

In children and adolescents (aged 5–17 years), what is the association between sedentary behaviour and health-related outcomes?

Evidence indicates that greater time spent in sedentary behaviour, especially recreational screen time, is related to poorer health outcomes (24, 35). For example, higher duration of screen time (including television viewing) is associated with poorer **fitness** and **cardiometabolic health** (24, 25) in children and adolescents. Evidence from device-based assessment of association with sedentary behaviour and interventions studies showed modest effects, although stronger effects for those already living with obesity (55). There is limited evidence suggesting that sedentary behaviour is not related to bone health in children and adolescents.

Despite more mixed results, evidence also suggests that sedentary behaviour may be associated with unfavourable measures of **adiposity** (24, 25). One review of largely cross-sectional studies, reported that sedentary behaviour (measured as total screen time) of more than 2 hours per day was positively associated with childhood overweight/obesity compared with lower levels (< 2 hours/day) (56). However, another review of 20 cross-sectional studies (57) found no statistically significant association between sedentary video gaming and body mass index among children or adolescents. A large review of 29 systematic reviews concluded that many studies report unfavourable associations between sedentary behaviour and markers of adiposity in young people when the behaviour is self-reported as some form of screen time (55). However, the review noted that the magnitude of such associations was small and, for studies using device-based assessment of sedentary time, largely zero (55). Intervention studies showed modest effects, although stronger effects for those already living with obesity (55). Further research is needed to inform the association between sedentary behaviours and measures of adiposity.

Although still an emerging area of research, some evidence shows that there may be a negative association between sedentary behaviour and **well-being and quality of life**, as well as an unfavourable relationship between **depression** and leisure screen time in children and adolescents (58, 59). For example, higher durations of sedentary behaviour, assessed as screen time, and some aspects of computer use, can be associated with poorer mental health (24). In another recent review, an association between sedentary behaviour

and anxiety symptoms was found in 5 of 8 studies, although results were inconsistent across different measures of sedentary behaviour within studies (60). Other evidence demonstrates that higher durations of television viewing and video game use were significantly associated with unfavourable measures of **behavioural conduct/pro-social behaviour** (24); and more screen time and television viewing is associated with shorter **sleep** duration, although there was no association between computer use/gaming and sleep duration (61). Investigations into the relationship between sedentary behaviours and mental health is a rapidly developing field with many unknowns, and reverse causality is likely to be in evidence. Further research is needed to inform on the direction and strength of this association.

The GDG concluded that:

- There is low certainty evidence that higher duration of sedentary behaviour (screen time) is significantly associated with lower physical fitness and cardiometabolic health in children and adolescents.
- There is very low to moderate certainty evidence that higher durations of sedentary behaviour (screen time, television viewing and video game use) are significantly associated with unfavourable measures of mental health and behavioural conduct/pro-social behaviour in children and adolescents.
- There is low certainty evidence that greater time spent in sedentary behaviour (screen time and television viewing) is associated with detrimental effects on sleep duration in children and adolescents.
- The benefits of limiting the amount of sedentary behaviour for children and adolescents outweigh the harms.

Is there a dose-response association (total volume, duration, frequency, intensity of interruption)?

There is insufficient evidence available to determine whether a dose-response relationship exists between sedentary time (including recreational screen time) and health outcomes in children and adolescents. Most of the evidence assessing the associations between sedentary behaviours and health outcomes in children and adolescents is cross-sectional in nature, with low certainty evidence according to GRADE, and a majority of studies relied on self- or parent-reported measures of sedentary time that are subject to measurement errors and recall biases. There is, however, evidence that less time spent in sedentary behaviours appears to be

better for health outcomes, and the association between sedentary behaviour and adverse health outcomes is generally stronger for sedentary behaviour when assessed as television viewing or recreational screen time as the exposure variable, than for total sedentary time. However, overall the evidence was considered insufficient to support specifying time limits.

Evidence that sedentary behaviours are linked to adverse health outcomes could be the result of either direct effects of the sedentary behaviours, displacement of time spent in more physically active behaviours, or both. Although there are studies that have reported associations between screen time and adverse health outcomes in children and adolescents, total sedentary time (as assessed in studies using device-based measurements of sedentary behaviour) has consistently not been associated with health outcomes when time in moderate- to vigorous-intensity physical activity is taken into account (62). Conversely, the evidence linking moderate- to vigorous-intensity physical activity to positive health outcomes is strong and well documented across diverse settings; replacing some sedentary behaviour with physical activity (especially moderate- to vigorous-intensity physical activity) may improve health outcomes.

Research investigating the associations and interplay between sedentary behaviour, physical activity and health outcomes is rapidly growing, and evidence from device-based measures of sedentary behaviour and cardiometabolic health show the association is attenuated when moderate- to vigorous-intensity physical activity is taken into account (i.e. statistically adjusted for) (62–64). There is therefore a need for further prospective studies using device-based measures of exposure, to advance knowledge of these associations and inform future recommendations.

The GDG concluded that:

- There is low certainty evidence that greater time spent in sedentary behaviour is related to poorer health outcomes.
- There is insufficient evidence to specify time limits on sedentary behaviour.
- Replacing sedentary time with moderate- to vigorous-intensity physical activity may provide health benefits.

Does the association vary by type or domain of sedentary behaviour?

The study of health effects of sedentary behaviour is a relatively new field of research. As such the findings are from studies using different instruments and measures of exposure. Exposure assessed as “total time spent doing sedentary behaviours” is frequently used, as is sedentary time spent using “screens” or “television viewing”. Available evidence suggests that the association between sedentary behaviour and adverse health outcomes is generally stronger for television viewing or recreational screen time than for total sedentary time (24, 35). The increased use of device-based assessment of sedentary behaviour in the more recent research is advancing knowledge, and when combined with standardized reporting will help inform future guidelines.

It is acknowledged that not all sedentary behaviour is harmful. Evidence suggests certain types of sedentary behaviour, such as reading and doing homework outside of school, are associated with higher academic achievement, indicating that there are differences in outcome depending on the activity (24, 25). Sedentary behaviour may include time spent engaged in educational pursuits/study or quiet play, or social interaction without electronic media. These pursuits (e.g. reading, doing puzzles, drawing, crafting, singing, music) are important for child development and have cognitive as well as other benefits.

The GDG acknowledged that:

- Some sedentary activities confer benefits for cognitive function and social interaction in children and adolescents.
- Evidence on the adverse health effects of sedentary behaviour is generally stronger for television viewing or recreational screen time than for total sedentary time.



PHYSICAL ACTIVITY RECOMMENDATION

For adults, physical activity can be undertaken as part of recreation and leisure (play, games, sports or planned exercise), transportation (wheeling, walking and cycling), work or household chores, in the context of daily occupational, educational, home and community settings.

In adults, physical activity confers benefits for the following health outcomes: improved all-cause mortality, cardiovascular disease mortality, incident hypertension, incident site-specific cancers,¹ incident type-2 diabetes, mental health (reduced symptoms of anxiety and depression); cognitive health, and sleep; measures of adiposity may also improve.

It is recommended that:

› **All adults should undertake regular physical activity.**

Strong recommendation, moderate certainty evidence

› **Adults should do at least 150–300 minutes of moderate-intensity aerobic physical activity; or at least 75–150 minutes of vigorous-intensity aerobic physical activity; or an equivalent combination of moderate- and vigorous-intensity activity throughout the week, for substantial health benefits.**

Strong recommendation, moderate certainty evidence

› **Adults should also do muscle-strengthening activities at moderate or greater intensity that involve all major muscle groups on 2 or more days a week, as these provide additional health benefits.**

Strong recommendation, moderate certainty evidence

› **Adults may increase moderate-intensity aerobic physical activity to more than 300 minutes; or do more than 150 minutes of vigorous-intensity aerobic physical activity; or an equivalent combination of moderate- and vigorous-intensity activity throughout the week for additional health benefits.**

Conditional recommendation, moderate certainty evidence

GOOD PRACTICE STATEMENTS

- Doing some physical activity is better than doing none.
- If adults are not meeting these recommendations, doing some physical activity will benefit their health.
- Adults should start by doing small amounts of physical activity, and gradually increase the frequency, intensity and duration over time.



¹ Site-specific cancers of: bladder, breast, colon, endometrial, oesophageal adenocarcinoma, gastric, and renal.

Supporting evidence and rationale

For these guidelines, the synthesis of evidence undertaken by the United States Physical Activity Guidelines Advisory Committee (PAGAC) (35) was used and updated.

The GDG considered the entire body of evidence, including both the findings reported by PAGAC and the 28 reviews and 3 pooled cohort studies, published from 2017 through to November 2019, that met inclusion criteria, and contributed evidence on the association between physical activity and health-related outcomes in adults. In addition, two umbrella reviews were commissioned to address evidence gaps and examine **i)** the relationship between occupational (i.e. work-related) physical activity and health-related outcomes (40); and **ii)** the association between leisure-domain physical activity and adverse health outcomes (41). The umbrella reviews identified 36 and 15 systematic reviews respectively. Evidence from longitudinal observational studies and intervention trials was prioritized, and reviews that solely, or primarily, synthesized cross-sectional evidence were not considered. Greater emphasis was given to evidence provided by reviews graded moderate certainty and above, and to those providing evidence from studies using device-based measures of exposure.

Full details of the methods, data extraction and evidence profiles can be found in the [Web Annex: Evidence profiles](#).

In adults (aged 18–64 years), what is the association between physical activity and health-related outcomes?

The association between physical activity and **all-cause mortality and cardiovascular disease mortality** in adults is already well-established (1). Findings from recent reviews reaffirmed that compared with the lowest levels of physical activity, higher levels of physical activity were associated with a lower risk of mortality. New evidence from studies using device-based measures of physical activity reaffirmed and extended the evidence showing that compared with the lowest levels of physical activity, *any* level and *all intensities* (including light intensity) of physical activity, were associated with a lower risk of mortality (65). For example, compared with the least active (referent, 1.00), adjusted HR for quartiles of total physical activity improved across quartiles of physical activity: 2nd quartile (0.48 [95% CI: 0.43 to 0.54]); 3rd quartile (0.34 [95% CI: 0.26 to 0.45]); and 4th quartile (0.27 [95% CI: 0.23 to 0.32]) (65). New evidence also reaffirmed the well-established (1) inverse relationship between physical activity and **cardiovascular disease mortality** (66).

The benefits of physical activity for reducing cardiovascular disease and hypertension incidence is well-documented (1). Physical activity promotes many physiological responses that cause beneficial short- and long-term autonomic and haemodynamic adaptations, resulting in lowered risk of **hypertension**, which is a key risk factor for **cardiovascular disease**.

Evidence reaffirmed an inverse relationship between physical activity and incident hypertension among adults with normal blood pressure, and that physical activity reduces blood pressure among adults with prehypertension and normal blood pressure (35).

The inverse association between physical activity and developing **type-2 diabetes** in adults is well-established (1). Recent evidence reaffirmed an inverse curvilinear relationship between higher volumes of physical activity and incidence of type-2 diabetes (35), with a decreasing slope at higher levels of physical activity. A new review found that this effect is consistent across individuals of different backgrounds with a reduced risk of developing type-2 diabetes in “highest” versus “lowest” levels of physical activity among non-Hispanic whites (RR= 0.71 [95% CI: 0.60 to 0.85]); Asians (RR= 0.76 [95% CI: 0.67 to 0.85]); Hispanics (RR = 0.74 [95% CI 0.64 to 0.84]); and American Indians (RR = 0.73 [95% CI: 0.60 to 0.88]), although the effect among non-Hispanic blacks was not significant (RR = 0.91 [95% CI: 0.76 to 1.08]) (67). Evidence suggests there is no effect modification by weight status and that the inverse relationship between a higher volume of physical activity and lower incidence of type-2 diabetes exists for people who have normal weight, overweight or obesity (35).

The associations between higher levels of physical activity and reduced risks of **colon cancer and breast cancer** have been well-established (1). In previous reviews of the evidence, higher levels of physical activity have been found to be associated with a reduced risk of

developing breast cancer and colon cancer (1). Following an extensive increase in physical activity and cancer research, there is new evidence demonstrating higher levels of physical activity are also associated with reduced risk of developing bladder, endometrial, oesophageal adenocarcinoma, gastric and renal cancers, as well as reaffirming that physical activity is protective for breast cancer and colon cancer (35). Higher levels of physical activity are associated with risk reductions ranging from approximately 10–20% (35). For example, one review reported an inverse association with liver cancer risk when comparing high levels of physical activity to low levels of physical activity (HR= 0.75 [95% CI: 0.63 to 0.89]) (68). There is insufficient evidence on the association between increased physical activity and decreased risks of hematologic, head and neck, ovary, pancreas, prostate, thyroid, rectal and brain cancer (35). While evidence suggests a reduction in risk of lung cancer between the highest versus lowest levels of physical activity, these findings may be confounded by tobacco use and it was determined that overall there is insufficient evidence to establish an association.

The association between physical activity and **adiposity** in adult populations is less well established despite a large, but heterogenous, body of evidence assessing this relationship across various outcome measures (weight gain, weight change, weight control, weight stability, weight status and weight maintenance) (35, 69, 70). Overall the evidence shows that higher levels of physical activity may be associated with more favourable measures of adiposity and attenuation of weight gain in adults (35). Further research is needed to establish consistent results and strength of associations.

Research on physical activity and **mental health, cognition and sleep** has increased substantially since the development of the 2010 *Global recommendations on physical activity for health* (1). At that time, there was sufficient evidence to conclude only that physical activity may reduce the risk of depression and cognitive decline in adults. New evidence reviewed for these guidelines showed that adults engaging in higher versus lower physical activity are at reduced risk of developing anxiety and depression. For example, adults with high, versus low, levels of physical activity were at reduced odds of developing anxiety (AOR= 0.81 [95% CI: 0.69 to 0.95]) (71) or depression (AOR= 0.78 [95% CI: 0.70 to 0.87]) (72). Greater amounts of moderate- to vigorous-intensity physical activity are associated with improvements in cognition (e.g. processing speed, memory, and executive function) (35), brain function and structure, and a reduced

risk of developing **cognitive impairment**, including Alzheimer's disease (73–76). The evidence included several adult populations representing a gradient of normal to impaired cognitive health status and the beneficial effects of physical activity were reported across a variety of types, including aerobic activity, walking, muscle-strengthening activity, and yoga (74). There is evidence that both acute bouts and regular physical activity improve **sleep and health-related quality of life** outcomes in adults (35).

Evidence examining physical activity and **symptoms of depression, symptoms of anxiety, and the development of anxiety and depression** indicated that physical activity was associated with reduced symptoms of anxiety (77, 78) and reduced symptoms of depression (77, 79).

All physical activity comes with some risk. Evidence from a commissioned review on the adverse effects, injuries and harms associated with leisure physical activity in adults (41) suggests an unfavourable association between levels of leisure-time physical activity and musculoskeletal injuries, and a favourable relationship between leisure-time physical activity and risk of fracture and onset of knee or hip osteoarthritis. Additional existing evidence (35) indicates sudden cardiac adverse events are rare and associated with acute sessions of relatively vigorous-intensity physical activity. Generally, the risks of adverse events are very low with moderate-intensity physical activity and when increases in physical activity frequency, intensity and duration are gradual (35).

The GDG concluded that:

- There is high certainty evidence that any level and any intensity of physical activity is associated with lower risk of all-cause mortality and cardiovascular disease mortality, incidence of hypertension, cardiovascular disease and type-2 diabetes.
- There is moderate to high certainty evidence on the associations between higher levels of physical activity and lower risk of incidence of site-specific cancers.
- There is moderate certainty evidence supporting an association between physical activity and improvements in mental health, cognitive health and sleep outcomes.
- There is evidence of an association between higher levels of physical activity and more favourable measures of adiposity and attenuation of weight gain in adults.
- There is low certainty evidence that physical activity recommended for adults will not be harmful and that the health benefits from such activity outweigh the risks.

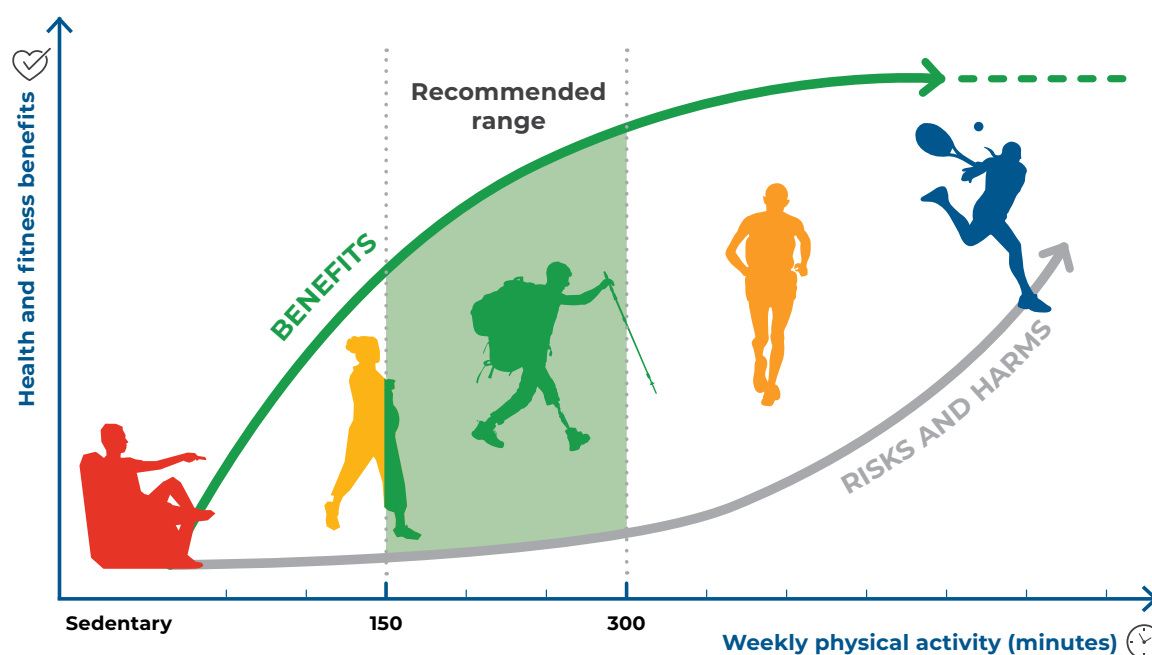


Figure 1: Dose response curve

Is there a dose-response association (volume, duration, frequency, intensity)?

Overall the evidence across cardiovascular and metabolic health outcomes shows a consistent curvilinear inverse dose-response relationship between physical activity and major outcomes such as all-cause mortality, cardiovascular disease mortality, incident type-2 diabetes (67), and incident site-specific cancers in adults. As described in **Figure 1**, the shape of the dose-response curve indicates that there is no lower threshold for benefit, and the greatest benefits are seen at the lower end of the dose-response curve (65). The curvilinear inverse association is consistently reported and across studies using different measures of physical activity. Important new evidence was provided in a meta-analysis of eight prospective cohort studies, with mean follow-up of 5.8 years (range 3–14.5 years) (65) that reported the adjusted HR for quartiles of total physical activity using device-based measures of exposure and **all-cause mortality**. The results showed a dose-response with increasing volume of physical activity and benefits of higher levels of *any* intensity of physical activity compared with the least active (referent, 1.00): 2nd quartile (adjusted HR= 0.48 [95% CI: 0.43 to 0.54]); 3rd quartile (adjusted HR= 0.34 [95% CI: 0.26 to 0.45]); and 4th quartile (adjusted HR= 0.27 [95% CI: 0.23 to 0.32]). Maximal risk reductions for moderate- to vigorous-intensity physical activity were observed at 24 minutes per day (equivalent to 168 minutes per week), which

closely reflects the recommendation of 150 minutes per week, and provides new device-based evidence reinforcing the existing global guidance to adults of 150–300 minutes of physical activity per week (65). These findings are consistent with the evidence from existing reviews (35) and the other new identified reviews (66).

At the upper end, higher levels of physical activity continue to provide benefits in terms of reduced risk of mortality with no increased risk of harms. For example, evidence from a new review with findings from a meta-analysis of individual data from device-based measures of exposure (65), indicates that although reduced risk of mortality is observed up to 750 minutes of moderate- to vigorous-intensity physical activity per week, the relative risk of mortality levels off beyond 300 minutes per week. These results accord with previous evidence which consistently showed that more physical activity is associated with further health benefits, although the relative benefits are reduced at higher levels of physical activity (35, 80, 81). There is, however, insufficient evidence to identify the exact physical activity level where diminished returns of health benefits begin for adults.

Evidence also reaffirmed the well-established inverse relationship between physical activity and **cardiovascular disease mortality**, providing additional evidence of a dose-response relationship well beyond current recommended volumes of physical activity.

A meta-analysis of 48 prospective studies assessing physical activity (total, leisure, and occupational) provided additional evidence of a dose-response relationship (66) well beyond current recommended volumes of physical activity. Compared with the recommended level of 750 MET minutes per week, participation in 5000 MET minutes per week (1000 minutes of moderate-intensity activity) resulted in a significantly lower risk for cardiovascular disease mortality (HR= 0.73 [95% CI: 0.56 to 0.95]) (66). Previous WHO recommendations (1) concluded that aerobic activity should be performed in bouts of at least 10 minutes duration. However, new evidence, using device-based assessments, demonstrates that physical activity of *any* duration, without a minimum threshold, is associated with improved health outcomes, including all-cause mortality (65, 82). For example, new evidence from reviews of studies assessing physical activity by accelerometry reaffirms similar associations between all indices of physical activity and all-cause mortality, with hazard ratios of 0.27 for total physical activity, 0.28 for 5-minute bouts, and 0.35 for 10-minute bouts, comparing the highest versus lowest quartiles (83). These results, reaffirmed by findings in the new review by Ekelund et al. 2019 (65), provide evidence that physical activity of any bout duration is associated with improved health outcomes, including all-cause mortality (82). Based on new evidence, the recommendation for bouts of least 10 minutes duration has been removed.

Although evidence showing the associations between higher levels of physical activity and lower risk of incidence of **site-specific cancers** was deemed to be consistent overall, there is insufficient evidence to determine the specific levels of physical activity that correspond to the reported risk reduction due to the large heterogeneity in the assessment and classification of exposure across studies. There is however, no evidence to suggest that there is a lower threshold below which no beneficial effect of physical activity is evident, thus suggesting that any level of physical activity can confer benefit on reducing the risk of site-specific cancers. Future research assessing the nature of the dose-response and using more consistent measures and reporting is needed to inform future guidelines.

Although there is a large body of evidence on the associations between physical activity and various measures of adiposity, weight gain and the management of a healthy weight status (35), currently there is insufficient evidence to describe more specifically

the dose-response relationship or identify a threshold of effect. Further research is needed to inform future guidelines.

Greater amounts of moderate- to vigorous-intensity physical activity are associated with improvements in **cognition** (e.g. processing speed, memory, and executive function) (35), brain function and structure, and a reduced risk of developing **cognitive impairment**, including Alzheimer's disease (73–76). There is evidence that both acute bouts and regular physical activity improve **sleep and health-related quality of life** outcomes in adults (35). There is however insufficient evidence to describe more specifically the dose-response relationship between physical activity and individual mental and cognitive health outcomes. Similarly, more evidence is needed to further describe the dose-response relationship between volume and/or intensity of aerobic physical activity and muscle-strength training and specific health outcomes. Such information is key to establishing minimal effective doses and maximum safety thresholds of physical activity for different population subgroups.

The GDG concluded that:

- There is evidence that more physical activity is associated with larger effects on health outcomes, although the relative benefits level off at higher levels of physical activity. There was insufficient evidence to identify the exact level where diminished returns start to occur.
- There is high certainty evidence that higher levels of physical activity are associated with lower risk of all-cause mortality, cardiovascular disease mortality, cancer mortality, cardiovascular disease incidence, and incidence of hypertension and type-2 diabetes, with no increased risk of harms.
- There is moderate certainty evidence that physical activity of any duration is associated with improved health outcomes, and prior specification that aerobic activity should be performed in bouts of at least 10 minutes duration should be removed.
- There is evidence that higher amounts of physical activity may be associated with more favourable measures of adiposity and attenuation of weight gain in adults and there is a low risk that physical activity will be harmful for the management of healthy weight status in adults.
- There is moderate certainty evidence that 150–300 minutes of moderate intensity aerobic physical activity or equivalent, per week, reduces risk for multiple health outcomes, and risk reduction continues, but starts to plateau, beyond 300 minutes per week.

Does the association vary by type or domain of physical activity?

Evidence shows that different types of physical activity and physical activity undertaken in different domains (i.e. occupation, transport, or leisure) can provide favourable health outcomes. For all-cause and cardiovascular disease mortality, undertaking aerobic physical activity alone, or combining with strength-promoting exercise shows beneficial associations, although performing recommended levels of both types is optimal (84).

More recent moderate certainty evidence indicates that muscle-strengthening physical activity, independent of aerobic physical activity, is also associated with lower risk of all-cause mortality. Results reported by Stamatakis et al. (2018), from a pooled analysis of 11 cohorts examining the 2 days per week muscle-strengthening exercise recommendation against all-cause mortality, showed that undertaking both aerobic and muscle-strengthening physical activity at recommended levels (1) versus not meeting either recommendation (adjusted HR= 0.71 [95% CI: 0.57 to 0.87]) as well as adherence to just the strength exercise recommendation versus not adhering (HR= 0.80 [95% CI: 0.70 to 0.91]) was associated with significantly lower risk of all-cause mortality (84). These data affirm that health benefits associated with muscle-strengthening exercise were independent of aerobic physical activity and also provide evidence to support recommending a frequency of 2 days per week of muscle-strengthening exercise. Other findings reported by Dinu et al. (2019) provided supporting evidence reaffirming that physical activity undertaken in domains other than leisure (or recreation) can be beneficial and specifically showed that active commuting (i.e. walking and cycling for transport) can significantly lower risk of all-cause mortality (RR= 0.92 [95% CI: 0.85–0.98]) (85).

Recent research provides evidence demonstrating that for those who participate in active commuting (i.e. walking or cycling for transport), there is reduced risk of cardiovascular disease (coronary heart disease, stroke and heart failure) compared with those participating in no active commuting (RR= 0.91 [95% CI 0.83 to 0.99]) (85); and that there is sufficient evidence from these health outcomes to conclude that activity in different domains can be beneficial. However, there is insufficient evidence to differentiate the effect of different domains of physical activity on every health outcome. For example, there is insufficient evidence to determine if the association between physical activity and cancer risk or type-2 diabetes incidence varies by type or domain of physical activity.

For mental health outcomes, evidence (35) shows that a variety of types of physical activity, including aerobic activity, walking, muscle-strengthening activity, and yoga can provide beneficial effects for reducing symptoms of depression and development of anxiety (74, 79, 86). For example recent evidence for the beneficial effects of resistance exercise interventions and mental health was provided by two reviews reporting moderately large reductions in symptoms of depression (77) and small reductions in symptoms of anxiety (78) compared with control conditions.

Evidence from a new review affirmed that high levels of occupational physical activity is associated with reduced risk of many cancers, coronary heart disease, and type-2 diabetes (40). However, higher levels of occupational physical activity may also be associated with an increased risk of osteoarthritis, poor sleep quality, and all-cause mortality among males (but not among females). There is insufficient evidence to determine the relationship between occupational physical activity and adiposity, prevention of body weight gain, mental health, and health-related quality of life (40). There is also insufficient evidence to determine if the association between physical activity and cancer risk varies by type or domain of physical activity. There is less evidence on associations by different domains of physical activity, and therefore it was difficult to differentiate the effect of different domains of physical activity on various health outcomes.

The GDG concluded that:

- There is moderate certainty evidence that muscle-strengthening activities undertaken on 2 or more days a week, provide additional health benefits, but there is insufficient evidence to specify a specific duration for optimal health benefits.
- There is moderate certainty evidence that physical activity undertaken in different domains (e.g. leisure, transport, occupational) can provide health benefits, although currently it is not possible to differentiate the effect of different domains of physical activity on various health outcomes.
- Although higher levels of occupational physical activity may be associated with an increased risk of osteoarthritis, poor sleep quality, and all-cause mortality among males (but not among females), overall there is moderate certainty evidence that occupational physical activity can provide health benefits.



SEDENTARY BEHAVIOUR RECOMMENDATION

For adults, sedentary behaviour is defined as time spent sitting or lying with low energy expenditure, while awake, in the context of occupational, educational, home and community settings, and transportation.

In adults, higher amounts of sedentary behaviour are associated with the following poor health outcomes: all-cause mortality, cardiovascular disease mortality and cancer mortality and incidence of cardiovascular disease, cancer and type-2 diabetes.

It is recommended that:

➤ **Adults should limit the amount of time spent being sedentary. Replacing sedentary time with physical activity of any intensity (including light intensity) provides health benefits.**

Strong recommendation, moderate certainty evidence

➤ **To help reduce the detrimental effects of high levels of sedentary behaviour on health, adults should aim to do more than the recommended levels of moderate- to vigorous-intensity physical activity.**

Strong recommendation, moderate certainty evidence

Supporting evidence and rationale

For these guidelines, the synthesis of evidence undertaken by PAGAC (35) was used and updated. The GDG considered the entire body of evidence, including both the findings reported by PAGAC and the 13 new reviews that met inclusion criteria, to contribute evidence on the association between sedentary behaviour and health-related outcomes in adults. Investigating the association between sedentary behaviour and health outcomes is a relatively new field of public health compared with that of physical inactivity, yet it has developed rapidly in the past decade. Studies have typically measured sedentary behaviour using either **i)** self-report questionnaires which ask about “total time” spent in sedentary behaviours, or time spent in specific behaviours, such as television viewing, computer/screen use, and sitting; or **ii)** device-based assessments. There are no standardized measures or analytical protocols for sedentary behaviour and thus the reporting of results is heterogeneous. Recent methodological developments include the use of device-based assessment of time spent sedentary which can reduce measurement error and other biases inherent in self-reported recall.

In considering the total body of evidence, the GDG gave greater emphasis to evidence provided by reviews graded moderate and above, taken from reviews providing evidence from studies using measures of total sedentary or sitting time, or device-based measures of sedentary behaviour where available.

Full details of the methods, data extraction and evidence profiles can be found in the [Web Annex: Evidence profiles](#).

Research on the potential adverse health effects associated with sedentary behaviour has rapidly accumulated during the past decade. In more recent studies, notable developments include an increase in evidence reporting on dose-response relationships between sedentary behaviour and multiple health outcomes, and on the interplay between sedentary behaviour and physical activity.

In adults (aged over 18 years), what is the association between sedentary behaviour and health-related outcomes?

Overall, there is evidence of an association between greater time spent in sedentary behaviour (examined mostly via self-reporting or device-based assessments of sitting or television viewing time) and higher all-cause mortality, cardiovascular mortality, cardiovascular disease incidence and type-2 diabetes incidence (8, 35, 65, 87). For example, supporting evidence includes results from a recent large meta-analysis ($n=36\,383$; mean age 62.6 years; 72.8% women) of accelerometer assessed total sedentary time and **all-cause mortality** (65) and showed that increasing time spent in sedentary behaviour was significantly associated with all-cause mortality. Similar findings from a meta-analysis comprising more than 1 million participants (87) showed associations for total sedentary behaviour with **all-cause mortality**, and **cardiovascular disease mortality**, after adjustment for physical activity (87), although in this study the associations with **cancer mortality** were not statistically significant after adjustment for physical activity (87).

Another recent meta-analysis (8) reported significant associations between sedentary behaviour (assessed as sitting) and **cardiovascular disease and cancer mortality**, with results indicating a 9–32% (p for trend < 0.001) higher risk of cardiovascular disease mortality with higher levels of sedentary behaviour when measured as sitting time in the “inactive”, lowest quartile of physical activity (~ 5 min/day). The study reported that adults who were sedentary (sitting) for more than 8 hours per day had a higher risk of cardiovascular disease mortality, except for those who were “most active” (i.e. > 35.5 MET-hours/week, or ~ 60 – 75 mins/day), where the association was mitigated. Results on the associations between sedentary behaviours and **cancer mortality** were generally weaker, although a 6–21% higher dose-related risk was observed with longer sitting time (particularly > 8 hours/day), but only among those in the lowest quartile of physical activity (< 2.5 MET-hours/week) (8).

Evidence supports an association between sedentary behaviour (measured as total sitting time) and increased **incident cardiovascular disease** (HR= 1.29 [95% CI: 1.27 to 1.30]) which was attenuated following adjustment for potential covariates, including level of physical activity (HR= 1.14 [95% CI: 1.04 to 1.23]) (88). A review of studies in south-east Asian populations provided

evidence of low certainty that greater sedentary time was associated with an increased likelihood of unfavourable **cardiometa-bolic indicators** (including type-2 diabetes, higher BMI, higher blood pressure) (89).

Two recent reviews report on the association of total daily sitting time (88) and total sedentary behaviour and television viewing (87) with **type-2 diabetes incidence**. Both studies found a higher level of sedentary behaviour was associated with increased risk of type-2 diabetes incidence. For example, a linear association with type-2 diabetes was observed for total sedentary behaviour (RR= 1.01 [95% CI: 1.00 to 1.01] $p < 0.001$) and television viewing (RR= 1.09 [95% CI: 1.07 to 1.12] $p < 0.001$), when adjusted for physical activity (87).

There is also supporting evidence for a significant association between sedentary behaviour (when measured as time spent viewing television) and **cancer mortality** (35, 87). Several more recent reviews, of low and very low certainty, provide supporting evidence for an association between sedentary behaviours and colorectal cancer (90), but no associations with incident prostate, breast or rectal cancer (90–93). Additional evidence (35) reported significant associations between greater time spent in sedentary behaviour and higher risk of developing endometrial, colon and lung cancers (35).

There is low certainty evidence of an unfavourable relationship between time spent in sedentary behaviour and **adiposity** and other indicators of weight status, and whether the relationship between sedentary behaviour and weight status varies by amount of moderate- to vigorous-intensity physical activity. Overall, it was concluded that there was insufficient evidence to inform these recommendations/guidelines and that further research is needed.

There is limited evidence assessing adverse effects of reducing sedentary time. Expert opinion informed the conclusion that recommending the reduction in sedentary time would be unlikely to increase risk of injury, especially if replaced with light-intensity physical activity.