Is 10,000 steps a day the magic number? And does it matter how fast I walk?

The full deal

Most people have heard of the 10,000 steps per day target and many people carry devices that count their steps per day. Some people know that the 10,000 step goal originated in a marketing campaign (in Japan, for a pedometer) rather than a piece of scientific research, but the number has stuck. The publicity around 10,000 steps per day led to research to test its validity and a lot is now known about stepping and health. The outcome of all this research has been to validate the original 10,000 steps per day target, but there is a lot more useful information in addition to the target itself in the research, in terms of type of steps, speed of stepping and the health benefits of stepping.

Stepping and public health physical activity guidance

Before examining the evidence for the health benefits of undertaking a regular number of steps per day it makes sense to consider how the stepping target relates to the evidence based public health guidance for physical activity. Public health guidance in the UK does not say anything about steps per day. The US guidance notes that steps could be a useful way to translate recommendations into something easily followed by individuals (Physical activity guidelines advisory committee, 2018). The UK guidance, in line with most similar guidance issued makes it recommendations for physical activity in terms of time spent being active. The UK guidance references minutes per week spent in moderate activity (150 minutes), or vigorous activity (75 minutes), strength exercises and reduced sitting (UK Chief Medical Officers' Physical Activity guidelines, 2019). In the accompanying infographic, climbing stairs counts as vigorous activity and walking as moderate activity, provided breathing is increased.

It is possible to compare the guidance for time spent exercising and the 10,000 steps a day recommendation. 10,000 steps per day is approximately 4.5 miles of walking for the average person, more for a short person and less for a tall person. At a comfortable walking speed of 3 miles an hour that's 90 minutes of walking for the average person. Repeated daily, 10,000 steps per day works out at a lot more than the public health guidance for moderate activity per week. A more sophisticated approach is to use metabolic data to link stepping data to intensity of exercise as set out in the physical activity guidance. A series of studies by Tudor Locke et al. (2019, 2020, 2021) have demonstrated that a stepping frequency of 100 steps per minute equates to moderate physical activity (3 Metabolic Equivalents, 1 Metabolic Equivalent is 3.5mL/Kg/minute of oxygen consumption) in age groups from 21 to 85. Below 100 steps per minute there is a linear relationship between stepping intensity and energy consumption, but it is relatively flat. Above 100 steps per minute the relationship remains linear, but the line on the graph is much steeper. At 130 steps per minute in age groups 21 to 60 energy consumption is typically 6 Metabolic Equivalents which is vigorous physical activity as defined in the physical activity guidance. The researchers were not able to draw a conclusion about the relationship between stepping intensity and vigorous exercise in older participants, the 61 to 85 age group, because not enough individuals in their sample reached a stepping intensity of 130 steps per minute in the metabolic study. Despite these more sophisticated measures, a simple calculation of the relationship between walking time and steps per day is likely to be flawed. Many of the steps undertaken today are not part of a purposeful walk and may fall far below walking at 3 miles an hour (3 Metabolic Equivalents). We will come back to this.

The 10,000 steps per day may contribute to other recommendations in the physical activity guidance. Periods of stepping throughout the day could help to reduce sedentary behaviour and may contribute to the strength recommendations if, for example, bags are carried whilst walking. The negative impact on health of long periods of sitting warrant a chapter of their own but it is worth noting here that the dangers of sedentary behaviour are independent of physical activity.

Back to the relationship between stepping and the moderative physical activity goal of 150 minutes per week; achieving this goal based on the 3 miles an hour walk would only require approximately 2,380 steps per day for the average person. This is very different to the 10,000 steps target. It is probably not a fair comparison; the 10,000 steps goal originated in a marketing campaign and at the time it was introduced it was not supported by evidence. The public health guidance issued in the UK by the government was developed on the basis of a significant body of evidence. The report from which the guidance is derived lists 114 references including peer reviewed studies, reviews and guidance from other bodies such as the World Health Organization and public health guidance from the USA and European countries. The goal of 150 minutes per week of moderate activity is taken from the dose response curve between minutes of activity and health benefits which starts with an almost linear relationship that begins to plateau around 150 minutes moderate physical activity per week. This means that health benefits accrue with less than the recommended activity time such that even a little bit of activity is better than being non-active. Further benefits accrue for activity above the recommended activity time.

The stepping target may have originated from a marketing campaign, but it is now supported by a considerable body of evidence. Many of the studies that investigate the health benefits of stepping follow a similar format. Steps per day are measured over a period of seven days using a device such as an accelerometer or pedometer that participants wear. The participants are then followed up for a period of years, either directly or through medical records and the morbidity and mortality in the participant group recorded. Most of the studies rely on collecting data from a large number of participants to generate statistically significant outcomes.

Stepping and mortality

One of the important questions that researchers have tried to address is whether it is simply the number of steps per day that benefits health or whether stepping intensity plays a role. Lee at al (2019) carried out a study in a cohort of 16,471 women (mean age 72, range 62-101) living in the USA. Participants wore an accelerometer for seven days and the step data were downloaded from the accelerometers by the researchers. Only participants who wore the accelerometers for at least

10 hours a day and for four or more days were included in the study. The number of steps per day was straightforward to calculate from the downloaded data. Stepping intensity was more difficult. The researchers calculated three measures of stepping intensity: the most steps carried out in a single minute of the day (peak one minute cadence), the average (mean) of the number of steps in the 30 most active minutes of the day (peak 30 minute cadence) and the average (mean) steps per minute in the five minute period with the most steps (peak 5 minute cadence). The researchers also measured the time spent at different stepping speeds 0 steps per minute, 1 to 39 steps per minute (incidental steps), 40 or more steps per minute (purposeful steps) and more than 100 steps per minute (moderate intensity or faster). Walking at 3 miles an hour fits into this last category of more than 100 steps per minute.

In the study the mean step count was 5,499 steps per day. For more than half the monitored time the participants took no steps, for just under half the time they took incidental steps; purposeful steps were only taken 3.1% of the time with almost negligible moderate intensity stepping. Participants were followed for 4.3 years and over that time there was a significant inverse relationship between the number of steps taken and death. This relationship was maintained when the data were adjusted for potential confounders including age, Body Mass Index (BMI measured in Kg/m^2) and underlying disease. As the number of steps increased, so did the reduction in mortality up to a maximum of 7,500 steps per day, above which there was no further benefit. There was a benefit at lower daily step counts; there was a reduction in mortality at 4,400 steps per day compared to 2,700. The data also showed a significant inverse relationship between stepping intensity and mortality, but when this was corrected for number of steps per day the effect size was reduced and at most intensity levels, not significant. It is interesting to note that the reduction in mortality arising from daily steps in this study was achieved at stepping intensities below that considered to be moderate exercise.

Saint-Maurice et al. (2020) undertook a similar study with seven-day accelerometer wear, but with a longer follow up; 4840 participants, 54% of whom were female were followed for 10 years. In this group the average number of steps was high at 9,124 steps. In this cohort there was a reduction in mortality for steps taken above a reference point of 4,000 steps and an increase in mortality at 2,000 steps. Overall, the relationship between steps and mortality was curvilinear with the effect plateauing at approximately 12,000 steps. Interesting there was a sex difference with the plateau occurring at 10,000 steps in women and 14,000 steps in men. The increase in mortality was larger for cardiovascular disease than for cancer. Looking at two different age groups 50-64 and 65+ there was no difference in the most protective number of steps. Low mortality data in the 40-49 age group made it difficult to draw conclusions as to the most protective number of steps in this age group. Higher step intensity was associated with lower mortality, but if the calculation was controlled for number of steps, the effect disappeared.

Other researchers have adopted a similar research methodology to Lee et al. (2019) and Saint-Maurice et al. (2020) so it is possible to combine data from multiple studies. Paluch et al (2022) combined the data from 15 studies, seven of which were published and the rest on-going or unpublished. Eight of the studies involved participants living in the US, four studies participants living in Europe, there was a study each on participants living in Japan and Australia, and one study included participants from 40 countries. All the study participants wore the step counting device for one week and were followed up for all-cause mortality. In the analysis the results were adjusted for age and sex and separately for potential confounders including lifestyle factors and underlying disease.

The analysis included 47,471 participants followed for an average of 7.1 years. There was an inverse relationship between steps and mortality with the benefits of increased steps plateauing around 6,000-8,000 steps for participants over 60 years old, and at 8,000-10,000 steps for those under 60 years old. The number of steps per day for health benefits were the same for men and women. Seven of the 15 studies included data on stepping rate. In these studies, the median peak number of steps carried out in any 30 minute or 60 minute period was 64.1 and 57.5 steps per minute respectively, both well below the three miles an hour, moderate intensity physical activity indicator. Higher stepping rates were associated with decreased mortality, but as in the Lee et al. (2019) study, this effect mostly disappeared when the data were adjusted to take into account step volume. The data supported peak stepping rate, a measure of fitness, as having a greater impact on mortality than stepping rate. There were no clear benefits above total steps taken in stepping at 40 steps per minute or 100 steps per minute. The authors make the point though that it is difficult to separate out number of steps from stepping rate in the data, as participants that do the most steps tend to be those that walk the fastest.

A powerful tool to examine the relationship between steps and morbidity and mortality is to combine data from multiple studies in a meta-analysis. In a meta-analysis the effect size of the individual studies is pooled, with higher weighting given to the larger studies. Banach et al. (2023) looked at the data from 17 high quality studies that covered 226,889 healthy participants with a median follow up of 7.1 years to examine the relationship between step count and both all cause and cardiovascular mortality. Step data in all the studies were collected from a seven-day period of accelerometer (or similar device) wear. They found that an increase of 1,000 steps per day in the studied population reduced all-cause mortality by 15% and cardiovascular mortality by 7%. They found a strong inverse curvilinear relationship between step count and both all cause and cardiovascular mortality with the biggest benefits being in the 6,000-10,000 steps a day range for participants over 60 and in the 7,000-13,000 step range in younger participants.

A study focusing on the influence of stepping on all cause mortality in a younger population (mean age 45.2 years) with 10.8 years of follow up after a seven day period of data collection with an accelerometer found that benefits from stepping occurred at 7,000 steps per day and that there was no further improvement above 10,000 steps per day (Paluch et al, 2021). The researchers found no association between stepping intensity or time spent at 100 steps per minute or more with reduced mortality.

All these data show that stepping reduces mortality in the study populations with a curvilinear relationship between stepping and mortality such that mortality decreases with the number of steps taken per day up to a certain threshold, above which the curve flattens, reducing the benefit from further steps. The threshold number varies between studies, but appears to be around 8,000 steps per day for people over 60 and 10,000 steps a day for those under 60. The number of steps taken per day appears to be more closely correlated with mortality than the stepping intensity.

Stepping and morbidity

Other studies have looked at health indicators and morbidity rather than mortality. A study based on a British cohort of participants focused on cardiovascular risk factors (Hamer et al, 2022). As with the mortality studies, step data were collected from an accelerometer worn for seven days. In this study the participants gave blood samples for the assessment of metabolic markers. 4665 participants, all aged 46 and healthy, were included in the study; just over half were female. Daily step count was higher in men than women, non-smokers than smokers, degree educated than not degree educated, non-obese than obese and in participants describing themselves as being in excellent health than those describing themselves as being in poor health. The metabolic biomarkers were inversely related with number of steps per day in a curvilinear manner, with the effect flattening at around 10,000 steps. The exception was HDL cholesterol where the benefits of stepping continued to increase up to 20,000 steps per day without plateauing. As with the mortality studies, controlling for stepping intensity did not materially change the results.

Another study, also looking at a British cohort considered markers for both cardiovascular disease and cancer (Del Pozo Cruz et al. 2022a). As with the other studies participants wore an accelerometer for seven days, but in this study, they were followed up seven years later for both mortality and morbidity. There were 78,430 participants with a mean age of 61.1, 55% female. In keeping with other studies, participants who took more steps per day were younger, had a lower BMI, were non-smokers and did not drink alcohol. Also, in line with the other studies a higher stepping rate was linked to younger, healthier participants who took more steps. Step count was inversely related to cancer incidence and mortality and to cardiovascular disease (CVD) incidence and mortality. The benefits of stepping on all four of these parameters increased in a curvilinear fashion up to approximately 10,000 steps per day after which the authors commented that statistical uncertainty made it difficult to draw any further conclusions. It is interesting to note that only 20% of the study participants achieved 10,000 steps per day, but that health benefits were seen at low numbers of steps per day. In this study there was a clear benefit of increased stepping intensity in terms of all-cause mortality and CVD and cancer morbidity. Also, in this study it was shown that both incidental steps and purposeful steps led to health benefits.

In a further study on the same patient cohort, step count was analysed in relation to dementia incidence (Del Ponzo Cruz et al, 2022b). All the participants were free from dementia at the start of the study and they were followed for a median of 6.9 years for the development of dementia through patient health and death records. An inverse relation between step count and dementia incidence was observed up to approximately 9,800 steps, with a minimum of 3,800 steps per day required to see a benefit. Again, the paucity of data above 10,000 steps per day prevented the authors from drawing conclusions about the benefits of higher step counts. Both stepping intensity and purposeful steps were associated with a reduced dementia risk, with the greatest benefit seen at approximately 100 steps per minute. Purposeful steps associated with exercise were found to be more beneficial than incidental steps taken around the house.

In addition to looking at morbidity from cardiovascular disease, cancer and dementia there are studies that look at the relationship between steps and common health conditions. A study by Master et al. (2022) took step data from patients' Fitbits and looked at the relationship between step data and hospital records. The stepping data in this study are different from the accelerometer studies as stepping data were available for at least 6 months, rather than for the seven days of accelerometer wear. There were 6,042 US based participants in the study with a median age of 56.7, 73% female. This group took a median of 7,731 steps per day and were followed up for 4 years. In the analysis the researchers controlled for age, sex and race. The analysis of results revealed that a higher number of steps was linked to a lower incidence of chronic disease and the biggest benefit of stepping was seen for obstructive sleep apnoea, obesity, type 2 diabetes, hypertension, gastro-oesophageal reflux disease and major depressive disorder. All the relationships between number of steps taken per day and disease incidence were linear except for hypertension and type 2 diabetes which were curvilinear with a plateau at 8,000-9,000 steps. It could be argued that participants with a chronic disease stepped less as a result of their condition that may not have been diagnosed at the start of the study. The authors attempted to control for this by excluding diseases that emerged in the first six months of follow up.

The data on the relationship between number of steps per day and morbidity are very similar to the mortality data with a curvilinear relationship for cardiovascular disease, diabetes and dementia plateauing at around 10,000 steps per day. For other chronic diseases there may be a more linear relationship, but data are limited. The morbidity data includes an indication that stepping rate also plays a role, with increased stepping intensity reducing morbidity.

Confounding factors

A factor to consider when considering all these data is the impact of confounding factors, meaning factors that contribute to mortality and morbidity that may also impact the number of steps taken and the stepping intensity. So, it is likely for example, that younger participants, without underlying health conditions, that are not obese and without mobility issues will take more steps, step more intensely and live longer. Most of the studies attempt to control for the potential confounding factors whilst acknowledging that it may not be possible to control for them all.

Lee et al. (2021) investigated the possibility that results from accelerometer studies are being misinterpreted because of reverse causation. Reverse causation occurs if study participants who are already suffering from a chronic disease, that may have yet to be diagnosed, are less physically active because of the condition. Reverse causation has the potential to exaggerate the benefits of physical activity on health. To reduce the impact of reverse causation on results many researchers choose to ignore morbidity or mortality that emerges in the first two years of follow-up. Lee et al. collected stepping data from their participants every two years and were able to show that eliminating stepping data collected in the last two years of the follow-up period reduced the association between physical activity and all-cause mortality, but that eliminating data from more than two years did not influence the relationship. This supports the decision of many researchers to eliminate mortality and morbidity that occur in the first two years of follow-up.

A study reported by Matthews et al. (2020) considered the potential confounding effect in accelerometer studies of poor health in more detail. In a sample of 4,840 participants all more than 40 years old, the researchers examined the relationship between stepping data, length of follow up and all-cause mortality with a single measure of steps at the start of the study, and a follow-up period up to 12 years. The researchers collected information on a wide range of chronic conditions indicative of poor health by questionnaire. They found, unsurprisingly, that poor health was associated with both inactivity and mortality risk. They were able to use the data they had collected on poor health to adjust their findings to remove the influence of poor health on the results. After doing this the relationship between inactivity and mortality risk remained. In this study poor health was increasing the relationship between inactivity and mortality risk and this bias was found to be strongest when the follow-up period was less than six years, suggesting that longer follow-ups may be required in studies of the relationship between activity and mortality. The researchers were also able to show from their data, that the use of fewer indicators of poor health at the time of the initial data collection, and considering participants 65 years old and above, also increased the relationship between inactivity and mortality, suggesting that these are both causes of bias and can influence the underlying relationship between activity and mortality.

Single or multiple data collection periods?

There is clearly a potential problem inherent in many of the stepping studies because they make the assumption that number of steps taken in a short period of accelerometer wear at the start of the study does not change in a follow-up period over many years. A potential solution to this problem is to collect data regularly over a long year period rather than rely on the single time point. In this regard Lee et al.'s 2021 study is very helpful. In this study stepping data, alongside other data on physical activity, were collected from participants through questionnaires, rather than from accelerometers. Data were collected every two years over a 28-year period. To allow the data from different types of physical activity to be compared the questionnaire data were converted by the researchers into Metabolic Equivalents. Usurpingly, higher levels of physical activity were associated with reduced all-cause mortality. The relationship between physical activity and all-cause mortality was strongest for the most recent physical activity data, but there was still a significant all-cause mortality benefit for the earlier physical activity data which support the assumption that physical activity data collected at the start of a study will continue into the future.

Another way to counter the criticism of single point data collection in accelerometer studies is to repeat the data collection during the follow-up period. Kozey-Keadle et al (2017) undertook repeated accelerometer measurements in a random sample of women approximately one and two years after the initial measurement. They found there were significant declines in total activity over time and that number of steps taken also modestly declined over time. Nevertheless, they were able to conclude that because the effects were small, that a single measure of activity is a good estimate of physical activity over time with the caveat that the study was limited to women, mainly older women that were white, highly educated and compliant within the study protocol in terms of accelerometer wear.

Speed of steps

Many of the studies investigating stepping and morbidity and mortality looked at whether walking intensity influenced the outcomes. Most of the results show that if there is a benefit from walking faster, for longer, it disappears when the investigators control for the number of steps. This is because people that walk faster usually take more steps. To try to understand more about the role of cadence or walking intensity on health outcomes a 2018 review by Tudor-Locke et al. is helpful. They identified 38 studies published since the year 2000 addressing this issue. The authors saw a lot of variability in the way walking intensity was measured, but there was general agreement that walking at 100 steps per minute was the equivalent of moderate activity and walking at more than 130 steps was the equivalent of vigorous activity. Older adults may be able to walk with less intensity and achieve the same level of activity. Most walking is not very vigorous. Only 3.6% of the US population walk at an intensity of 100 steps per minute or more for a minimum of 30 minutes per day.

The relationship between steps and metabolic activity may change with age. The metabolic cost of walking is higher in older adults. To investigate the relationship between stepping intensity and moderate physical activity in older adults Yates et al. (2023) measured metabolic parameters in a UK cohort of 53 participants, average age 73 who wore an accelerometer for seven days. The participants walked a median of 6,988 steps per day of which 2,554 were in bouts of a minute or more. Of these longer step bouts, 96.4% were at 70 steps a minute or more and 67% were above 100 steps per minute. In this group the metabolic data showed that the threshold for achieving moderate activity was reached at 70 steps per minute, which was the stepping rate of nearly all the stepping bouts longer than a minute. The results of this study suggest that for older people the public health guidance should focus on increasing bouts of continuous stepping rather than trying to increase stepping intensity.

Steps at work or play?

Another question to consider is whether it matters how the steps are taken, for example is there a difference between steps taken as part of a job and steps taken for recreation. It is already known that physical activity that is work related does not have the same health benefits as leisure-based exercise. Christensen et al. (2023) set out to determine whether this so called "physical activity paradox" also applied to steps. In this study a group of 937 Danish workers from 22 different workplaces, mainly in blue collar occupations provided stepping data and were followed up to see if they had periods of long-term sickness absence from work (six or more weeks). The participants wore an accelerometer for four working days. Compared to some of the other studies considered so far, these participants took a lot of steps per day. They were divided into four equal groups: less than 9,472 steps per day, 9472-12,496 steps per day, 12,497-16,473 steps per day, and more than 16,473 steps per day. 20% of the participants experienced a sickness absence of more than six weeks over the course of the study. There was significant relationship between steps taken and sickness absence, but this time the relationship was positive, such that more steps was related to more sickness absence. The researchers were able to separate out steps taken at work and steps taken not at work. They saw a significant relationship between the steps taken at work and sickness absence and a protective effect in terms of sickness absence from steps taken outside work, but the protective effect was not large enough to mitigate the negative effect of steps taken at work. The relationship between steps taken at work and sickness absence was maintained when the results were controlled for sex, age, smoking and job type. This was an observational study and the authors were not able to explain why steps taken at work had a negative impact on health, but they suggest it may be due to the lack of control the individuals had at work on the number of steps taken and when they were taken.

A study by Cowley et al (2021) contradicts these results and does not support the physical activity paradox as applied to steps. In this study blood pressure was used as the health indicator and examined in relation to daily stepping in a group of workers. Steps were measured by a pedometer over a five-day period with at least two of the days being work days. The study participants kept diaries so that the steps per day could be allocated to work steps or leisure steps. The analysis included 694 workers of which 560 self-identified as blue collar and 134 as white collar. Overall, a higher number of steps was associated with lower (healthier) blood pressure, but in this study the steps taken at work were also beneficial for the blue-collar workers. Moreover, there was no significant relationship between steps taken at leisure and lower blood pressure. There are some possible explanations for this unexpected finding. The study did not look at steps taken on leisure days and steps on these days could be influencing blood pressure. Overall, the number of leisure steps was low, mean 5490 and may be below the threshold to influence blood pressure in a sample of this size.

Stepping every day?

The number of days that individuals have do the minimum number of steps to protect their health has also been investigated. The question to address here is whether the target number of steps has to be achieved every day, or does reaching the target on just some days suffice. As with the physical activity paradox for work and leisure based physical activity, there is a precedent on the number of days required for physical activity benefits to consider. This one is called "the weekend warrior" where it has been shown that exercising on just a couple of days per week can have the same health benefits as exercising more regularly. Inoue et al. (2023) undertook a study in the US with an active population undertaking on average more than 8000 steps in one day and looked at all cause and cardiovascular mortality over a ten year follow up period. There were 3101 participants altogether, average age of 50 and 51% female. They were divided into three groups; those doing no days at more than 8,000 steps per day, those doing 1-2 days at more than 8,000 steps per day and those doing 3-7 days at more than 8,000 steps per day. As is typical in this research field the authors corrected their data for the typical confounders and for total step count. They did not correct for stepping intensity. They found that those taking the higher number of steps per day were younger, male, non-smokers, not obese, with fewer comorbidities and higher self-rated health. Compared to the group that had no days of more than 8,000 steps, those taking 8,000 steps on one to two days per week had a 14.9% lower all-cause mortality risk and this increased to 16.5% for those taking 8,000 steps or more three to seven days per week. Overall, the relationship between number of days taking 8,000 steps or more and both all cause and cardiovascular mortality risk was curvilinear with the benefit of stepping plateauing at three to four days. This suggests that stepping just at the weekend is insufficient for health benefits but that it's not necessary to maintain a high step count every day of the week.

What does the research tell us?

Most studies of the health benefits of stepping are based on a single data collection period, usually of seven days, and many years of follow-up up of morbidity and mortality in the participant group. Results do vary, but taken together the studies show a consistent curvilinear relationship between number of steps taken and health benefits with the optimal benefit seen at around 10,000 steps, vindicating the 10,000 steps a day target. This benefit occurs at physical activity intensity levels that are below those in the government physical activity guidelines. On the other hand, the time spent taking 10,000 steps is longer than the daily physical activity time recommended in the guidance. There is currently no stepping recommendation in the UK government physical activity guidance.

The evidence indicates that the number of steps taken per day is more important for health than stepping intensity. The limited data that are available suggest that it is not necessary to reach the stepping target every day and that 10,000 steps three to four days per week may be sufficient to achieve health benefits and that some benefits accrue at one or two stepping days per week. It is not clear whether steps taken at work or for leisure are equally beneficial with some data favouring leisure-based stepping with others concluding that it is the number of steps not where they are taken that is important.

Studies of stepping benefits have to be carefully controlled to ensure that confounding factors do not lead to inaccurate findings. Younger, healthier participants will take more steps. There is also a danger of reverse causation in these studies such that participants with a yet to be diagnosed chronic disease take fewer steps. This can be overcome with long follow-up periods and discarding adverse health outcomes that occur in the first two years of the study.

Overall, those promoters of the pedometer seem to have got it about right in advocating 10,000 steps. What they did not say is that health benefits begin to accrue at much lower stepping thresholds.

References

Banach M, Lewek J, Surma S, Penson PE, Sahebkar A, Martin SS, Bajraktari G, Henein MY, Reiner Ž, Bielecka-Dąbrowa A, Bytyçi I. The association between daily step count and all-cause and cardiovascular mortality: a meta-analysis. Eur J Prev Cardiol. 2023 Aug 9:zwad229. doi: 10.1093/eurjpc/zwad229. Epub ahead of print. Erratum in: Eur J Prev Cardiol. 2023 Aug 18;: PMID: 37555441.

Christensen MR, Nabe-Nielsen K, Holtermann A, Gupta N. Does it matter for health if steps are taken during work or leisure? A prospective accelerometer study using register-based long-term sickness absence. Int J Behav Nutr Phys Act. 2023 Jun 9;20(1):69. doi: 10.1186/s12966-023-01468-4. PMID: 37296445; PMCID: PMC10251587

Crowley P, Gupta N, Vuillerme N, Madeleine P, Holtermann A. Number of steps and systolic blood pressure: Do work and leisure matter? Scand J Med Sci Sports. 2021 Oct;31(10):1962-1970. doi: 10.1111/sms.14010. Epub 2021 Jul 9. PMID: 34181778; PMCID: PMC9290469.

Del Pozo Cruz B, Ahmadi MN, Lee IM, Stamatakis E. Prospective Associations of Daily Step Counts and Intensity With Cancer and Cardiovascular Disease Incidence and Mortality and All-Cause Mortality. JAMA Intern Med. 2022(a) Nov 1;182(11):1139-1148. doi: 10.1001/jamainternmed.2022.4000. PMID: 36094529; PMCID: PMC9468953.

Del Pozo Cruz B, Ahmadi M, Naismith SL, Stamatakis E. Association of Daily Step Count and Intensity With Incident Dementia in 78 430 Adults Living in the UK. JAMA Neurol. 2022(b) Oct 1;79(10):1059-1063. doi: 10.1001/jamaneurol.2022.2672. Erratum in: JAMA Neurol. 2022 Sep 9;: PMID: 36066874; PMCID: PMC9449869.

Inoue K, Tsugawa Y, Mayeda ER, Ritz B. Association of Daily Step Patterns With Mortality in US Adults. JAMA Netw Open. 2023 Mar 1;6(3):e235174. doi: 10.1001/jamanetworkopen.2023.5174. Erratum in: JAMA Netw Open. 2023 Apr 3;6(4):e2311413. PMID: 36976556; PMCID: PMC10051082

Lee IM, Shiroma EJ, Kamada M, Bassett DR, Matthews CE, Buring JE. Association of Step Volume and Intensity With All-Cause Mortality in Older Women. JAMA Intern Med. 2019 Aug 1;179(8):1105-1112. doi: 10.1001/jamainternmed.2019.0899. PMID: 31141585; PMCID: PMC6547157.

Lee DH, Rezende LFM, Ferrari G, Aune D, Keum N, Tabung FK, Giovannucci EL. Physical activity and all-cause and cause-specific mortality: assessing the impact of reverse causation and measurement error in two large prospective cohorts. Eur J Epidemiol. 2021 Mar;36(3):275-285. doi: 10.1007/s10654-020-00707-3. Epub 2021 Jan 11. PMID: 33428024; PMCID: PMC8035269.

Hamer M, Blodgett JM, Stamatakis E. Dose-response association between step count and cardiovascular disease risk markers in middle-aged adults. Scand J Med Sci Sports. 2022 Jul;32(7):1161-1165. doi: 10.1111/sms.14173. Epub 2022 Apr 28. PMID: 35460292; PMCID: PMC9428935.

Keadle SK, Shiroma EJ, Kamada M, Matthews CE, Harris TB, Lee IM. Reproducibility of Accelerometer-Assessed Physical Activity and Sedentary Time. Am J Prev Med. 2017 Apr;52(4):541-548. doi: 10.1016/j.amepre.2016.11.010. Epub 2017 Jan 3. PMID: 28062274; PMCID: PMC5362292.

Master H, Annis J, Huang S, Beckman JA, Ratsimbazafy F, Marginean K, Carroll R, Natarajan K, Harrell FE, Roden DM, Harris P, Brittain EL. Association of step counts over time with the risk of chronic disease in the All of Us Research Program. Nat Med. 2022 Nov;28(11):2301-2308. doi:

10.1038/s41591-022-02012-w. Epub 2022 Oct 10. Erratum in: Nat Med. 2023 Apr 12;: PMID: 36216933; PMCID: PMC9671804.

Matthews CE, Troiano RP, Salerno EA, Berrigan D, Patel SB, Shiroma EJ, Saint-Maurice PF. Exploration of Confounding Due to Poor Health in an Accelerometer-Mortality Study. Med Sci Sports Exerc. 2020 Dec;52(12):2546-2553. doi: 10.1249/MSS.0000000000002405. PMID: 32472927; PMCID: PMC7669589.

Paluch AE, Bajpai S, Bassett DR, Carnethon MR, Ekelund U, Evenson KR, Galuska DA, Jefferis BJ, Kraus WE, Lee IM, Matthews CE, Omura JD, Patel AV, Pieper CF, Rees-Punia E, Dallmeier D, Klenk J, Whincup PH, Dooley EE, Pettee Gabriel K, Palta P, Pompeii LA, Chernofsky A, Larson MG, Vasan RS, Spartano N, Ballin M, Nordström P, Nordström A, Anderssen SA, Hansen BH, Cochrane JA, Dwyer T, Wang J, Ferrucci L, Liu F, Schrack J, Urbanek J, Saint-Maurice PF, Yamamoto N, Yoshitake Y, Newton RL Jr, Yang S, Shiroma EJ, Fulton JE; Steps for Health Collaborative. Daily steps and all-cause mortality: a meta-analysis of 15 international cohorts. Lancet Public Health. 2022 Mar;7(3):e219-e228. doi: 10.1016/S2468-2667(21)00302-9. PMID: 35247352; PMCID: PMC9289978.

Paluch AE, Gabriel KP, Fulton JE, Lewis CE, Schreiner PJ, Sternfeld B, Sidney S, Siddique J, Whitaker KM, Carnethon MR. Steps per Day and All-Cause Mortality in Middle-aged Adults in the Coronary Artery Risk Development in Young Adults Study. JAMA Netw Open. 2021 Sep 1;4(9):e2124516. doi: 10.1001/jamanetworkopen.2021.24516. PMID: 34477847; PMCID: PMC8417757.

Physical Activity Guidelines Committee (2018) https://health.gov/sites/default/files/2019-09/PAG_Advisory_Committee_Report.pdf

Saint-Maurice PF, Graubard BI, Troiano RP, Berrigan D, Galuska DA, Fulton JE, Matthews CE. Estimated Number of Deaths Prevented Through Increased Physical Activity Among US Adults. JAMA Intern Med. 2022 Mar 1;182(3):349-352. doi: 10.1001/jamainternmed.2021.7755. PMID: 35072698; PMCID: PMC8787676.

Tudor-Locke C, Han H, Aguiar EJ, Barreira TV, Schuna JM Jr, Kang M, Rowe DA. How fast is fast enough? Walking cadence (steps/min) as a practical estimate of intensity in adults: a narrative review. Br J Sports Med. 2018 Jun;52(12):776-788. doi: 10.1136/bjsports-2017-097628. PMID: 29858465; PMCID: PMC6029645.

Tudor-Locke C, Aguiar EJ, Han H, Ducharme SW, Schuna JM Jr, Barreira TV, Moore CC, Busa MA, Lim J, Sirard JR, Chipkin SR, Staudenmayer J. Walking cadence (steps/min) and intensity in 21-40 year olds: CADENCE-adults. Int J Behav Nutr Phys Act. 2019 Jan 17;16(1):8. doi: 10.1186/s12966-019-0769-6. PMID: 30654810; PMCID: PMC6337834.

Tudor-Locke C, Ducharme SW, Aguiar EJ, Schuna JM Jr, Barreira TV, Moore CC, Chase CJ, Gould ZR, Amalbert-Birriel MA, Mora-Gonzalez J, Chipkin SR, Staudenmayer J. Walking cadence (steps/min) and intensity in 41 to 60-year-old adults: the CADENCE-adults study. Int J Behav Nutr Phys Act. 2020 Nov 10;17(1):137. doi: 10.1186/s12966-020-01045-z. PMID: 33168018; PMCID: PMC7654058.

Tudor-Locke C, Mora-Gonzalez J, Ducharme SW, Aguiar EJ, Schuna JM Jr, Barreira TV, Moore CC, Chase CJ, Gould ZR, Amalbert-Birriel MA, Chipkin SR, Staudenmayer J. Walking cadence (steps/min) and intensity in 61-85-year-old adults: the CADENCE-Adults study. Int J Behav Nutr Phys Act. 2021 Sep 23;18(1):129. doi: 10.1186/s12966-021-01199-4. PMID: 34556146; PMCID: PMC8461976.

UK Chief Medical Officers’ Physical Activity guidelines (2019). https://assets.publishing.service.gov.uk/media/5d839543ed915d52428dc134/uk-chief-medical-officers-physical-activity-guidelines.pdf

Yates T, Henson J, McBride P, Maylor B, Herring LY, Sargeant JA, Davies MJ, Dempsey PC, Rowlands AV, Edwardson CL. Moderate-intensity stepping in older adults: insights from treadmill walking and daily living. Int J Behav Nutr Phys Act. 2023 Mar 18;20(1):31. doi: 10.1186/s12966-023-01429-x. PMID: 36934275; PMCID: PMC10024004.