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ORIGINAL

Accumulated daily step counts versus physical fitness and sedentary behaviour: A systematic review and meta-analysis

Recuento de pasos diarios acumulados frente a forma física y comportamiento sedentario: Una revisión sistemática y meta-análisis

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Abstract

Background: Physical inactivity and a sedentary lifestyle are major causes of many health issues, including diabetes, obesity, and cardiovascular disorders. Physical activities like walking, which are simple to include into everyday routines, have been pushed as a means of addressing these health issues. Increasing the number of steps taken each day is one such tactic that is frequently suggested to enhance physical health and fitness. The objective of this research was to evaluate the effects of higher daily step counts on various physical fitness metrics while accounting for the diverse results documented in earlier investigations.

Methods: Several databases were combed in accordance with the PRISMA procedure to find pertinent publications. To account for the expected heterogeneity, the meta-analysis generated forest plots showing mean difference (MD) under a random effects (RE) model.

Results: A total of 13 studies were examined. According to certain research, there was little change in heart rate, weight, or body fat. Others demonstrated that some people's cholesterol and body fat decreased. Combined, the data suggested that walking more steps had no effect on VO2 max, a fitness metric (average difference -0.26, 95% confidence interval [-1.27, 0.75], I2 = 79%, p = 0.008). However, increasing step count did appear to reduce body mass index (BMI) (average difference -1.14, 95% confidence interval [-1.92, -0.36], I2 = 32%, p = 0.18). The resting heart rate (RHR) was not significantly affected by an increase in step count (average difference -1.85, 95% confidence interval [-3.82, 0.12], I2 = 0%, p = 0.67).

Conclusion: The review emphasised how different step counts have an influence on health outcomes. Although there were increases in certain fitness metrics, such as BMI, there were no discernible changes in VO2 max and RHR. It is advised to take into account higher step counts as part of a multifaceted strategy to improve general health and well-being, based on the thorough analysis of available data. These results highlight the necessity for tailored advice for physical activity levels depending on particular fitness objectives and health profiles.

Key words: Step counts, Physical fitness, Sedentary behaviour, VO2 max, BMI, Heart rate, Body fat percentage.

Resumen

Antecedentes: La inactividad física y el sedentarismo son causas importantes de muchos problemas de salud, como la diabetes, la obesidad y los trastornos cardiovasculares. Las actividades físicas como caminar, que son fáciles de incluir en las rutinas diarias, se han impulsado como medio para abordar estos problemas de salud. Aumentar el número de pasos que se dan cada día es una de las tácticas que se sugieren con frecuencia para mejorar la salud física y la forma física. El objetivo de esta investigación era evaluar los efectos de un mayor número de pasos diarios en varios parámetros de la forma física, teniendo en cuenta los diversos resultados documentados en investigaciones anteriores.

Métodos: Se examinaron varias bases de datos de acuerdo con el procedimiento PRISMA para encontrar publicaciones pertinentes. Para tener en cuenta la heterogeneidad esperada, el metaanálisis generó diagramas de bosque que mostraban la diferencia de medias (DM) según un modelo de efectos aleatorios (ER).

Resultados: Se examinaron un total de 13 estudios. Según algunas investigaciones, apenas se produjeron cambios en la frecuencia cardiaca, el peso o la grasa corporal. Otros demostraron que el colesterol y la grasa corporal de algunas personas disminuyeron. Combinados, los datos sugerían que caminar más pasos no tenía ningún efecto sobre el VO2 máx, una métrica de la forma física (diferencia media -0,26, intervalo de confianza del 95% [-1,27, 0,75], I2 = 79%, p = 0,008). Sin embargo, el aumento del número de pasos sí pareció reducir el índice de masa corporal (IMC) (diferencia media -1,14, intervalo de confianza del 95% [-1,92, -0,36], I2 = 32%, p = 0,18). La frecuencia cardiaca en reposo (FCR) no se vio afectada significativamente por un aumento del recuento de pasos (diferencia media -1,85, intervalo de confianza del 95% [-3,82, 0,12], I2 = 0%, p = 0,67).

Conclusiones: La revisión enfatizó cómo los diferentes recuentos de pasos influyen en los resultados de salud. Aunque se produjeron aumentos en determinadas métricas de la forma física, como el IMC, no hubo cambios perceptibles en el VO2 máx. y la RHR. Se aconseja tener en cuenta un mayor número de pasos como parte de una estrategia polifacética para mejorar la salud y el bienestar general, basándose en el análisis exhaustivo de los datos disponibles. Estos resultados ponen de relieve la necesidad de un asesoramiento personalizado sobre los niveles de actividad física en función de los objetivos de forma física y los perfiles de salud particulares.

Palabras clave: Recuento de pasos, Condición física, Comportamiento sedentario, VO2 máx, IMC, Frecuencia cardiaca, Porcentaje de grasa corporal.

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Introduction

A number of health issues, including obesity, type 2 diabetes, and cardiovascular diseases, have been related to physical inactivity[1]. It is more important than ever to identify effective measures to raise levels of physical activity in today's society, where sedentary lifestyles are common[2]. Walking has been proposed as a useful strategy to improve physical fitness and lessen the negative effects of a sedentary lifestyle. Walking's value as exercise can be readily measured using daily step counts[3]. Sedentary behaviour is important for the onset and progression of chronic illnesses and is significantly linked to higher chances of death and hospital admissions[3]. Conversely, increasing physical activity is recognised for its critical health benefits, which include delaying and avoiding the onset of several chronic illnesses.

Given the crucial role that physical exercise plays in the management and prevention of chronic illnesses, it is imperative to promote an active lifestyle[4]. Many therapies, rehabilitation programmes, and physical activity guidelines have been developed to promote an active lifestyle among people worldwide[3-6]. In spite of these efforts, new data from the World Health Organisation (WHO) indicates that physical inactivity continues to be a concern for 80% of teenagers and 23% of adults worldwide[6].

The primary component creating this issue seems to be a very low long-term commitment to appropriate physical activity and a healthy lifestyle. This makes it even more crucial to look at strategies that encourage consistent commitment to a healthy lifestyle and adequate daily activity, especially in populations with chronic conditions[7]. Empirical data substantiates the efficaciousness of structured behaviour modification strategies, encompassing individual education sessions, group talks, telephone counselling, and the distribution of printed educational materials, in elevating physical activity levels[8]. As a result, the progression of chronic diseases may be slowed.

Although most of the evidence for this has come from observational studies and studies on healthy populations, setting goals has also been cited as a potential motivational strategy to improve physical activity[9]. However, these strategies often require a significant time and cost commitment, which may compromise long-term adherence and raise issues with their applicability in conventional clinical settings[10-12]. Thus, there is ongoing study and development of workable and durable solutions to encourage physical exercise and healthy lifestyles.

Nevertheless, the relationship between daily step counts and health outcomes is complex, with many moving parts[4]. Quite a number of papers have looked at how more steps each day affect fitness measures like body mass index (BMI), resting heart rate (RHR), and maximal oxygen consumption (VO2 max). But the results are mixed, so it's hard to say for sure how increasing step counts affects health[5]. BMI helps tell if a person is a healthy weight. Some studies found that walking more can lower BMI[6], while others didn't find any link[7]. It's also unclear how step counts relate to RHR, which tells us about heart health. Some studies found that more steps mean lower RHR[8], but others didn't find this[9]. There's also mixed data about the link between step counts and VO2 max, which tells us about fitness levels[10].

The mixed results might be because the studies were done differently, looked at different people, or used different ways to measure and increase step counts[11-14]. Many studies only looked at certain groups of people, like those with chronic diseases or obesity[12-14]. Because of these mixed results, we conducted a systematic review and meta-analysis to get a clearer picture of how more steps each day might affect fitness. This should help us understand better the link between step counts and fitness.

Materials and methods

Review protocol and PECO

This review was carefully guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol[15], the schematics of which are represented in **figure 1**. A clear, thorough, and reproducible process was used. Using particular keywords and MeSH phrases, a thorough literature search was first carried out across several databases to find pertinent studies. The search was limited to publications written in the English language, and there was no time limit, thus all relevant material was gathered. After removing duplicates, the relevancy of the titles and abstracts was checked. After that, the full texts of the possibly qualifying studies were obtained and evaluated in light of the pre-established inclusion and exclusion standards. To lessen bias and mistake, the study selection procedure includes two independent reviewers. Any differences of opinion were settled by consensus or by talking to a third reviewer.

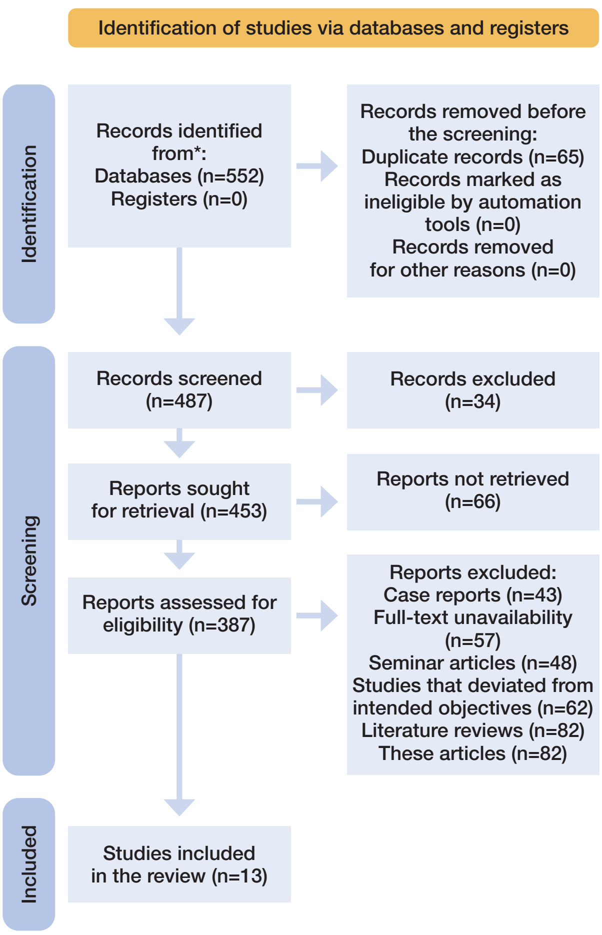
The PECO (Population, Exposure, Comparator, Outcome) protocol used for this review is delineated below-

- **Population:** The studies included individuals of various demographics, including different age groups, genders, and health statuses, from a wide range of geographical regions.
- **Exposure:** The main exposure under consideration was the accumulation of daily step counts. This is typically achieved through walking or other physical activities that can be measured in terms of steps.
- **Comparator:** The comparator was individuals with lower daily step counts or those following their usual lifestyle habits without any specific step-based interventions.
- **Outcome:** The outcomes of interest were indicators of physical fitness and sedentary behaviour.

Database search protocol

The following eight databases were searched: PubMed, EMBASE, Web of Science, Cochrane Library, CINAHL, PsycINFO, Scopus, and Google Scholar. The database search protocol was used. MeSH (Medical Subject Headings) terms and free-text keywords were combined to create a search strategy that ensured comprehensive coverage of the literature. To combine the search phrases, boolean operators AND and OR were employed. The three main concepts that dominated the search phrases were: outcomes (BMI, VO2 max, resting heart rate), walking or step counts as the exposure, and adults as the population. Each topic was given a list of related keywords and MeSH terms. Next, the Boolean operator AND was used to combine the lists of keywords for the three concepts, as shown in **table I**.

Figure 1: PRISMA protocol representing the study selection process for the review.



Inclusion and exclusion criterion

Cohort studies, cross-sectional studies, randomised controlled trials, and non-randomized controlled trials were among the study designs covered in the review. This wide range of inclusion allowed for a thorough comprehension of the evidence that was available. On the other hand, because of their poor quality of evidence, editorials, case reports, and case series were not included. Adults who were at least eighteen years old made up the target population. In order to keep the focus on the adult population as a whole, studies including children, adolescents, or certain patient groups (such as individuals with chronic conditions) were eliminated. Any intervention meant to increase step counts by walking or other comparable activities was the intervention of interest. Studies that concentrated on exercise or other types of physical activity were not included. A lower step count, no intervention, or standard care could serve as the comparative. Studies that reported on any of the pre-specified health-related outcomes –weight, body fat, heart rate, BMI, VO2 max, and RHR– were included in terms of results. Excluded were any studies that did not report on these outcomes. Furthermore, because of the review team's proficiency in the language, studies had to be published in English. Excluded were studies that were published in other languages. Finally, to guarantee the validity of the review findings, studies with a high risk of bias –as indicated by the risk of bias assessment– were also omitted.

Data extraction protocol

A standardized data extraction form was created to capture information relevant to the review question. This form included fields for study characteristics (e.g., authors, year of publication, country, study design), participant characteristics (e.g., age, sex, health status), details about the intervention and comparator, outcome measures, and key findings. Once the form was finalized, two independent reviewers were assigned to extract data from the included studies. Each reviewer was responsible for a set of studies, extracting the data individually. To ensure accuracy and consistency, a pilot test was conducted wherein both reviewers independently extracted data from a subset of included studies and compared their results. Discrepancies were discussed, and the data extraction form was refined as needed. Following the pilot test, the reviewers proceeded with data extraction for their assigned studies. After completing the data extraction, the reviewers cross-checked a random sample of each other's work to verify the accuracy of the data and the consistency of the extraction process.

Table I: Search strings utilised across the selected databases.

Database	Search string
PubMed	("daily step counts"[All Fields] OR "physical activity"[All Fields]) AND ("physical fitness"[MeSH Terms] OR "sedentary behaviour"[All Fields])
Web of Science	(TS=("daily step*") OR TS=("physical activity")) AND (TS=("physical fitness") OR TS=("sedentary behavior"))
Scopus	(TITLE-ABS-KEY("daily step counts") OR TITLE-ABS-KEY("physical activity")) AND (TITLE-ABS-KEY("physical fitness") OR TITLE-ABS-KEY("sedentary behaviour"))
PsycINFO	(AB("daily step counts") OR AB("physical activity")) AND (AB("physical fitness") OR AB("sedentary behaviour"))
CINAHL	(MH "daily step counts" OR MH "Physical Activity") AND (MH "Physical Fitness" OR MH "Sedentary Behavior")

The interrater reliability test was carried out using Cohen's kappa statistic, which measures the agreement between two raters beyond chance. The kappa values were calculated for the pilot test and the cross-checking stage. The kappa value for the pilot test was 0.82, indicating "almost perfect" agreement according to Landis and Koch's benchmarks. After refining the data extraction form, the kappa value for the cross-checking stage increased to 0.91, further demonstrating the high reliability of the data extraction process. In case of disagreements during data extraction or cross-checking, the reviewers discussed the issue to reach a consensus. If a consensus could not be reached, a third reviewer was consulted.

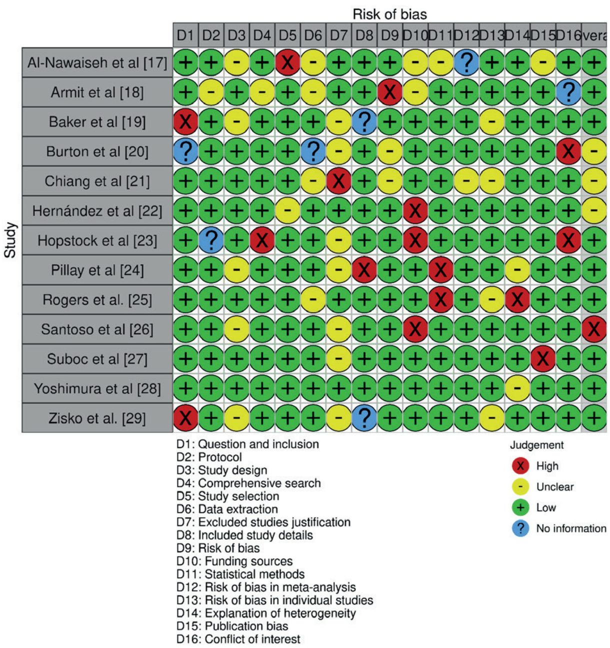
Bias assessment

The risk of bias in the included studies was assessed using the Cochrane's Risk of Bias 2.0 (RoB 2.0) tool [16]. This tool is specifically designed for assessing the risk of bias in randomized trials, the results of which have represented through **figure 2**.

Meta-analysis protocol

The meta-analysis for this review was carried out using Review Manager 5 (RevMan 5, version 5.4.1). The data extracted from the individual studies were first entered into RevMan 5. For each study, the MDs and standard deviations for the VO2 max, BMI, and RHR between the intervention and control groups were entered. Studies that reported medians and interquartile ranges instead of means and standard deviations were excluded from the meta-analysis due to the different statistical properties of these measures. Following this, a random-effects (RE) meta-analysis was conducted for each outcome. The RE model was chosen due to its ability to account for both within-study and between-study variability, which is particularly important when the included studies are heterogeneous in terms of their populations, interventions, or methods. The results of the meta-analyses were presented in forest plots, which provide a visual representation of the individual and pooled effect sizes along with their 95% CIs. The size of the square reflected the weight of the study in the meta-analysis. A diamond was used to represent the pooled MD and its 95% CI. The heterogeneity among the included studies was assessed using the I^2 statistic.

Figure 2:
Bias representation across different domains pertaining to the included trials.



Results

Study selection process

The article selection procedure started by identifying possible research from several databases, which produced a total of 552 documents at first. No entries from registries were found. After the identification stage, 487 records remained to be inspected after 65 duplicate records were eliminated. During this screening stage, automated methods were used; however, none of the records were flagged as ineligible by these technologies. Furthermore, at this point, no records were deleted for other reasons. After 34 data were excluded throughout the screening procedure, 453 reports were still sought after for retrieval. 387 of them were then evaluated for eligibility after 66 of the reports could not be obtained. A number of reports were excluded during the eligibility phase examination due to different criteria. Due to their intrinsic limits in offering high-quality evidence and information that can be applied generally, a total of forty-three case reports were eliminated. 48 seminar pieces and 57 reports that could not be found in full text were also eliminated since they frequently lacked peer-reviewed confirmation. Furthermore, 62 papers that did not provide pertinent data for the analysis and diverged from the review's original aims were eliminated. A sizable portion of thesis papers (n = 82) and literature reviews (n = 82) were also disregarded because it was thought that these secondary sources would not offer new information for our meta-analysis. Following this meticulous and methodical procedure of selection, thirteen studies[17-29] in all were found to be eligible and included in the final review.

Assessed bias in the studies

The majority of studies showed low levels of bias with regard to the question and inclusion criteria, indicating that their research questions and inclusion criteria were well-defined. A few studies, though, were marked as having significant bias or causing some worries, suggesting that there might be problems with their inclusion criteria or study question[17,19,29]. The majority of the evaluations of the research selection process were low bias, suggesting that the studies used strict and objective procedures to choose their sample. A few research, meanwhile, raised some questions, and one study showed a significant bias[17]. The majority of data extraction evaluations were found to have low bias, demonstrating the adoption of trustworthy data collection techniques in the investigations. A few studies, nevertheless, raised some red flags, and one study's data was unavailable[20]. The majority of research evaluated the publishing bias to be minimal, while a few were found to have high bias[20,23]. Although the conflict of interest was rated as minimal overall, a few research raised some red flags, and one study was found to have significant bias[26]. Most of the studies were judged to have low bias overall, meaning that they were transparently and dependably conducted and reported. A few studies, nevertheless were judged to have somewhat of a noticeable overall bias[19,29].

Demographic characteristics

Table II shows the demographic variables assessed across the included papers[17-29]. All the studies were either RCTs or case-cohort studies. The studies were conducted across USA[17,20,25,27], Australia[18], Scotland[19], Taiwan[21], Spain[22], Norway[23,29], South Africa[24], Indonesia[26], and Japan[28]. The number of participants in each study ranged from as few as 10 to as many as 136. The age range of the participants also varied greatly. Some studies included participants in specific age ranges, such as 18-30 years[17], 50-70 years[18], and 18-65 years[19], while others included participants who were over 18 years of age[21,22,27], and some studies provided the mean age of participants[20,25]. One study did not specify the age range[26]. The gender ratio of participants in each study was predominantly male, with the number of males ranging from 5 to 71 across the studies. Some studies did not specify the gender ratio[21,26]. The follow-up period for these studies ranged from as short as 4 days[24] to as long as 8 months[28], with many studies conducting follow-ups at the 3-month mark[17,18,19,27]. One study did not specify the follow-up period[25].

Inferences assessed

Al-Nawaiseh et al.[17], Armit et al.[18], and Burton et al.[20] didn't observe significant changes in weight, body fat, or heart rate as a result of increasing step counts. Chiang et al.[21] noticed one group had a lower heart rate after a fitness test when their step counts increased. In a similar vein, Hernández et al.[22] reported that participants who increased their steps experienced a boost in positive emotions. Hopstock et al.[23] and Pillay et al.[24] found that stepping more improved some health outcomes like body fat and cholesterol levels in certain groups, but not in all. Rogers et al.[25] discovered that groups that increased their steps lost more weight and had less body fat. Santoso et al.[26] reported a decrease in weight and body fat among participants who increased their step counts. Suboc et al.[27] discovered similar results, with added observations that higher step counts were linked with better exercise capacity. Yoshimura et al.[28] found that groups with higher step counts had improved lipid levels post-exercise, but no changes were seen in other health markers. Zisko et al.[29] reported that increasing step counts led to improvements in aerobic fitness. (**Table III**)

Statistical findings pertaining to changes in VO2 max

Figure 3 compares the impact of step count increase on VO2 max changes in different studies. The combined data shows no clear effect on VO2 max, as the mean difference was -0.26 [-1.27, 0.75]. The studies show high variation (I^2 = 79%), confirmed by a significant Chi^2 test (p=0.008). In one study[24], the VO2 max was notably lower in the step-increase group. Two other studies[26,29] showed no significant VO2 max difference between groups. This refers to the fact that the combined results did not show a clear improvement. In some studies, VO2 max even decreased slightly in the group that increased their step count. There was also a high level of difference between the results of the studies, suggesting that other factors may be affecting the outcome.

Table II: Demographics variables observed in the selected studies.

Study ID	Region assessed	Protocol	Sample size (n)	Age range (in years)	Gender ratio	Follow-up period (in months)
Al-Nawaiseh et al[17]	USA	RCT	118	18-30	22 males	3
Armit et al[18]	Australia	RCT	136	50-70	54 males	3
Baker et al[19]	Scotland	RCT	79	18-65	16 males	3
Burton et al[20]	USA	RCT	10	25.7 ± 1.8 (mean)	7 males	1
Chiang et al[21]	Taiwan	RCT	64	>18	Unspecified	2
Hernández et al[22]	Spain	RCT	67	>18	23 males	6
Hopstock et al[23]	Norway	RCT	16	55-74	11 males	6
Pillay et al[24]	South Africa	Case-cohort	70	21-49	35 males	4 (days)
Rogers et al.[25]	USA	RCT	10	30 ± 7 (mean)	5 males	Unspecified
Santoso et al[26]	Indonesia	Case-cohort	80	Unspecified	Unspecified	2
Suboc et al[27]	USA	RCT	114	≥18	71 males	3
Yoshimura et al[28]	Japan	RCT	109	30-60	59 males	8
Zisko et al.[29]	Norway	RCT	24	30-50	All males	1.5

Table III: Step counts observed across the included papers and their associated outcomes.

Study ID	Groups assessed	Modality employed for step count	Assessed variables	Inferences pertaining to step counts observed
Al-Nawaiseh et al[17]	Control (58) and Intervention (56)	Not specified	Body weight, body fat percentage, BMI, step count	• Baseline step count was higher in the control group but not statistically significant (p=0.056). • Post-intervention, no significant difference in body weight, body fat percentage, and BMI between the two groups.
Armit et al[18]	GP (number not specified), GP+ES (number not specified), GP+ES+P (number not specified)	Pedometer for GP+ES+P group	BMI, resting systolic and diastolic blood pressure, resting heart rate, heart rate after two levels of the Canadian Home Fitness Test	• No significant change in BMI across all groups from week 1 to week 12 (p > 0.05). • No significant change in the resting heart rate for any group. • Decrease in heart rate after level 1 and 2 of the Canadian Home Fitness Test in the GP group was significant (p = 0.01), but not in the other groups.
Baker et al[19]	Intervention group and Control group	Pedometer	Daily step-counts, PANAS score, EQ-5D tariff score, EQ VAS score, Height, Body mass, BMI, Waist and hip circumferences, Waist:hip ratio, Body fat percentage, Systolic and diastolic blood pressure, Heart rate	• Intervention group had a significant increase in steps per day from 6802 at baseline to 9977 at week 12. • Control group showed a minor increase from 6924 to 7078 steps/day. • PANAS positive score slightly improved in the intervention group, while it slightly decreased in the control group. No major changes in other health outcomes in both groups.
Burton et al[20]	Ten participants across LOW, LIMITED, and NORMAL steps trials	Not specified	Daily step count, Heart rate, RPE, Oxygen consumption, Postprandial plasma triglyceride response	• No significant differences were noted in the control days' average daily steps. Significant differences were noted in the daily steps on the first two days of the intervention among LOW, LIMITED, and NORMAL trials.
Chiang et al[21]	Walking Step Goal group (WSG), Walking Exercise group (WEG), Control group (CG)	Smartwatch	Daily step counts, Body composition, Metabolic syndrome variables	• Average daily steps over 8 weeks did not significantly differ between the WSG and WEG. • The WEG exhibited significant improvements in terms of hip circumference, visceral fat area, high-density lipoprotein cholesterol, fasting glucose, and triglycerides. • The CG and WSG showed no improvement in body composition.
Hernández et al[22]	Control group and Intervention group	Pedometer app	Daily step counts, Weight, BMI, Body fat percentage, Muscle mass, Body water percentage	• The intervention group had a significantly greater decrease in weight and BMI than the control group at both 3 and 6 months. • The percentage of body fat was significantly lower in the intervention group compared to the control group at both 3 and 6 months. • There was no significant difference in muscle mass between the two groups at either 3 or 6 months. • The percentage of body water was significantly higher in the intervention group than in the control group at both 3 and 6 months.
Hopstock et al[23]	Single group composed of 11 men and 5 women aged 57-74 years	Physical activity trackers	Adiposity (weight, BMI, body composition, waist circumference), Physical activity, Cardiometabolic risk factors (blood pressure, HbA1c, blood lipids), Diet, Physical capacity	• Participants' body weight significantly decreased from an average of 106.2 kg at the start of the study to 103.4 kg at the end. • BMI also showed a significant reduction. • A decrease was observed in the body fat mass. • Lean body mass showed an upward trend. • There was an increase in weight satisfaction from 0% at baseline to 20% at the end of the intervention. • The gap between participants' actual weight and their self-reported ideal weight decreased significantly.
Pillay et al[24]	Low group (< 5000 steps/d), High-Low group (≥ 5000 steps/d, no aerobic steps), High-High group (≥ 5000 steps/d, including some aerobic steps)	Pedometer	Estimated maximal oxygen uptake (VO2max), Blood pressure (BP), Body mass index (BMI), Percentage body fat (%BF), and Waist circumference (WC)	• The higher the physical activity level, the lower the body fat percentage. • A higher physical activity level is associated with a lower BMI. • Waist circumference decreased with increased physical activity. • The maximum volume of oxygen a person can use during intense exercise increased with physical activity level. • The number of pedometer steps per day was lowest in the Low group, higher in the High-Low group, and highest in the High-High group.

Study ID	Groups assessed	Modality employed for step count	Assessed variables	Inferences pertaining to step counts observed
Rogers et al.[25]	Single group tracked over multiple conditions	Indoor track at a pace of 100 steps/min	Resting energy expenditure (REE), Respiratory exchange ratio (RER), Fat oxidation rate (FATOX), Triglycerides (postprandial lipemia; PPL), Nonesterified fatty acids (NEFAs), Insulin, Glucose	• PPL was significantly higher after 2 K versus 10 K. • NEFAs were significantly higher after 15 K versus 2 K. • No differences were found for insulin, glucose, or REE among conditions. RER and FATOX were not significantly different among conditions. • 10 K steps elicited the greatest decrease in PPL, an established cardiovascular disease risk factor. • NEFA levels were highest after the 15 K condition.
Santoso et al[26]	High school students in Palembang, divided into 2 groups: the motivation of physical activity and the control group	Accupedo application	VO2max values measured using the Multistage Fitness Test and the number of daily steps	• The pre-test VO2max for the intervention group was 40.5 ± 0.96 (mean ± standard deviation), and this value increased to 42.9 ± 0.93 in the post-test. The difference in averages between the pre-test and post-test was 2.45. This significant increase (p-value < .0001) indicates a marked improvement in VO2max, and thus aerobic fitness, in the intervention group following the intervention. • In the control group, the pre-test VO2max was slightly higher at 41.2 ± 1.08. However, the post-test value of 42.7 ± 1.03 marked a smaller increase than that seen in the intervention group, with an average difference of 1.52. Although this increase was also statistically significant (p-value < .0001), the smaller magnitude of change compared to the intervention group suggests that the intervention had a positive effect on improving VO2max.
Suboc et al[27]	Sedentary older adults aged ≥50, randomized into 3 groups: No intervention (Group 1), Pedometer-only intervention (Group 2), and Pedometer with an interactive website (Group 3)	Pedometer	Endothelial function by brachial flow-mediated dilation (FMD%), vascular stiffness by tonometry, step-count by pedometer, PA intensity/distribution by accelerometer, weight, BMI, waist circumference, glucose, insulin, QUICKI, HOMA-IR, total cholesterol, LDL cholesterol, triglycerides, hsCRP, systolic and diastolic blood pressure, heart rate	• Step-count increased in groups 2 and 3 but not in group 1. • Both groups 2 and 3 increased MPA ≥30 min/day. Only group 3 increased MPA in continuous bouts of ≥10 minutes and improved FMD% (P=0.001). • Neither achievement of ≥10 000 steps/day nor ≥30 min/day of MPA resulted in improved FMD%. However, achieving ≥20 min/day in MPA bouts resulted in improved FMD%. • All groups lost some weight over time but the use of a pedometer, whether alone or with a website, did not lead to a significantly different weight loss compared to the control. • The interventions did not significantly affect the change in BMI over time. • There were minor and insignificant changes for glucose, insulin, QUICKI, HOMA-IR, total cholesterol, LDL cholesterol, triglycerides, hsCRP, systolic and diastolic blood pressure, and heart rate
Yoshimura et al[28]	Two groups: one group using a smartphone app, and the control group	Smartphone App	Daily physical activity (step count) measured by accelerometer, body weight	• Both groups increased their step count and step counts per wear time over the intervention period. The smartphone app group showed a slightly greater increase. 2. There may be a statistically significant difference in step counts per wear time between the two groups. • No significant difference in weight loss between those using the smartphone app and the control group. • Both groups saw a slight increase in moderate to vigorous physical activity (MVPA) over time.
Zisko et al.[29]	Thirty healthy males (39±6 yrs) not exposed to structured exercise training, randomized to either 1x4 min AIT (1-AIT), 4x4 min AIT (4-AIT), or 47 min of MCT at 70% HRmax	Not Specified	Total energy expenditure (TEE), active energy expenditure (AEE), number of steps, active time, sedentary time, VO2max, mitochondrial function in m. vastus lateralis	• TEE increased 14% and AEE increased 43% after MCT. • There was no change in TEE or AEE after 1-AIT or 4-AIT. • 1-AIT had significantly lower TEE and step-count compared to MCT post intervention. • VO2max increased 7% after 1-AIT and 9% after 4-AIT, with no change after MCT.

Statistical findings pertaining to changes in BMI

Figure 4 looks at BMI changes due to increased step counts. The combined data shows a significant decrease in BMI (mean difference of -1.14 with a confidence interval of [-1.92, -0.36]). The studies show some variation (I2 = 32%), but the Chi² test was not significant (p=0.18), implying consistent findings and suggesting that increasing the step count might have helped to reduce your BMI. However, not all studies agreed on this, with multiple studies[17,18,19,21,27] showed no significant BMI difference between groups. However, two studies[22,24] reported significantly lower BMI in the step-increase groups.

Statistical findings pertaining to changes in RHR

Figure 5 elucidates the impact of increased step counts on RHR changes. The combined data from four studies shows no significant effect (mean difference of -1.85 with a confidence interval of [-3.82, 0.12]). The combined data did not show a clear decrease in RHR with increased step count. In some studies, the RHR was the same for both those who increased their steps and those who didn't. However, one study did find a significant decrease in RHR for those who increased their step count. The studies show low variation (I2 = 0%), supported by a non-significant Chi2 test (p=0.67). Three studies[18,19,21] showed no significant RHR difference between groups. However, one study[27] reported a significantly lower RHR in the step-increase group.

Figure 3: Effect of higher step counts on change in VO2 max.

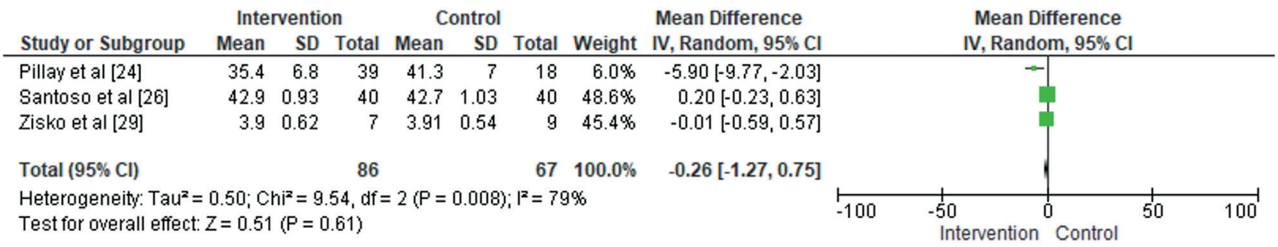


Figure 4: Effect of higher step count on change in BMI.

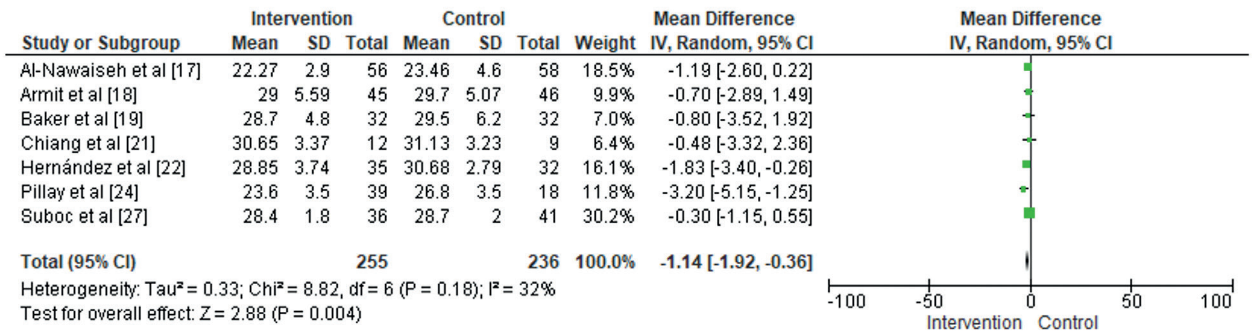
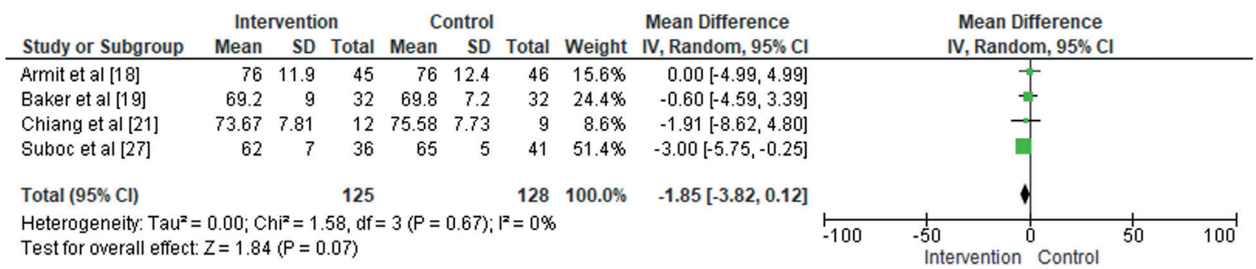


Figure 5: Effect of higher step count on change in RHR.



Discussion

In this analysis, we employed BMI, VO2 Max, and RHR as surrogate measures of sedentary behaviour because the majority of the selected studies revealed a directly associated measure. When taken together, these three metrics offer a clear picture of a person's degree of fitness and physical activity as well as an implicit indicator of how sedentary their lifestyle is[30-31]. The relationship between increasing step counts and declining rates of sedentary behaviour can be inferred thanks to the combination of BMI, VO2 Max, and RHR, despite the fact that these are indirect markers. It is important to keep in mind that these assessments are subject to a variety of influences and that, although they may indicate patterns in sedentary behaviour, they are not accurate indicators of it[30-31].

When examining the collective results of these investigations comprehensively, it is evident that a multifaceted network of factors interact to shape the association between steps taken, a measure of physical activity, and different health outcomes. Increases in step counts were not significantly correlated with improvements in body weight, body fat percentage, BMI, or resting heart rate, according to several of the included publications[17-18]. This brought up the question of whether step counts directly affected these health consequences. However, other research, such that done by Baker et al.[19] and Hernández et al.[22], found a link between higher step counts and better health outcomes. Hernández et al.[22] found that taking more steps per day was linked to significant decreases in weight and BMI as well as an increase in body water percentage. Baker et al.[19] saw improvements in mood. These results suggest that walking more steps can have a major positive impact on one's health. Chiang et al.[21] and Hopstock et al.[23] report improvements in health parameters such as visceral fat area, hip circumference, and high-density lipoprotein cholesterol. This suggested that improving health might be influenced by variables other than the quantity of steps completed.

Burton et al.[20] and Pillay et al.[24] noted significant variations in daily steps during the first two days of the intervention. Furthermore, a relationship was discovered between the degree of physical activity and decreased waist circumference, lower BMI, and body fat percentage, suggesting the possible benefits of higher step counts and activity levels on health outcomes. Research like that conducted by Suboc et al.[27] and Rogers et al.[25] has shown that varying levels and kinds of physical activity might affect health outcomes. For example, step counts can alter some metabolic indicators, and continuous activity raises FMD%. Santoso et al.[26], Zisko et al.[29], and Yoshimura et al.[28] came to similar conclusions on the effects of organised therapy and various exercise regimens on weight loss and fitness outcomes.

A meta-analysis of 19 RCTs by Ashur et al.[32] revealed a substantial increase in V'o2max and daily step count in CR participants who used accelerometers or pedometers. These findings are in contrast to ours, where we found that there was significant heterogeneity in the data and no discernible influence on V\o2max. The disparity between our results and those of Ashur et al.[32], who concentrated exclusively on cardiac rehabilitation patients, may be the result of variations in the research populations. Furthermore, there were variations in the quantity of RCTs incorporated into the meta-analysis, which might have affected the accuracy and dependability of the findings. The effectiveness of wearable-based interventions in increasing physical activity and cardiometabolic health in people with chronic conditions was thoroughly assessed by Franssen et al.[33]. Significant reductions in low-density lipoprotein cholesterol content, waist circumference, and systolic blood pressure were observed, along with improvements in physical activity levels. These results only agree with our review in part. While there was no discernible change in heart rate, we did see a considerable drop in BMI. Once more, the differences in study populations and the particular outcomes assessed in each review may be the cause of the diversity in results.

Step count and death rate were found to have a strong negative connection by Paluch et al.[34], with lower all-cause mortality hazard rates being associated with quartiles having higher daily step counts. While our review indicated a more moderate link, these findings were partly consistent with our findings, which also found an unfavourable correlation between step count and mortality. Paluch's study[34], which had a longer median follow-up of 7.1 years and a larger sample size of 47,471 people, may have contributed to the variations in participant diversity. In response to the widespread belief that 10,000 steps a day is the ideal, Sheng et al.[35] discovered evidence of a nonlinear dose-response association between step count and the risk of cardiovascular disease or all-cause death. This was consistent with our findings, which showed a nonlinear relationship as well. Sheng et al.[35] did point out that in contrast to the first quartile, the third quartile had a noticeably decreased risk of cardiovascular events and all-cause death. Our research, which discovered a more gradual decline in risk with greater step count, did not find this precise cut-off point.

Activity trackers have been shown to effectively enhance physical activity, body composition, and fitness across many age groups and both clinical and non-clinical populations, according to Ferguson et al.'s comprehensive review[36]. They reported losing about 1 kg of body weight and taking about 1800 more steps a day on average. On the other hand, their impacts on psychosocial (pain and quality of life) and physiological (blood pressure, cholesterol, and glycosylated haemoglobin) outcomes were generally modest and frequently non-significant. Similar to what we discovered in our research, activity trackers are useful for promoting physical activity.

However, while we did see a significant drop in BMI, we were unable to identify a meaningful impact on heart rate. The variations in the physiological and psychosocial results may result from the different parameters that were assessed in each study. Step counts increased by 1126 steps per day at ≤4 months, decreased to 464 steps per day at one year, and then decreased to 434 steps per day at 3-4 years, as demonstrated by Chaudhry et al.[37] using multivariate meta-analysis. They discovered that smartphone apps and body-worn trackers performed worse than pedometers. The results of our review, which shown a considerable increase in daily step count with the usage of activity trackers, were partly compatible with these findings. Some of the difference in results, however, may be explained by the fact that our review did not examine the effect over time or differentiate between different types of activity trackers.

Over the last twenty years, step counters have been a standard component of behavioural techniques used in outpatient settings to increase physical activity among individuals who are not active[11, 38-39]. There is a substantial body of research that condenses this element [11, 38-39]. Bravata et al.'s study[11] examined studies that employed pedometers –devices that track your steps– to motivate people to move more. In randomised controlled trials, which are studies in which participants are assigned to different groups at random, the researchers discovered that pedometer-using groups boosted their daily step count by an average of 2491 more than the group that did not use pedometers. Pedometer users raised their daily steps by an average of 2183 from what they were performing previously in studies that were not controlled in this manner. Setting a step goal and maintaining an activity log were useful tactics. Upon analysing all the studies together, they discovered that using a pedometer was associated with a minor drop in both systolic blood pressure (the pressure in your arteries during a heartbeat) and body mass index (a measurement of body fat based on height and weight).

Richardson et al.[38] identified nine studies that satisfied their requirements; the studies' average duration was 16 weeks, but they ranged from 4 to 52 weeks. They discovered that participants in the research they included dropped 1.29 kg, or roughly 2.8 pounds, on average. Participants lost almost 0.05 kg every week on average. They came to the conclusion that longer programmes resulted in greater weight loss and that pedometer-based programmes only little reduced weight. In a study by Kang et al.[39], they examined earlier research that promoted regular physical activity with pedometers. They specifically searched for research that recorded the number of steps taken before and after an intervention, and that employed pedometers to encourage participants to move more. Additionally, only studies with an intervention lasting at least four weeks were included. Nevertheless, not all of them offered sufficient information to determine the impact size—a metric used to measure how successful a specific intervention is. The average impact size for the 32 studies that were conducted was 0.62, meaning that the group who used pedometers increased their daily step count on average by 2000 steps. They discovered that when a daily target of 10,000 steps was set, the pedometers had a bigger impact on the female participants.

Limitations

The present investigation had certain inherent weaknesses that should be addressed as they may have had an impact on the outcome. Their conclusions showed a substantial lot of heterogeneity, which the meta-analysis occasionally corroborated with significant Chi2 tests. This suggests that other factors that the research did not account for could be influencing the outcomes. Moreover, although several research papers associated greater step counts with positive health outcomes, these findings were not consistent across all studies or health indicators. While some research produced contradictory results, other studies found no appreciable changes in RHR, weight, or body fat. The aforementioned disparity highlights the necessity for additional investigation to completely grasp the complex correlation between physical activity and health consequences. It could be the result of differences in the methods used for assessment, demographics, or study design.

Recommendations for everyday practice

It is advised to take into account higher step counts as part of a multifaceted strategy to improve general health and well-being, based on the thorough analysis of available data. This can be attributed to the documented advantages concerning particular health metrics, including a reduction in BMI. It is imperative to acknowledge that the impact of elevated step counts on health outcomes may not be uniformly relevant and may differ among distinct demographic subgroups. Walking and related activities may still be beneficial, even though there was no conclusive evidence of a substantial increase in VO2 max or RHR with higher step counts. Step counts are correlated with total physical activity, which is known to have a wide range of positive health effects, including the avoidance of chronic diseases and improvements in mental health.

The literature in this regard continuously emphasises how important it is to approach health promotion with a context-specific and tailored strategy. Given the variances observed between various geographic regions and demographic groupings, interventions must to be customised to take individual traits, cultural norms, and environmental factors into account. Furthermore, a holistic approach to health should take into account not just the promotion of physical activity but also other lifestyle factors like dietary habits, sleep patterns, and stress management.

Conclusion

We have found out that there is a relationship exists between the degree of physical activity and decreased waist circumference, lower BMI, and body fat percentage, suggesting the possible benefits of higher step counts and activity levels on health outcomes. Also, literatures suggests that accumulating steps counts over 8000 steps/day or more has reduced the risks that leads to cardiovascular mortality. We may not have taken into account other characteristics such as age, gender, lifestyle, and environment, which could explain the inconsistent results. Despite the wide range of results, they do point to the possibility that exercise can enhance wellbeing and health. However, further study is required to fully comprehend this. A challenge facing our study was the diversity of the research we examined, each with a unique set of participants. Future studies should aim to determine the significance of additional variables and how they interact with physical activity to influence health. Better, more individualised guidance on how to increase wellbeing and health through exercise may result from this. We ought to strive towards providing individuals with more comprehensive guidance on physical activity, considering the intricate correlation between various health consequences and physical exercise. Ultimately, Walking is a low-impact, affordable, and easily accessible type of physical activity that is suitable for a variety of people, regardless of their financial situation or degree of fitness. Therefore, encouraging higher step counts can still improve public health and noticeable changes in particular health markers.

Conflicts of Interest

The authors declare no conflict of interest.

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