas et al., 2021) suggested a linear relationship between them, while a non-linear relationship was reported in 3 other works of literature (Hansen et al., 2020; Jefferis et al., 2019; I. M. Lee et al., 2019). Lee et al. (I. M. Lee et al., 2019) reported a steady decline in the mortality rates with more steps up to approximately 7500 steps per day. We discovered that the all-cause mortality rate would continue to decrease as the daily step count increases even if it is exceeded 7500 steps per day, but the percentage of risk reduction was lower with the increase of step count. Therefore, a small increase in step count seems to be more economical and meaningful for sedentary people. However, the risk declined with walking more. The goal of 10,000 steps per day was arbitrary and had limitations. The daily step count

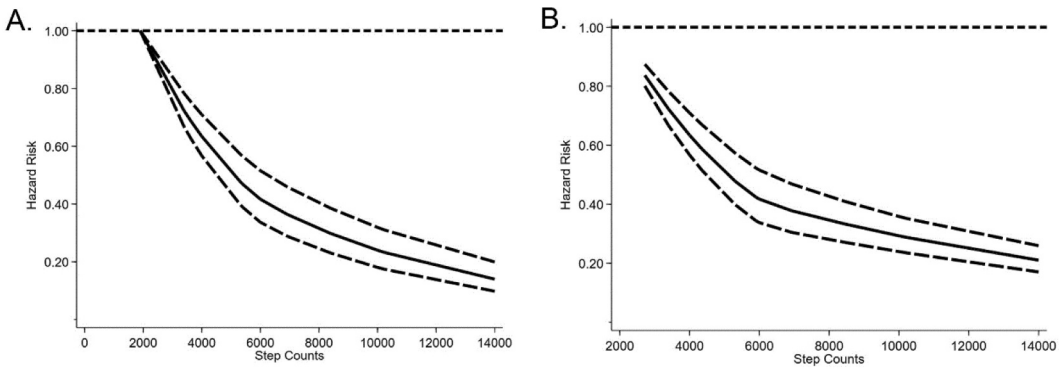

Figure 4. Non-linear association of the daily step count with all-cause mortality based on sex. The Wald test calculated a p-value for curve nonlinearity. The generalized least squares method was used to estimate the trend of the combined dose-response data. a. association of daily step count and all-cause mortality in males; b. association of the daily step count with all-cause mortality in females.

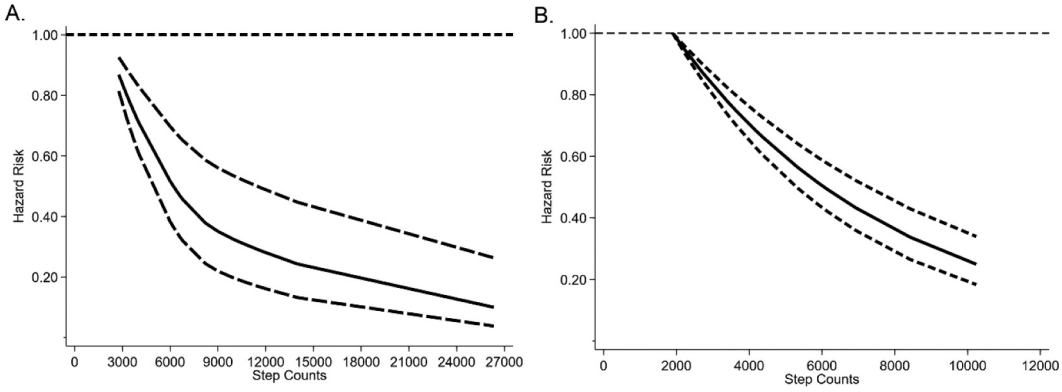

Figure 5. Non-linear association of the daily step count with all-cause mortality based on the participants' age. The Wald test calculated a p-value for curve nonlinearity. The generalized least squares method was used to estimate the trend of the combined dose-response data. a. association of daily step count and all-cause mortality in participants younger than 65; b. association of the daily step count with all-cause mortality in participants older than 65.

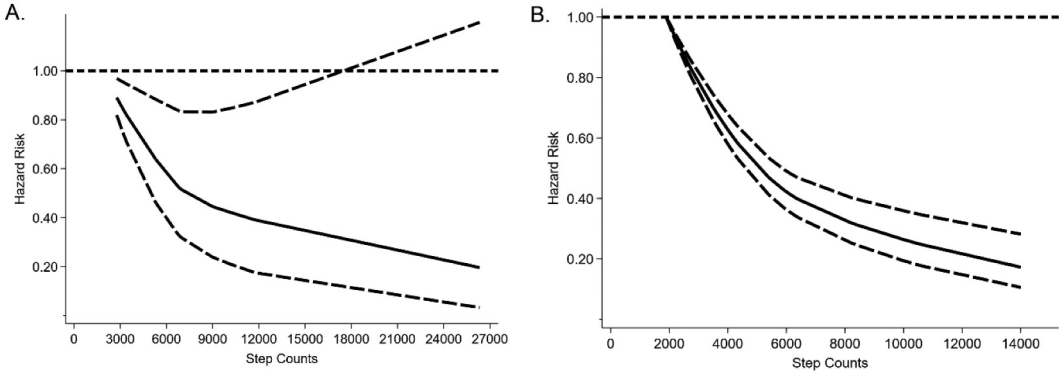

Figure 6. Non-linear association of the daily step count with all-cause mortality based on the wearable devices. The Wald test calculated a p-value for curve nonlinearity. The generalized least squares method was used to estimate the trend of the combined dose-response data. a. association of daily step count assessed by pedometer and all-cause mortality; b. association of the daily step count assessed by the accelerometer with all-cause mortality.

target should be flexible and depend on the basal condition of people. Whether there is a basic threshold for the daily step count to maintain health, further studies should be performed to detect the relationship between the daily step counts in different chronic diseases.

The rate of mortality risk ranged between 6% and 48% in the included cohort studies. Various influencing factors induced the difference, including the country, age, race and degree of poverty. Several studies were also adjusted by the factors of smoking and drinking.

Subgroup analysis revealed that all-cause mortality was reduced by increasing the daily step count both in males and females, and a non-linear association was detected in both subgroups. Previous research on the relationship between the level of physical activity and all-cause mortality showed that the increase in female physical activity has a more significant effect on the reduction of all-cause mortality (Löllgen et al., 2009; Samitz et al., 2011). Saint-Maurice et al. (Saint-Maurice et al., 2020) reported that mortality risk was higher in males compared with females with the same daily step count when the latter step was more than 14,000 steps per day. However, Dwyer et al. (Dwyer et al., 2015) and Yamamoto et al. (Yamamoto et al., 2018) revealed that there was no significant correlation between the daily step count and sex. In this study, due to the difference in the reference, we cannot compare the relationship between the daily step count and all-cause mortality directly between different sex subgroups, while the tendency of the associations was alike. Low heterogeneity was detected in both sex subgroups. Further research is needed to clarify if a sexual difference exists in the relationship between the daily step count and all-cause mortality.

Due to the older age of the participants in some studies, more accurate results can be obtained by excluding death data within 1–3 years of follow-up (Dwyer et al., 2015; Jefferis et al., 2019; I. M. Lee et al., 2019; Yamamoto et al., 2018). The mean age of the cohort studies ranged from 56.8 to 78.8 years, so the result would be considered for old people. Hansen et al. (Hansen et al., 2020) and Saint-Maurice et al. (Saint-Maurice et al., 2020) performed a 10-year follow-up for middle-aged people, and a higher level of the interval of daily step counts with a lower mortality risk reduction were reported in these 2 studies. We performed subgroup analysis according to the end age of follow-up, and found that nonlinear association in participants younger than 65 years old, while a linear association was shown in participants older than 65 years old. Importantly, a better benefit of decreasing all-cause mortality was associated with more step counts for older people. Nowadays, no cohort research study of young people has been reported. The relationship between the daily step count and all-cause mortality in all ages needs to be investigated to reveal the long-term effect of the daily step count on mortality.

The instrument used for step assessment contributed to the heterogeneity of the dose-response relationship. The accuracy of pedometers is more compromised at slower walking speeds (≤2 mph), while the appeal of the accelerometers is the detailed and relatively precise manner, in which the frequency, duration, pattern, and intensity of activity can be monitored over days, weeks, and even longer (Ainsworth et al., 2015). Most studies included in this meta-analysis measured step counts by using accelerometers. Subgroup analysis results indicated that a higher step count was associated with lower all-cause mortality, and a nonlinear relationship between step count and all-cause mortality was found in both pedometer and accelerometer subgroup. Dwyer et al. (Dwyer et al., 2015) assessed the step count by pedometers and reported very active participants (13,501–39,164 steps), but the number in this level was small, which made the curve had a wider 95% CI at the lower end. The nonlinear curve of the accelerometer subgroup would be more valuable for reference due to its narrow 95% CI. Moreover, smartphones and smartwatches were also used to measure step counts, and they were lower cost and convenient in daily life. More researches were needed to investigate the difference between the wearable devices and the relationship with all-cause mortality. Interestingly, interventions using smartphone apps or physical activity trackers have a significant small-to-moderate effect in increasing physical activity (1850 steps daily; Laranjo et al., 2021). It would be a good way to promote physical activity.

More attention should be paid to the effect of stepping intensity on all-cause mortality. According to Lee et al. (I. M. Lee et al., 2019) and Saint-Maurice et al. (Saint-Maurice et al., 2020), the stepping intensity may not be an influencing factor in all-cause mortality, while the number of the steps is more significant. However, Stamatakis et al. (Stamatakis et al., 2018) emphasised that increasing the walking pace could reduce the risk for all-cause and cardiovascular disease mortality. More research works were needed to conduct a subgroup analysis to clarify the effect of stepping intensity.

Strength and limitation

The major strength of this meta-analysis is that we included 9 studies and interpreted the dose-response relationship between the daily step count and all-cause mortality risk. And we performed subgroup analyses by participants' age, sex and the wearable devices. We listed risk reduction of all-cause mortality for several step levels, which provided suggestions when setting a step count target.

This study has some limitations. Firstly, healthy status was an influencing factor of daily step count, healthier people walked more obviously. The year of follow-up, the stage of chronic diseases, smoking and drinking may also affect the causal interpretations. We can't define the causal relationship between walking and health. Secondly, although the included literature is of high quality, the stepping intensity could not be evaluated, and further analysis could not be performed from the perspective of exercise. Finally, the period of follow-up in some research works was short, and the range of the age was large, these might also be a source of heterogeneity.

Conclusions

The mortality risk in people with a high-level daily step count was lower than in those with a low-level daily step count. There was a non-linear association between the daily step count and all-cause mortality. The tendency of the relationship between the daily step count and all-cause mortality was similar in males to that in females, they were both non-linear associations, and all-cause mortality was decreased with the increase in the daily step count.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the Natural Science Foundation of Jiangsu Province [BK20190999]; Natural Science Foundation of Xuzhou [KC21029]; Natural Science Foundation of the Jiangsu Higher Education Institutions of China [19KJB320009]; The Cultivation Project of Nanjing Sport Institute [PY202012].

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