Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (13-17 years): An Integration of Physical Activity, Sedentary Behaviour, and Sleep

Acknowledgements

The University of Wollongong (UOW) gratefully acknowledges the contribution to and support of the following individuals and organisations in the development of these guidelines.

Commonwealth Department of Health

Anthony Okely, Timothy Olds, Rachel Jones, Dylan Cliff, Anne-Maree Parrish, Sarah Loughran, Lisa Kervin, Simon Eckermann, Rebecca Stanley, Trevor Shilton, Davina Ghersi, Mark Tremblay, Sandra Downie and Julie Sherring were members of the Guideline's Leadership Group that managed the guideline development process. The members of the Guideline Development Group are detailed in Annex 3.

Systematic reviews of evidence were led by Sarah Loughran (Adam Verrender), Dylan Cliff (Zhiguang Zhang), Anne-Maree Parrish (John Kar-Hau Chong) and Timothy Olds (Dorothea Dumuid and Hayley Lewthwaite). The reviewers were assisted by PhD students whose names are indicated in parentheses.

Yvonne Ellis helped with finalising this report and conducting parts of the stakeholder consultation.

Executive summary

In 2004, the Australian Government funded the development of the first national recommendations for physical activity for children and adolescents **(1)**. In 2012, these physical activity recommendations were updated with new Australian Guidelines **(2)** and, for the first time, separate Australian Sedentary Behaviour Guidelines for children and young people were developed **(3)**. More recently, there has been a move to develop guidelines that take into account, from a movement perspective, the entire day. Referred to as 24-hour integrated movement guidelines **(4),** they acknowledge that the whole day matters and individual movement behaviours such as physical activity, sedentary behaviour and sleep need to be considered in relation to each other when examining their associations with health and developmental outcomes in children. Furthermore, movement behaviours are co-dependent: if we change the amount of time spent doing one behaviour, such as sleep, we must reduce the amount of time we spend in the others (physical activity and sitting). In 2016, Canada was the first country to release integrated 24-hour movement guidelines for school-aged children and youth **(4)**. These guidelines reinforce the importance of considering the integration of movement behaviours with evidence showing that meeting all three movement behaviours guidelines was better than meeting any two, and meeting any combination of two guidelines was better than meeting just one in terms of associations with health indicators **(5-7)**.

In early 2018, the Australian Government provided funding to update the Australian Physical Activity Guidelines and Australian Sedentary Behaviour Guidelines for Children and Young People, to be an integration of movement behaviours across the 24-hour period, consistent with the Australian 24-hour Movement Guidelines for the Early Years **(8)**. The potential benefit for Australia was that it could leverage the considerable work done in Canada in the development of their 24-hour guidelines to complete what would normally be a much longer process, in considerably less time and requiring fewer resources. The GRADE-ADOLOPMENT approach allows guideline developers to follow a well-accepted and transparent process for developing guidelines (GRADE) in an efficient manner by adapting or adopting an existing evidence-based guideline. This could potentially prevent the need to undertake (or repeat) costly tasks such as conducting full systematic reviews **(9)**. At the same time, it allows local guideline developers to take into consideration factors that are specific to their local context.

Based on the Canadian Guideline Development Panel's use of the GRADE approach to develop the *Canadian 24-Hour Movement Guidelines for Children and Youth*, and the successful use of the GRADE-ADOLOPMENT approach to develop the Australian 24-hour Movement Guidelines for the Early Years, it was decided to use the GRADE-ADOLOPMENT approach in the development of the *Australian 24-Hour Movement Guidelines for Children and Young People*. The Guideline Development Report outlines the process and outcomes for the ADOLOPMENT of the *Canadian 24-Hour Movement Guidelines for Children and Youth* to develop the *Australian 24-Hour Movement Guidelines for Children and Young People*. This process started in April 2018 and was completed by the end of January 2019.

Recommendations for 24-hour physical activity, sedentary and sleep behaviours for children and young people in Australia

Preamble

These guidelines are relevant to all apparently healthy children and young people irrespective of gender, cultural or linguistic background, geographic location, or the socio-economic status of the family. Children and young people are encouraged to live an active lifestyle with a daily balance of physical activities, sedentary behaviours and sleep that supports their healthy development. These guidelines may be appropriate for children and young people with a disability or medical condition; however, a health professional should be consulted for additional guidance.

Children and young people should participate in a range of physical activities in a variety of environments (eg home/school/community; indoors/outdoors; land/water) and contexts (eg play; recreation; sport; active travel; hobbies; jobs). Limited time should be spent sitting. For recreational sedentary screen time, establish consistent boundaries (eg duration; content; quality). When using screen-based electronic media, positive social interaction and experiences are encouraged. Children and young people should establish and maintain healthy sleep patterns; this includes having a consistent bed time routine, avoiding screen time before sleep, and keeping screens out of the bedroom.

Following these guidelines is associated with better body composition, cardiorespiratory and musculoskeletal fitness, cardiovascular and metabolic health, academic achievement and cognition, mental health and quality of life, emotional regulation, and pro-social behaviours. Adhering to these guidelines may be challenging at times, however, the benefits of following them far exceed potential harms. For those not currently meeting these 24-hour movement guidelines, a progressive adjustment toward them is recommended.

These guidelines were informed by the best available evidence, expert consensus, stakeholder consultation, and consideration of values and preferences, applicability, feasibility, resource use (cost) and equity. More details on the guidelines, including the background research, and their interpretation and guidance on how to achieve them, are available at http://www.health.gov.au.

Guidelines

For optimal health benefits, children and young people (aged 5–17 years) should achieve the recommended balance of high levels of physical activity, low levels of sedentary behaviour, and sufficient sleep each day. A healthy 24 hours includes:

- Accumulating 60 minutes or more of moderate to vigorous physical activity per day involving mainly aerobic activities.
- Several hours of a variety of light physical activities;
- Limiting sedentary recreational screen time to no more than 2 hours per day;
- Breaking up long periods of sitting as often as possible;
- An uninterrupted 9 to 11 hours of sleep per night for those aged 5–13 years and 8 to 10 hours per night for those aged 14–17 years; and
- Consistent bed and wake-up times.

Activities that are vigorous, as well as those that strengthen muscle and bone should be incorporated at least 3 days per week.
For greater health benefits, replace sedentary time with additional moderate to vigorous physical activity, while preserving sufficient sleep.

Contents

Background and Rationale

The current Australian Physical Activity and Sedentary Behaviour Guidelines for children (5-12 years) and young people (13-17 years) were released by the Australian Government in 2012. Australia was one of the first countries to update their guidelines (the ones prior to this were released in 2004) and to include national guidelines for sedentary behaviour (2, 3). Importantly, a consortia of researchers in Canada, the United States, New Zealand and United Kingdom have worked together over the past 10 years to ensure, as much as possible, harmonization with guidelines in these age groups across jurisdictions.

Since 2010, there have been many societal changes, especially in the area of hand-held technologies. iPads and other tablets became available in 2010 and Smart phone apps and games have increased dramatically in the past five years. The attraction of interactive gaming across social platforms has successfully targeted children and adolescents. Not surprisingly, the American Academy of Pediatrics reported that "It is common for adolescents today to engage in more than one form of media at the same time, a practice referred to as media multitasking." This multitasking may include watching TV and using a computer or being online and engaging in more than one activity at a time.

Our current recommendations do not adequately cater for these changes. As such, they are frequently criticized professionally and portrayed in the media as being "outdated" and unrealistic. Without supporting evidence, it is challenging to refute these criticisms.

More recently, there has been a move to develop guidelines that take into account, from a movement perspective, the entire day. Referred to as 24-hour integrated movement guidelines they acknowledge that the whole day matters and individual movement behaviours such as physical activity, sedentary behaviour and sleep need to be considered in relation to each other when examining their associations with health and developmental outcomes in children. In 2016, Canada was the first country to release integrated 24-hour movement guidelines for school-aged children and young people. These guidelines reinforced the importance of considering the integration of movement behaviours with evidence showing a monotonic relationship between the number of movement behaviour guidelines met by an individual and associated health indicator. That is, meeting all three guidelines was better than meeting any two, and meeting any combination of two guidelines was better than meeting just one. These guidelines have been very well received in Canada.

It has been reported that over the past several decades, physical activity has decreased (10, 11) sedentary behaviours have increased (10) and sleep deprivation has become common among children and youth (12). At the same time, overweight/obesity and their associated co-morbidities have steadily increased (13, 14). These "lifestyle behaviours" tend to track through- out the life course (15), meaning that habits and practices established in childhood are likely to continue throughout adulthood; establishing healthy active lifestyles early on in life is of critical importance for promoting and maintaining holistic health and well-being.

Improving the physical activity, sedentary and sleep time behaviours of children and young people will contribute to their physical health, reduce the risk of developing obesity and the associated non-communicable diseases (NCDs) in later life and improve mental health and wellbeing. Recent evidence suggests that obesity, in turn, reduces physical activity, creating a vicious cycle of increasing body fat levels and declining physical activity.

The important interactions between physical activity, sedentary behaviour/screen time and adequate sleep time on physical and mental health and wellbeing were recognized by the World Health Organization's

Commission on Ending Childhood Obesity, that called for clear guidance on these three aspects of movement for children and young people in Recommendation 2.1(16).

This report outlines the steps that were taken to develop the "Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (13-17 years): *An Integration of Physical Activity, Sedentary Behaviour, and Sleep*". These guidelines have been requested by the Commonwealth Department of Health of Australia, and informed by a rigorous scientific process, and are based on four comprehensive systematic reviews of the evidence together with quantitative and qualitative data compiled through online surveys, focus groups and key stakeholder interviews.

Scope and purpose of guideline

The overall goals of this guideline are to provide recommendations on the amount of time children and young people (aged 5-17 years) should spend being physically active, sitting, or sleeping for their health and wellbeing, and the maximum recommended time these children and young people should spend in screen-based sedentary activities.

Scope of guideline and PICO questions

The Leadership group reviewed the existing international physical activity guidelines for Children and young people. This is detailed in Annex 6. Each of the guidelines was reviewed to determine if it met the following list of criteria:

- Followed the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) process
- Addresses clear questions (can identify Population, Intervention, Comparator, and Outcome (PICO) elements)
- Has benefits and harms assessments
- Assessed using Appraisal of Guidelines for Research & Evaluation (AGREE)
- Allows for updating
- Has existing and accessible evidence tables/summaries
- Has risk of bias assessment
- Were integrated (24hr)
- Costs associated with implementing guideline
- Accompanying – how they are going to implement – disseminate the guidelines

The leadership group agreed that it was clearly evident that the Canadian guidelines met the selection criteria above all other guidelines reviewed. Therefore, the PICOs used in the Canadian guidelines were also reviewed and the group agreed on some minor amendments that were relevant to the Australian context. The group then determined to undertake an update of the systematic reviews already undertaken in the development of the Canadian guidelines.

Systematic reviews

The systematic reviews conducted up to December 2014/January 2015 for the Canadian 24-hour integrated movement guidelines for children and youth were led by Drs Valerie Carson (17), Veronica Poitras (18), Jean-Philippe Chaput (19) and Travis Saunders (20) under the overall leadership of Dr Mark Tremblay. These systematic reviews were registered with the International Prospective Register of Ongoing Systematic Reviews and used the GRADE framework to determine the quality of evidence. Dr Anthony Okely oversaw the updating of these systematic reviews for the Australian guidelines through to July 2018. This resulted in the addition of 42 studies on physical activity, 32 on sedentary behaviour, 74 on sleep and 20 on integrated behaviours (21).

Physical activity

For optimal health benefits, children and young people (aged 5–17 years) should achieve the recommended balance of high levels of physical activity, low levels of sedentary behaviour, and sufficient sleep each day. A healthy 24 hours includes:

- **Accumulating 60 minutes or more of moderate to vigorous physical activity per day involving mainly aerobic activities; ***
- **Several hours of a variety of light physical activities; ***
- Limiting sedentary recreational screen time to no more than 2 hours per day;
- Breaking up long periods of sitting as often as possible;
- An uninterrupted 9 to 11 hours of sleep per night for those aged 5–13 years and 8 to 10 hours per night for those aged 14–17 years; and
- Consistent bed and wake-up times.

Activities that are vigorous, as well as those that strengthen muscle and bone should be incorporated at least 3 days per week. *
For greater health benefits, replace sedentary time with additional moderate to vigorous physical activity, while preserving sufficient sleep. *

* *Bold text refers to the focus on physical activity*

Question

In children 5-17 years of age what dose (i.e., volumes, durations, frequencies, patterns, types, and intensities) of physical activity, as measured by objective and subjective methods, is associated with favourable health indicators?

Summary of evidence

The 2015 Canadian systematic review of the relationship between physical activity and health indicators in children and young people assessed 499 full text articles and identified 205 studies that met the inclusion criteria (22). Forty-two additional studies were incorporated up to July 2018 for the update to inform the Australian guidelines process. The GRADE table for physical activity is available in Annex 1.

Physical activity was associated with fitness, adiposity and cardiometabolic health and skeletal health in observational studies. Moderate-to-vigorous, vigorous- and total physical activity were consistently associated with several health indicators and although it was not possible to determine the most favourable frequency or duration of physical activity, more physical activity appeared to be better.

Overall, there is no evidence that contradicts the existing guidelines, however new evidence suggests light-intensity physical activity (LPA) needs further investigation.

Some other summary points include:

- ~50% of LPA relationships were negative for Adiposity.
- LPA was unrelated to Fitness.

- There was a positive, null or mixed (+/null) evidence for LPA and cardiometabolic health
- There may be a negative relationship between physical activity and spinal injuries however more evidence is needed.
- There is a growing body of evidence on Cognitive Development/Academic Achievement or Behavioural Conduct/Prosocial Behaviour.
- Physical activity may have a positive effect on "on-task behaviour in the classroom" however more evidence is needed.

Additional considerations

The recommendation for 60 minutes per day of physical activity was recommended in the Australian Guidelines in 2012, based on expert consensus and included in the United Kingdom and the Canadian Guidelines in 2012. There is no evidence to refute this recommendation. The current evidence is available from studies that assessed compliance with this 60-minutes per day duration of physical activity vs non-compliance and the former shows an association with better health outcomes.

Quality of the evidence

For the critical outcomes, there was low to moderate quality evidence for adiposity, fitness and cognitive/academic and low-quality evidence for cardiometabolic biomarkers, behavioural conduct/pro social behaviour, and harms and injuries. The overall quality of evidence was rated as very low.

Values and Preferences

There was low variability in parents' and stakeholders' preference for similar recommendations in the Australian stakeholder survey and focus groups on the integrated 24-hour movement guidelines for children and young people.

Benefits vs Harms

For children and young people, the benefits of increased levels of physical activity include improved motor and cognitive development, and fitness. Most studies showed a favourable or inconclusive association with adiposity, and very few studies showed an unfavourable association.

There is no evidence that physical activity is associated with serious risk of harms or injury in any age group.

The Guideline Development Group concluded that desirable outcomes of promoting physical activity outweigh possible harms.

Resource implications of implementation of recommendation

The systematic reviews informing these Guidelines did not locate any evidence on the cost or cost-effectiveness of implementation in this age group. Seventy-eight percent of respondents to the Australian stakeholder survey on the integrated 24-hour movement guidelines for children and young people believed the benefits outweighed the costs and 63% felt the cost to use or implement the guidelines would be minimal (19, 21, 23, 24).

While the Guideline Development Group acknowledged that in some settings there may be additional resource requirements to ensure children and young people meet physical activity recommendations, the panel considered resource implications to be minimal. As such, the Guideline Development Group concluded that the potential benefits of promoting physical activity outweigh the costs.

Equity

The Australian stakeholder survey with all socio-economic groups showed that adhering to the integrated 24-hour movement guidelines for children and young people is likely to benefit all groups equally and recommendations could be achieved equitably. The Guideline Development Group judged that promoting more physical activity in the longer-term would probably increase health equity by improving health outcomes.

Acceptability

There was strong support for the Guidelines as evidence in the online survey and focus groups.

Feasibility

Physical activity can be increased in various ways requiring minimal facilities or equipment, but safe environments should be ensured. Tailored communication and/or resources may be required for certain settings (such as low resource settings) and special populations (children with disabilities).

Sedentary time

For optimal health benefits, children and young people (aged 5–17 years) should achieve the recommended balance of high levels of physical activity, low levels of sedentary behaviour, and sufficient sleep each day. A healthy 24 hours includes:

- Accumulating 60 minutes or more of moderate to vigorous physical activity per day involving mainly aerobic activities;
- Several hours of a variety of light physical activities;
- Limiting sedentary recreational screen time to no more than 2 hours per day; *
- Breaking up long periods of sitting as often as possible; *
- An uninterrupted 9 to 11 hours of sleep per night for those aged 5–13 years and 8 to 10 hours per night for those aged 14–17 years; and
- Consistent bed and wake-up times.

Activities that are vigorous, as well as those that strengthen muscle and bone should be incorporated at least 3 days per week.

For greater health benefits, replace sedentary time with additional moderate to vigorous physical activity, while preserving sufficient sleep. *

* *Bold text refers to the focus on sedentary time*

Question

In children 5-17 years of age what dose [i.e., durations, patterns (frequency, interruptions), and type] of sedentary behaviour, as measured by objective and subjective methods, is associated with favourable health indicators?

Summary of evidence

The 2015 Canadian systematic review of the relationship between sedentary behaviour and health indicators in children and young people assessed 923 full text articles and identified 235 studies that met the inclusion criteria (25). Thirty-two additional studies were incorporated up to July 2018 for the update to inform the Australian guidelines process.

In the update, the Australian leadership group included studies with psychological distress outcomes. This required a search of the database before 2015 as per the Canadian study as well as the updated which resulted in the inclusion of two studies.

The GRADE table for sedentary behaviour is available in Annex 1, section 1.2.

In summary, it was evident that the associations between sedentary behaviour and health indicators were not consistent across types of sedentary behaviour for any indicator.

Screen time was consistently associated with the most health indicators and evidence continues to support the current ≤2 hr/day recommendation for optimal health.
Total sedentary time (objectively measured sitting) was not consistently associated with any health indicator. The findings from this review do *not* provide sufficient evidence on the minimal amount of total daily sedentary time for optimal health to inform the integrated guidelines.

Additional considerations

Similar to previous Australian guidelines on sedentary behaviour for this age group, these new guidelines have been derived from expert consensus (26). There is no evidence to refute this recommendation. Current evidence is available from studies that assessed compliance with this recommendation vs non-compliance and the former shows an association with better health outcomes.

The Guideline Development Group recognised that time spent in sedentary behaviour may include pursuits such as reading drawing, crafting, music etc. and that these activities have cognitive benefits.

Quality of the evidence

For the critical outcomes, there was moderate to very low-quality evidence for screen time and adiposity, motor and cognitive development and psychosocial health and very low-quality evidence for total sedentary time and adiposity, motor development and psychosocial health. The overall quality of evidence was rated as very low.

Values and Preferences

There was low variability in parents' and stakeholders' preference for similar recommendations in the Australian stakeholder survey and focus groups on the integrated 24-hour movement guidelines for children and young people.

Benefits vs Harms

The benefits of less screen-based sedentary behaviour (TV viewing, watching videos, playing computer games) include reduced adiposity, improved motor and cognitive development and psychosocial health.

The benefit of more time spent reading include higher academic achievement and lower blood pressure (BP). There was no evidence of risks of harms associated with reducing screen-based sedentary time and time spent in restrained sitting.

The Guideline Development Group concluded that desirable outcomes of reducing sedentary screen time outweigh possible harms.

Resource implications of implementation of recommendation

The systematic reviews informing these Guidelines did not locate any evidence on the cost or cost-effectiveness of implementation in this age group. Seventy-eight percent of respondents to the Australian stakeholder surveys on the integrated 24-hour movement guidelines for children and young people believed benefits outweigh costs and 63% felt the cost to use or implement the guidelines would be minimal (19, 21, 23, 24).

Equity

The Australian stakeholder survey with all socio-economic groups showed that adhering to the integrated 24-hour movement guidelines for children and young people is likely to benefit all groups equally and recommendations could be achieved equitably. The Guideline Development Group judged that limiting sedentary recreational screen time in the longer-term would probably increase health equity by improving health outcomes.

Acceptability

There was strong support for the Guidelines as evidenced in the online survey and focus groups.

Feasibility

Implementing these recommendations requires minimal resources. Some stakeholders in the focus groups expressed concerns that meeting the integrated 24-hour movement guidelines on screen-based sedentary time may be challenging.

Sleep time

For optimal health benefits, children and young people (aged 5–17 years) should achieve the recommended balance of high levels of physical activity, low levels of sedentary behaviour, and sufficient sleep each day. A healthy 24 hours includes:

- Accumulating 60 minutes or more of moderate to vigorous physical activity per day involving mainly aerobic activities;
- Several hours of a variety of light physical activities;
- Limiting sedentary recreational screen time to no more than 2 hours per day;
- Breaking up long periods of sitting as often as possible;
- An uninterrupted 9 to 11 hours of sleep per night for those aged 5–13 years and 8 to 10 hours per night for those aged 14–17 years; and *
- Consistent bed and wake-up times. *

Activities that are vigorous, as well as those that strengthen muscle and bone should be incorporated at least 3 days per week. *

For greater health benefits, replace sedentary time with additional moderate to vigorous physical activity, while preserving sufficient sleep. *

* *Bold text refers to the focus on sleep time*

Question

In children and young people aged 5 -17 years of age what duration of sleep, as measured by objective and subjective methods, is associated with favourable health indicators?

Summary of evidence

The 2016 Canadian systematic review of the relationship between sleep duration and health indicators in children and young people (19, 27) assessed 318 full text articles and identified 141 studies that met the inclusion criteria. Seventy-four (74) additional studies were incorporated up to July 2018 for the update to inform the Australian guidelines process. The GRADE table for sleep duration is available in Annex 1, section 1.3.

Shorter sleep duration was associated with higher adiposity, poorer emotional regulation and poor quality of life/well-being. There were no clear associations between sleep duration and harms/injuries and cardiometabolic biomarkers.

Additional considerations

Previous sleep duration recommendations have been derived from expert consensus (19, 28, 29). There is no evidence to refute the existing recommendations. Current evidence is available from studies that assessed compliance with sleep duration recommendations vs. non-compliance and the former shows an association with better health outcomes.

Quality of the evidence

For the critical outcomes, there was high quality evidence for adiposity, cognitive development and emotional regulation, low quality evidence for quality of life/well-being and very low-quality evidence for harms/injuries and cardiometabolic biomarkers.

Values and Preferences

There was low variability in parents' and stakeholders' preference for similar recommendations in the Australian stakeholder survey and focus groups on the integrated 24-hour movement guidelines for children and young people.

Benefits vs Harms

Shorter sleep duration is adversely associated with adiposity, emotional regulation, growth, cognitive development. Shorter sleep duration is associated with more TV viewing and time spent playing computer games and with an increased risk of injury.

The Guideline Development Group concluded that desirable outcomes of promoting adequate sleep and preventing shorter sleep duration outweigh possible harms (including family inconvenience or burden).

Resource implications of implementation of recommendation

The systematic reviews informing these Guidelines did not locate any evidence on the cost or cost-effectiveness of implementation in this age group. Seventy-eight percent of respondents to the Australian stakeholder surveys on the integrated 24-hour movement guidelines for children and young people believed benefits outweigh costs and 63% felt the cost to use or implement the guidelines would be minimal (19, 21, 23, 24).

The Guideline Development Group noted that there may be some resource implications to meet the recommendations for adequate sleep in homes with limited space and where behaviours and routines of the children and their parents are not conducive to sufficient sleep and regular sleep and wake times. However, in the view of the Guideline Development Group the potential benefits of ensuring adequate sleep outweigh the costs.

Equity

The Australian stakeholder surveys with all socio-economic groups showed that adhering to the integrated 24-hour movement guidelines for children and young people is likely to benefit all groups equally and recommendations could be achieved equitably (21, 24). The Guideline Development Group judged that the promoting appropriate sleep durations would probably increase health equity by improving health outcomes.

Acceptability

There was strong support for the Guidelines as evidence in the online survey and focus groups.

Feasibility

The Guideline Development Group noted that in some settings, implementing these recommendations is feasible. However, in other settings implementing these recommendations may require changes to the behaviours and routines of the children and young people, their parents and caregivers, and physical environment in the places where children sleep.

Integrated recommendations

For optimal health benefits, children and young people (aged 5–17 years) should achieve the recommended balance of high levels of physical activity, low levels of sedentary behaviour, and sufficient sleep each day. A healthy 24 hours includes:

- Accumulating 60 minutes or more of moderate to vigorous physical activity per day involving mainly aerobic activities;
- Several hours of a variety of light physical activities;
- Limiting sedentary recreational screen time to no more than 2 hours per day;
- Breaking up long periods of sitting as often as possible;
- An uninterrupted 9 to 11 hours of sleep per night for those aged 5–13 years and 8 to 10 hours per night for those aged 14–17 years; and
- Consistent bed and wake-up times.

Activities that are vigorous, as well as those that strengthen muscle and bone should be incorporated at least 3 days per week.
For greater health benefits, replace sedentary time with additional moderate to vigorous physical activity, while preserving sufficient sleep. *

** Bold text refers to the focus on integrated recommendations*

Question

In children 5-17 years of age what are the relationships between each of the following combinations of movement behaviours and health indicators?

- Sleep and Sedentary Behaviour
- Sleep and Physical Activity
- Sedentary Behaviour and Physical Activity
- Sleep and Sedentary Behaviour and Physical Activity

Summary of evidence

The 2015 Canadian systematic review of the relationship between combinations of movement behaviours and health indicators in children and young people (20) assessed 71 full text articles and identified 14 studies that met the inclusion criteria. In the Australian update, 20 articles were included in the combined review. The GRADE table for combined movement behaviours is available in Annex 1, section 1.4.

In general, more MVPA, at the expense of sedentary time and LPA (and less so, sleep) is favourable. There is some indication that sleep may be important for better behavioural (and some cardiometabolic) outcomes however longitudinal 24-hr studies considering a wider variety of health outcomes are needed.

It was evident that the relationships between increasing/decreasing an activity and health are not necessarily symmetrical. For example, increasing MVPA by 30 minutes is associated with a smaller magnitude of difference in outcome than decreasing MVPA by 30 minutes.

In the view of the Guideline Development Group, although in some settings there may be additional resource requirements to ensure children and young people meet all recommendations, the potential benefits of meeting all the recommendations outweigh the costs.

Equity

The Australian stakeholder survey with all socio-economic groups showed that adhering to the integrated 24-hour movement guidelines for children and young people is likely to benefit all groups equally and recommendations could be achieved equitably. The Guideline Development Group judged that promoting the replacement of sedentary time with additional moderate to vigorous physical activity, while preserving sufficient sleep, in the longer-term would probably increase health equity by improving health outcomes.

Acceptability

There was strong support for the Guidelines as evidence in the online survey and focus groups.

Feasibility

The Guideline Development Group determined that the integration of the movement behaviours may enhance the feasibility of implementation of individual movement and sleep recommendations by providing parents and caregivers with opportunities to gradually replace undesirable behaviours with more desirable behaviours and recognising the importance of quality interaction with caregivers and preserving sufficient sleep

Research gaps

The Guideline Development Group identified a number of research gaps in the development of these Guidelines. These include the need for more high-quality studies, with a particular focus on studies that:

1. examine the entire 24-hour day and physical activity, sedentary behaviour and sleep duration in children and young people;
2. establish standardised procedures and objective measurement to enable comparison between studies;
3. study a broader range of health indicators, including additional indicators of motor, cognitive and psychosocial development and the long-term effects of early interventions;
4. examine contemporary screen time (e.g., social media, etc) and types of screen time (Entertainment vs Communication vs Education);
5. use direct objective measures of sitting (i.e., thigh-mounted activity monitors) and sleeping;
6. examine the use of screen time measures with established psychometrics;
7. provide a cost-effectiveness analysis of interventions to improve physical activity, sedentary behaviours and sleep duration in children and young people;
8. examine the impact of sedentary screen-based activities compared with interactive sedentary screen-based activities on health indicators;
9. examine the relationship between sleep duration and motor development, growth and harms or injuries;
10. consider confounders such as diet;
11. use narrower age groups that align with the current sleep duration recommendations;
12. examine sleep quality, sleep efficiency, sleep timing (bed/wake times, napping), sleep architecture, sleep consistency, and sleep consolidation using longitudinal and intervention studies (24-hr);
13. examine the best mix of activities for individual health outcomes;
14. examine the best mix of activities for overall health and well-being in "at-risk" populations (overweight/obese); and
15. examine the key factors that enable dissemination, adaptation, activation, implementation and uptake of the guidelines.

Dissemination, implementation and evaluation

The goal of these Guidelines is to provide policymakers and the public with recommendations on how much time children and young people should spend each day being physically active and sleeping, and provide recommendations on maximum time children and young people should spend in sedentary recreational screen activities or in restrained sitting. Dissemination of these Guidelines in a manner that is accessible, understandable, and encourages behaviour changes without making end-users feel guilty and does not imply that additional equipment or facilities are necessary, will be vitally important for the public. Children and young people, and those who work with and care for them seek advice from a number of different professionals and dissemination of the guidelines to all those who have contact with these stakeholders will be essential.

Communication, Dissemination, Implementation and Integration Planning

During the Guideline development process, the Guideline Development Group participated in a workshop where they were able to collaboratively brainstorm and discuss strategies for the communication, dissemination, implementation and integration of the Guidelines.

The group was presented with the following indicative communication objectives:

- Raise awareness of the new Australian 24-hour movement Guidelines (physical activity, sedentary behaviour and sleep) (clear messaging, media, web, communications)
- Establish these as the trusted set of guidelines for 24-hr movement behaviours for Australian children and young people
- Engage stakeholders across sectors to support promotion and implementation of the Guidelines
- Engage Parents to understand and implement the Guidelines
- Develop and disseminate tools for stakeholders that are easily accessible, targeted and clear

Workshop Methodology

The workshop was held in a 'world-café' style, where nominated facilitators stayed with one table while participants rotated to three groups/tasks. On each rotation the table facilitator summarised the views of the preceding group and asked participants to add value to these or suggest additional points. The summaries that follow are the collective views of all participants/groups.

Workshop questions:

A brainstorm of communication, dissemination and implementation (integration) activities across the following domains:

- **Group 1:** Media and complimentary guideline implementation packages/kits
- **Group 2:** Training – using kits/guides
- **Group 3:** Programs - Scale-up of proven programs

Summary of results:

Group 1: Media and complementary guideline implementation packages/kits

Media

- It was agreed that a **visual identity and brand** was important for any campaign to build awareness and create momentum for change and a call to action
    - A visual logo and name
    - Consider an animated creature mascot for younger children
    - Differing views on the Canadian '4' brand. Some liked it, some found it confusing and too reliant on awareness of the messages. Any brand needs to be tested with an Australian audience.
    - Some difference of view on the Canadian 'Build your best day' concept. Should review in light of Canadian evaluation. The website doesn't appear to have hit the mark.
    - More common view that we test and develop our own Australian brand to reflect the guidelines
- Complementary mass media is important across appropriate channels:
    - *Apply evidence* to ensure media is delivered with suitable dose and frequency to achieve results
    - *Mass media* channels remain important – TV, radio, outdoor, online, digital etc Complemented by *social media* platforms people want to communicate with e.g. Facebook, Instagram and other forms of social media.
    - *Messaging/creative*
        - Ensure delivery elicits an emotional response from the consumer (mix of emotion, personal stories, information)
        - Messaging should aim to contribute to culture change

        - Ensure targeting to low SES groups, cultural considerations
    - *Posters, prompts and environmental cues* in key settings and locations, using outdoor media
    - Important to *add value* and relate to other campaigns e.g. Move It Aus, Girls make Your Move.
    - *Target older teenagers with appropriate well-researched messages that tap into their motivations*
        - Test messages to focus on friends, fun, appearance and other motivations
        - Targeted through social media and devices, interrupting social media, flashed on their device. Healthy pop ups
- Annual 'Active Kids Day'. Consider an annual 'Active Kids Day', linked to campaign branding to kickstart activity and mobilise communities
- Online *video and infographic materials* important to simplify the guidelines, clock style, 24 hours.
- Potential for use of Ambassadors and role models to deliver messages from settings/sectors that resonate with young people. To inspire participation by young people, children and parents (through media, social media, use of video, sponsorships).
- Creation of an electronic direct mail
    - avenue for interested parents
    - engaged professionals
    - communicating through schools to parents (for much bigger reach) e.g. how much PA is your child getting at school, travelling to and from school.
- Attempt to win support of established media outlets and programs/ programming for
    - Product placement in popular TV radio shows
    - TV shows kids watch e.g. *Home and Away*
    - Built into children's TV viewing
    - School TV program. Interview experts. ABC for Kids news. BTN
    - Netflix series
- Messages to parents
    - Printed and web-based materials
    - Some liked the current brochures and posters for the previous Australian guidelines
    - Posters and prompts in key settings and locations, using outdoor media
    - Cheap and easy to do
    - Add in examples on "how to" looking at the branding from Canada
    - Graphics – active green (good) Sedentary red (bad)
    - Podcasts eg ABC kids, Mamamia (inexpensive)
- Culturally appropriate activities are important to consider, giving people examples that they can identify with of how to achieve guidelines

Complimentary packages

- Targeted kits for different settings (schools, child care, after school care, local governments, transportation, parents, health care, sport and recreation)
- Provide kits for schools to
    - Engage with media e.g. media releases, including releases for schools to use, stakeholder kit, school, council kits
    - Support walking and cycling to school programs
    - Link to academic achievement 3 stickers

- Universities: Integrating into tertiary packages for training teachers
    - Current teachers and also next generation post-graduate teachers and principals. Providing updates from sectors that are visible to them.
- Target relevant conferences putting up/sponsoring a keynote speaker re the guidelines (e.g. Principals, PE teaches etc)
- A dedicated website with
    - Embedded videos
    - Downloadable tools
- After school care – reward for meeting standard. Link to educational setting
- Consider monitoring and assessment of PA/ PE add into NAPLAN
- Consider the built environment
    - A package for child-friendly environments
    - Build on package to the Heart Foundation's Healthy Active by design
        - why do we need active spaces? Healthy school design, healthy facility design, public open spaces, nature, walking and cycling infrastructure to schools and destinations, public transport.
- Parent kits for reducing child screen use
    - Give the screen a rest, Unplug and Play, Active play is best example fact sheet
- School and parent body kits for promoting walking and cycling to school.
- Health professionals targeting
    - 715 child health check (GP)
    - Side note: at 4 year old kindergarten health check include question on screen time and physical activity and provide guidelines at this check
- Train GPs about messaging re the 24 hour Period (moderate to vigorous PA, adequate sleep, and reduced screen time and sedentary behaviour).
- Recruit peak health bodies i.e. Heart Foundation and AMA as allies, advocates and potential partners for the campaign

Group 2: Training – using kits/guides

- Parent kits:
    - Checklist video clip
    - Targeted media/ social media
    - Parent education through sporting associations
    - Parent education through school Parent and Citizen groups/ part and Friends
    - – what to do at each time period – 4 stickers
- Health care professionals
    - Training continuing education for practicing health professionals tapping into CME point systems
        - Medical e.g., RACGP, AMA, AMSs
    - Health professionals
        - Allied health, public health, health promotion
    - integrated into University curricula
- Sport and recreation

    - Via peak sporting bodies, via sport development officers, Departments of Sport and Recreation, local governments
- Planning and local government
    - Promoting green space concept
    - Via health promotion officers, planners, environmental health officers
    - Urban planning training
    - Transport office training
    - Small grant/funding to improve environment in prompting guidelines recommendations
- Teachers and school administrators
    - Out of school hours care
        - Before and After school activity program training
    - Professional development for teachers of physical education and health
        - Online modes
        - Face to face modes
        - Via conferences such as ACHPER
    - Training for generalist primary teachers
        - Increase self-efficacy and competence among general class teachers
        - Online an face-to face modes
    - Tied funding for school to improve environment
    - Policy (restrict wifi access, mobile phone access in classroom)

Group 3: Programs - Scale-up of proven programs

- Walking and cycling to school
    - Ride and walk to school programs
    - Scale up proven programs e.g. Make Tracks 2 school, Your Move
    - Walk and cycle hot spots
    - Build on work of the Australian Health Policy Collaborative
- Sporting schools
    - Address/broaden eligibility criteria
- Whole of School physical activity programs:
    - Active classroom (additional support for teachers)
    - Incorporate across the curriculum e.g art, English, science, (make a debating topic), technology related class, screen use, Maths s (look at 24 hour fraction, graphing)
    - Monitoring and benchmarking schools around physical activity/ physical education/ walking and cycling targets
    - Training of specialists and generalist (see above) – in accord with standards
    - National policy on:
        - minimum school PE minutes per week for every child
        - minimum PA per lesson
- Local Governments
    - Scale up programs – via local government associations
- Fiscal /financial measures
    - Support increase in tax on sugary drinks
        - Revenue used to support this campaign and related infrastructure and programs

    - Tax incentives/tax cuts for activity participation, sport, active transport etc, especially for disadvantaged families /kids
    - Tax incentives for active transportation, bicycle purchases
- Environments
    - Facility funding schemes through local government (facilities to improve quality of programs)
    - Focus on public open spaces and nature for kids
    - Smart Park (use technology/gaming to increase physical activity)
    - Build on the Heart Foundation's National Healthy Active by Design program and website
        - Healthy school design, healthy facility design, public open spaces, nature, walking and cycling infrastructure to schools and destinations, public transport.
- Cross sector training programs (see above)
- Targeted programs through key Government Departments
- Every education and health department access to the guidelines incorporate e. g in internal media, training, video, magazines etc)
- Endorsement program by peak bodies e.g., ACECQA, AMA, NESA, Heart Foundation and various stakeholder groups
- Awards program for best practice initiatives targeting children and young people

Ensure consultation in relation to all of the above, especially with parents - awareness that while parents may support the guidelines, there might be outside factors making it difficult i.e., safety, cultural appropriateness of sporting clubs, negative feedback from the community.

Management of guideline development process

Guideline Leadership Group

The Leadership Group included experts in the areas of physical activity, obesity in children and young people, sleep, education, health economics. The members of the Guideline Leadership Group are available in Annex 2.

The Leadership Group drafted the scope of the guidelines, the PICOs from Canada, reviewed the declaration of interests, drafted, reviewed and finalised the guideline.

Guideline Development Group

The Guideline Development Group consisted of a broad group of relevant experts in the field and end users of, and persons affected by, the recommendations. The members of the Guideline Development Group are available in Annex 3.

The Guideline Development Group decided on the final PICO questions (slight variation from the Canadian PICOs), reviewed the existing systematic reviews and identified updates required. The group agreed on the process for decision-making on recommendations and the strength of the evidence to be applied.

Declarations of Affiliations and Interests

All Guideline Development Group members completed and submitted a form titled *Declaration of Affiliations and Interests Form and Checklist*. The Leadership Group reviewed and assessed the declarations of interest submitted by each member. This was completed prior to the Guideline Development Group meeting to ensure transparency, and provide an opportunity to determine whether an individual should remove themselves at a point in time where it was considered a conflict of interest.

Evidence to recommendations

In accordance with the GRADE process, the Guideline Development Group considered the proposed wording of the recommendations and the rating of its strength (strong or conditional) considering not just the nature and quality of evidence but an assessment of caregiver, children's and young people's values and preferences, the balance between benefits and harms and the impact of the recommendation on gender, social and health equity, as well as the acceptability, feasibility and resource implications. Decisions were reached by consensus.

Assessment of the quality of evidence

Using the GRADE framework, the Guideline Development Group examined the quality of primary research contributing to each outcome identified in the PICOs and assessed the overall quality taking consideration the risk bias, consistency, precision, directness of the evidence and publication bias across each outcome. GRADE tables detailing this information for each PICO are available in Annex 1.

Values and Preferences

In developing the Australian 24-Hour movement guidelines for children and young people, stakeholder surveys and focus group discussions were held with parents, teachers, children and those involved in implementing the guidelines. Informants of the focus group discussions included those from vulnerable communities. These sources of information were used to determine the values and preferences, in addition to expert knowledge from the Guideline Development Group on the situation in their settings.

Resource implications

The systematic reviews informing these Guidelines did not locate any evidence on the cost or cost-effectiveness of implementation in this age group. Seventy-eight percent of respondents to the Australian stakeholder surveys on the integrated 24-hour movement guidelines for children and young people believed benefits outweigh costs and 63% felt the cost to use or implement the guidelines would be minimal.

In the view of the Guideline Development Group, although in some settings there may be additional resource requirements to ensure children and young people meet all recommendations, the potential benefits of meeting all the recommendations outweigh the costs.

Acceptability and feasibility

Data from the Canadian 24-hour Movement Guidelines for Children and Youth and the Australian 24-hour Movement Guidelines for the Early Years stakeholder surveys and focus group discussions (21, 30-32), were considered by the Guideline Development Group when discussing feasibility and acceptability of the recommendations.

In addition, data from studies of children's and young people's current physical activity, sedentary and sleep behaviours informed Guideline Development Group discussion.

Evaluation

Discussions were held with Sport Australia and the Australian Bureau of Statistics with respect to incorporating questions recommended by the surveillance sub-committee of the Guideline Development Group for surveillance and monitoring of the Guidelines in national surveys. The Surveillance sub-committee was tasked with recommending questions that could be used for surveillance and monitoring of the Guidelines. This sub-committee met several times via teleconference and also met with Sport Australia and the Australian Bureau of Statistics as part of their work.

Updating

These guidelines will be updated after 10 years, unless further research in the area provides additional evidence to warrant an earlier update.

Timeline for the Project

See Figure 1.

Figure 1. Timeline and sequence of events involved in the development of the Australian 24-hr movement guidelines for children and young people: an integration of physical activity, sedentary behaviour, and sleep.

Stakeholder Consultation

Summary of the key stakeholder interviews and focus groups

Key stakeholders from the disability, community, transport, education (policy makers, school principals and school counsellors) and the after-school sectors were invited to participate in the interviews and focus groups. Recruitment involved convenience sampling techniques using personal contacts and contacts of the Guideline Discussion Group.

To date, 13 interviews have been conducted and three focus groups. Parents of children and young people aged 5-17 years, as well as children aged 9-16 have been involved in the interviews and focus groups. Key stakeholders have been recruited from five Australian states and territories (NSW, ACT, VIC, TAS, SA). The Table below highlights the diversity of the key stakeholders recruited.

Interview	State/Territory	
1	ACT	Culturally and Linguistically Diverse Sector Parent
2	NSW	Community sector Tennis and fitness coach
3	NSW	Disability sector Teacher and policy maker
4	ACT	Education sector Higher education and international education/curriculum policy maker
5	TAS	Education sector Principal of low SES school
6	VIC	Education sector School Counsellor – Girls Private Catholic School
7	NSW	Education sector School Counsellor – Co-ed Private School
8	VIC/TAS	Transport sector Active transport initiatives
9	SA	Education sector Policy maker
10	VIC	After-school sector After-school Director and teacher
11	NSW	Aboriginal young person
12	SA	Active Healthy Kids Australia Project Officer
13	NSW	Indigenous parent
Focus Group		
1	Various	5 children and young people aged 9-14 years
2	NSW	2 parents from low-SES area
3	NSW	4 children from Indigenous backgrounds aged 15-16 years

Each interview and focus group were guided by a pre-determined script. A summary of the data from the key stakeholders' interviews and focus groups is below.

Awareness Movement Guidelines

More than half of the key stakeholders were aware of the current Australian Physical Activity and Sedentary Behaviour Guidelines for children aged 5-17 years. Key stakeholders provided mixed responses with regards to children and young people currently meeting these Guidelines. Some suggested that children and young people were not meeting any of the current Guidelines while others suggested that children and young people were possibly meeting some of the Guidelines but not meeting others. Both adult and children key stakeholders suggested that technology played a significant role in children and young people's compliance with the Guidelines. For example, a principal from a school located in a low SES geographic area commented:

> *"With a massive onset of technology as well, which is a big worry... I think it's cutting out a lotta of physical activity … with particularly overweight children. Children are into their gaming and getting a … getting a lack of sleep."* [Education Sector, TAS]

The use of technology was supported by the children and young people key stakeholders with a number suggesting that significant periods of their time is spent watching YouTube and engaging in social media.

> *"YouTube plays a big factor…..* You would just YouTube for, like four hours, when we get home." [Children and Young People]

> *"I definitely go over two hours because I can't … I check my social media throughout the day at school and then I'm on it for … like stopping and starting quite a bit in the afternoon."* [Children and Young People]

Integrating Movement Guidelines

All key stakeholders unanimously agreed with the 'integrated' nature of the new 24-Hour Movement Guidelines. Key stakeholders suggested that integrating the Guidelines made the information more accessible. A number of key stakeholders commented that it made sense to have them integrated as the behaviours were so closely interrelated/interwoven and it was critically important to look at these behaviours in a holistic way. A key stakeholder from the education sector succinctly summarised this:

> *"I think they're so interwoven as measures of health for children and young people, so I think having them not just focusing on physical activity, or not just focusing on sleep or focusing on sedentary, to actually realise how interwoven and interdependent they are… so when you put them together they all hold the same degree of importance, and are highlighted as … of equally valuable input for the health of children."* [Education Sector, School Counsellor, NSW]

Presentation Movement Guidelines

On the whole all of the key stakeholders suggested that the new 24-Hour Movement Guidelines were clearly presented (i.e. three dot points) and were understandable, in general, for professional and policy makers "*but not for the children themselves*" [Education Sector, ACT]. Some key stakeholders suggested that they thought the prescription (i.e. the number of hours) of each behaviour was helpful.

A number of key stakeholders, including the children and young people key stakeholders, suggested that the wording of the physical activity Guidelines was confusing and needed to be modified. A number of key stakeholders made comments similar to the ones below:

> *"…in that first point they talk about something that you have to do every day, but then they talk about other things that you have to … that you should do on at least three days per week so you kind of think 'Oh what do I have to do…"* [Children and Young People]

> *"Does it mean 60 minutes of moderate to vigorous activity three times a week, or 60 minutes a day plus either activities…"* [Children and Young People]

> *"Maybe I don't. No I actually … I … I actually read that as 60 minutes at least three days per week. Yeah I … yeah right … yeah that's a bit … bit … yeah I'd rewrite that one. That's not … that's not clear. No."* [Education Sector, Principal, TAS]

> *"I had to read twice a couple of things so I … I suspect that might be an indication that maybe a little bit more work needs to be done on them. I'm thinking, 'In 24 hours, what do I have to do? I … in … in that 24-hour block, I've got to accumulate 60 minutes of physical activities, and I've gotta do three day … how the … what? Three days of what do I have to do in 24 hours?".* [Education Sector, SA]

> *"Make it a bit more basic for some people, yes get rid of some of the words that might be difficult for especially aboriginal people. To make it a bit more cultural appropriate."* [Indigenous parent, NSW]

The wording of the Guideline relating to sedentary behaviour also raised some questions. Stakeholders were not clear what was meant by long periods of time and how this would be operationalized by children and young people.

> "*Breaking up long periods of sitting as often as possible', well what's a long period? They would say 'Oh, maybe five … maybe you mean five hours. So maybe after five hours I have to have a break' and you go 'No no no no no'. Way before that'. And when they have a break they go, 'Oh well I got up and went to the toilet and had a break so now I can go another five hours'…. and how they interpret the same language is very very different."* [Education Sector, School Counsellor, NSW]

Some stakeholders suggested that additional information further highlighting the importance of sleep routines, quality of sleep as well as the relationship between the movement behaviours and broader health outcomes such as self-esteem, health and wellbeing would have been a valuable addition to the guidelines.

> *"It is understandable, I can understand it. Maybe in the guidelines have more of the proof of you know some statistics or knowledge of what other kids are doing. Not just what should be done, but what is happening."* [Indigenous parent, NSW]

Use of Movement Guidelines

Irrespective of sector, all stakeholders suggested that they would be able to use the new 24-Hour Movement Guidelines in the professional practice or in their home environment. However, a number of suggestions to maximize use by end users were provided by the stakeholders, for example, inclusion of "*examples of different types of physical activities*" [Education sector, NSW and VIC] or "*examples of how to limit screen*

time" [Children and Young People]. An explanation of some of the more complex words such as moderate-to vigorous-intensity physical activity was also suggested.

For optimal use within the Education Sector, key stakeholders suggested that the Guidelines should be embedded with the Australian Curriculum and the link between the 24-hour movement behaviours and educational outcomes and learning needed to be extremely clear. Key stakeholders were highly conscious and aware of the already overcrowded curriculum and the high workload of students. Thus, they suggested that teachers and principals were unlikely to incorporate or promote the Guidelines in their core business unless there was direct link to educational outcomes, as one stakeholder suggested:

> *"and one of those key settings is schools, and at the moment I don't think that the Guidelines necessarily speak to the core business of schools which is learning…"* [Education Sector, SA]

Additionally, some stakeholders suggested that the integrated nature (i.e. having all three behaviours together) of the Guidelines could potentially result in end users feeling overwhelmed and in turn disregarding the Guidelines. Stakeholders suggested perhaps the marketing and promotional material should take on a 'tiered approach', inclusive of a very simply version for children and young people to a more complex version for parents and professionals.

> "*I think that they should try and make it a little bit more so it's about … more teenage and younger children friendly in a way. Some pictures and images would be helpful."* [Children and Young People]

> *"Seems really formal, too much like yeah. Like a graphic way, design it or something. It feels very plain"* [Indigenous young person]

Dissemination approaches

The Stakeholders suggested a number of wide stream dissemination options for the new 24-Hour Movement Guidelines. Most stakeholders suggested the need for a multi-level approach that could be inclusive of: flyers and brochures in community centres, gyms and health professional environment (e.g. GP surgeries), promotion through external facilitated sport in schools (for example, Auskick and Hotshots), ministerial communications at both the Federal and State levels, social media campaigns, traditional media campaigns (inclusive of personal testimonies), websites, peak bodies for educators and principals, additional professional development for educators and inclusion in pre-service training.

The main dissemination avenue suggested was through parents and schools. Parents would have more influence in promoting these behaviours for younger children whilst schools could have a huge impact for young people (i.e. those aged 12-17 years). However as suggested previously, the direct link between the movement behaviours and children's educational outcomes and learning would need to be the main focus. Stakeholders suggested that if schools committed to promote the Guidelines and incorporate it into all areas of learning (including numeracy and literacy) then the evidence-base information supporting the relationship between these behaviours and educational outcomes would need to be clear. If the promotional materials were optimal, a number of avenues could be used in the school environment to promote the 24-Hour Movement Guidelines (e.g. newsletters, social media, health and physical education departments in schools, home room leaders/teachers, school counselors). One key stakeholder highlighted this point clearly:

"Totally it's something that we feed into when we do check-ins with kids, health checks, and I don't mean like actual health checks but when we sit and have counselling sessions and we're talking about their overall wellbeing, we look at all aspects of their health. It's really easy for us to integrate this information in there… we'll pass it onto the PE Department, they can integrate that stuff into their curriculum, application wise, certainly can do the education and promote it. We could even do … do things like put it in a school newsletter, start those sorts of conversations, yeah. So, there's lots that we can do to support it, obviously part of it relies on home stuff where we have a lot less input… messages could be delivered through lots of different departments – e.g. maths department/English department etc, Head of teaching and Learning." [Education Sector, School Counsellor, NSW]

Given the diverse target group of the new 24-Hour Movement Guidelines, an overall emphasis by all stakeholders was on the importance of tailored dissemination approaches, approaches that children of different ages could relate to and engage with. Irrespective of target age, the stakeholders suggested that consistent messaging between families, schools and other places/people of influence was critical.

Barriers

A number of barriers were highlighted by the key stakeholders that would need to be considered as promotional material were developed. The obvious social change around phones and screen time was a consistent barrier mentioned by many stakeholders. The time poor nature of parents, the over scheduled children and young people routines and cost and access to facilities were other barriers mentioned. As two stakeholders suggested it is difficult for parents to find time to adjust these behaviours for their children:

"So lots of working parents have working long hours, kids in After School Care, parents come home tired and exhausted, the thought of going for a walk or kicking the ball out the back with your kid for half an hour is … they're exhausted, it's not on their radar. So part of … while these Guidelines address what's important for children, I think one of the large obstacles to it is that we have a culture that worships working, and money and possessions, and so people put a lot of their time and energy into that, and things like technology and the things they used as babysitters and entertainment." [Education Sector, School Counsellor, NSW]

"They don't have time so they usually drop the kids off, either for their training or their competition time, pick them up, and it's very … it's very set, you don't see a lot of kids … you don't … it's very rare when you see kids getting there early, to practice or stay later but also…" [Community Sector, NSW]

"When you are in our Year, we have a lot of work out school to do at home. And then if you have a part-time job as well, it makes it harder" [Indigenous young person]

Another barrier mentioned was media and highlighting the potential risks associated with physical activity, thus compensating for this time in other behaviours such as screen time. Ongoing funding at State and Federal levels to support existing or new programs, such as *Ride to School* initiatives and *Premier's Be Active Challenge* was also highlighted as a barrier for further promotion of the new 24-Hour Movement Guidelines.

Stakeholders suggested that there would be an ongoing challenge of promoting all three movement behaviours. Physical activity and sedentary behaviours have been a key focus for a number of years, however sleep has not had the same attention. Thus, concerted effort would be needed to ensure that all behaviours are equally promoted in the dissemination of the new 24-Hour Movement Guidelines. All three behaviours are needed in a 24-hour period for a health and wellbeing.

A final comment from one stakeholder:

> *"…thank you to you and your team for doing it. You are great potential to make a lot of difference in children's lives, so it's wonderful to have this authoritative document to be able to talk about with people. It just adds a lot of weight to what we talk about and have talked about for years. So it's … I'm very grateful actually. So, pass that on to your team of people and everyone else doing the research. It makes a difference to lots of people on the ground like us doing stuff to actually be able to have a bit more weight with parents emphasising how important it is…* [Education Sector, NSW]

Online Survey Results

The online survey was conducted using the Survey Monkey tool. Members of the Guidelines development group received the link to the survey and using the snowball method, the link was emailed on to colleagues and others who work with children and young people.
The survey went live on 17/9/2018 and closed on 29/10/2018

A total of 237 people responded to the survey. As people progressed through the survey, the number of respondents who declined increased slightly however it must be noted that the number of responses to the qualitative questions was high.

The Title is clearly stated.

Total n	Strongly Agree	Somewhat Agree	Combined Agreement	Neither Agree Nor Disagree	Somewhat Disagree	Strongly Disagree
237	124 (52.3)	74 (31.2)	198 (83.5)	7 (3.0)	28 (11.8)	4 (1.7)

Do you agree with the Title?

Total n	Strongly Agree	Somewhat Agree	Combined Agreement	Neither Agree Nor Disagree	Somewhat Disagree	Strongly Disagree
235	90 (38.3)	93 (39.6)	183 (77.9)	22 (9.4)	26 (11.1)	4 (1.7)

It was evident that there was strong agreement that the title is clearly stated (77.9% of respondents) and supported. Likewise, the Preamble was considered clear (95.7), 93.8% respondents agree with the Preamble and 84.8% would use the preamble.

The Preamble is clearly stated.

Total n	Strongly Agree	Somewhat Agree	Combined Agreement	Neither Agree Nor Disagree	Somewhat Disagree	Strongly Disagree
210	123 (58.6)	78 (37.1)	201 (95.7)	3 (1.4)	4 (1.9)	2 (1.0)

Do you agree with the Preamble?

Total n	Strongly Agree	Somewhat Agree	Combined Agreement	Neither Agree Nor Disagree	Somewhat Disagree	Strongly Disagree
209	133 (63.6)	63 (30.1)	196 (93.8)	6 (2.9)	6 (2.9)	1 (0.5)

Would you use (e.g., circulate) the Preamble?

Total n	Always	Frequently	Combined Frequent Use	Occasionally	Seldom	Never
210	90 (42.9)	88 (41.9)	178 (84.8)	15 (7.1)	13 (6.2)	4 (1.9)

The 24-Hour Guidelines are clearly stated.

Total n	Strongly Agree	Somewhat Agree	Combined Agreement	Neither Agree Nor Disagree	Somewhat Disagree	Strongly Disagree
199	125 (62.8)	58 (29.2)	183 (87.1)	5 (2.5)	8 (4.0)	3 (1.5)

Do you agree with the 24-Hour Guidelines?

Total n	Strongly Agree	Somewhat Agree	Combined Agreement	Neither Agree Nor Disagree	Somewhat Disagree	Strongly Disagree
200	144 (72.0)	50 (25.0)	194 (97.0)	3 (1.5)	3 (1.5)	0 (0.0)

There was clear support and agreement with the Guidelines. The qualitative responses (detailed below) indicated clearly that those who disagreed with the Guidelines, mainly did so because they considered the Guidelines to be too technical and aimed at a high reading level.

Which phrase is the most appropriate for communicating the physical activity recommendation?

An accumulation of at least 60 minutes per day of moderate to vigorous physical activity involving a variety of aerobic activities	138 (70.8%)

An accumulation of at least one hour per day of moderate to vigorous physical activity involving a variety of aerobic activities	57 (29.2%)
Total n	**195**

Are the 24-Hour Guidelines important to you?

Total n	Yes	No
200	190 (95.0)	10 (5.0)

Would you use the 24-Hour Guidelines?

Total n	Always	Frequently	Combined High Use	Occasionally	Seldom	Never
201	79 (39.3)	96 (47.8)	175 (87.1)	21 (10.5)	5 (2.5)	0 (0.0)

Would you use the Integrated Guidelines?

No, I would not use the guidelines at all	5 (2.6)
Yes, I would use the Integrated Guidelines instead of the stand-alone guidelines (i.e., physical activity, sedentary behaviour, sleep)	97 (49.5)
Yes, I would use the Integrated Guidelines in addition to the stand-alone guidelines.	94 (48.0)
Total n	**196**

How easy or difficult would you find using the 24-Hour Guidelines?

Total n	Very Easy	Somewhat Easy	Combined Ease	Neither Easy Nor Difficult	Somewhat Difficult	Very Difficult
196	71 (36.2)	89 (45.4)	160 (81.6)	20 (10.2)	13 (6.6)	3 (1.5)

In comparison to separate physical activity, sedentary behaviour and sleep guidelines, do you find these 24-Hour Guidelines...

Total n	Much More Useful	More Useful	Combined Usefulness	Neutral	Less Useful	Much Less Useful
			162 (82.2)			

197	65 (33.0)	97 (49.3)		31 (15.7)	4 (2.0)	0 (0.0)

The costs for you to use, or your organisation to implement, the 24-Hour Guidelines are likely to be small or negligible compared to not using the Guidelines.

Total n	Strongly Agree	Somewhat Agree	Combined Agreement	Neither Agree Nor Disagree	Somewhat Disagree	Strongly Disagree	I Don't Know	Not Applicable
191	71 (37.2)	50 (26.2)	121 (63.4)	24 (12.6)	12 (6.3)	2 (1.1)	19 (10.0)	13 (6.8)

The benefits of using the 24-Hour Guidelines are likely to outweigh the costs.

Total n	Strongly Agree	Somewhat Agree	Combined Agreement	Neither Agree Nor Disagree	Somewhat Disagree	Strongly Disagree	I Don't Know
190	104 (54.8)	45 (23.7)	149 (78.4)	19 (10.0)	5 (2.6)	0 (0.0)	17 (9.0)

Following the 24-Hour Guidelines is likely to benefit all population groups equally, irrespective of gender, cultural or language background, geographic location, or socio-economic status of the family.

Total n	Strongly Agree#	Somewhat Agree	Combined Agreement	Neither Agree Nor Disagree	Somewhat Disagree	Strongly Disagree	I Don't Know
186		149 (80.1)		17 (9.1)	11 (5.9)	4 (2.3)	5 (2.7)

#Due to an error in the survey design, "strongly agree" and "somewhat agree" were combine automatically for this question.

It was apparent that almost half of the respondents were aligned with Education, as well as Research (19.8%) and public health (8.0%) to a lesser extent.

With what sector do you primarily associate?

Sector	n	%
Sport	4	2.1
Education	93	49.7
Recreation	1	0.5
Healthcare	12	6.4
Public health	15	8.0

Physical activity/fitness	2	1.1
Research	37	19.8
Government	10	5.4
Disability	0	0.0
Health	9	4.8
Other	4	2.1
Total n	**187**	

Where do you primarily work?

	n	%
NSW	92	49.5
ACT	12	6.5
QLD	8	4.3
WA	13	7.0
SA	14	7.5
NT	1	0.5
Vic	15	8.1
Tas	10	5.4
Outside of Australia	21	11.3
Total n	**186**	

When the final version of the 24-Hour Guidelines is complete, would you like to be contacted for final review so that, if supportive, your organisation can decide if it would like to be listed in a "supported by" section associated with the 24-Hour Guidelines?

Total n	Yes	No	I Don't Know
186	94 (50.5)	62 (33.3)	30 (16.1)

Half of the respondents indicated their interest in being identified as a supporter of the Guidelines. However, of those who indicated disinterest, the majority commented that they would need to seek permission from their employer before they could confirm support.

Summary of qualitative responses from online survey regarding the 24-Hour Movement guidelines for children and young people

Individual comments regarding the **Title**

- Suggest use of the word daily instead of 24-hour
- Add age range
- title is too long
- Ensure consistency in terminology ie young people instead of youth
- Suggested that this is only suitable for educated people or people involved in research
- Not suited to the entire population – could put some people off
- Confusion around the word integration – suggest using the term "combining"

Individual comments regarding the **Preamble**

- Language is too technical and complex; prefer simplified language
- People not happy with the use of the word "should" as it has negative implications
- Preference for age grouping
- Not keen on the use of "apparently"
- Body composition is not part of daily vernacular
- Suggest use of the word challenges instead of harms
- Good to see that the guidelines acknowledge that it can be difficult to achieve this
- Suggest that the bed routine and avoiding screen before sleep should be justified with reasoning.

Individual comments about using the **Integrated guidelines.**

- Too academic
- Suggest that examples of aerobic activity should be included, as well as moderate and vigorous.
- Consistency between hours and minutes
- Age should be included
- Terminology will be difficult for all to understand
- Suggestion that mobile phones be separately addressed.
- Could be helpful to use infographic
- Another word instead of "preserving"
- Examples of exercise would be helpful
- Preference for the layout to be in dot points or in a table format.
- Good to see recreational screen time separated from work/school screen time.

Individual comments regarding the **Integrated Guidelines compared with separate guidelines**

- Happy that sleep is now included
- Some concerns that it is too prescriptive
- Prefer examples to be included.
- Easier having all the information in one spot
- Good idea of demonstrating how people can balance their time
- Could suggest changes to the amount of time required being physical activity within the school curriculum.
- Suggest the use of the word balance instead of integrated
- Consider the language off putting and not empowering to the user.
- Good to that sleep is being recognised as important as physical activity in terms of all-round health.
- A great improvement on individual guidelines.

Individual comments on the **costs for you to use**, or your organisation to implement, the *24-Hour Guidelines* are likely to be small or negligible compared to not using the Guidelines.

- Suggestion that cost should be in terms of health promotion eg magnets, hats, phone cases
- Teacher comment "if it becomes part of what I teach, it becomes easier. If it becomes extra, it becomes harder."

Individual comments regarding the suggestion that the **benefits** of using the *24-Hour Guidelines* are likely to **outweigh the costs**.

- Health prevention has been proven to reduce health costs
- Having students healthier will always outweigh the cost of ill-health. Need for students to understand this.
- "Could possibly have a detrimental impact on educational outcomes….

Individual comments regarding the suggestion that following the *24-Hour Guidelines* is likely to b**enefit all population groups equally, irrespective of gender, race, ethnicity, or the socioeconomic status of the family**.

- *For the guidelines to benefit all population groups equally, they must have equal access to the guidelines. It will be important to focus on promoting the guidelines to all population groups and ensuring key intermediaries are supported to implement and activate the guidelines. It would be helpful to know how these guidelines will be promoted and if this will include plain language summaries. In addition, the guidelines should include culturally competent information relevant to Aboriginal and Torres Strait Islander Australians and other culturally and linguistically diverse populations. The guidelines are also repetitive – suggest revising to address this.*
- *I don't think you can discount the effect of SES on behaviour, including physical activity and sedentary behaviour. It is almost like ignoring the social determinants of health. Those living in intergenerational cycles of poverty are more likely to be experiencing stress and/or depression, may lack the motivation to be more physically active, and perhaps lack education about how they could easily be more physically active.*
- *SES has a huge bearing on engaging in formalised sports ie membership of a sports club, there are subsidies available from councils but they fall well short. We have talented kids not being given opportunities to engage in sports. Larger scope of activities needs to be promoted as not all kids are soccer/footie players, private sports like cheerleading/dance is expensive and not available everywhere. We have huge rural and remote communities who are not set up for sports. Gaming is a difficult one to monitor for parents, it's a way of young people connecting when they play shared games in teams. Working parents cannot monitor gaming time. As children get older they begin to be more autonomous and regulate their own sleep and activity levels. Iceland has an interesting model which reduced AOD harm by allowing kids more after school activity and offering subsidies to parents to pay for this.*
- *Part time work may be an obstacle for teenagers achieving the guidelines.*
- *Specific genders, ethnicities and socioeconomic statuses face their own individual challenges in regards to physical activity and health. Therefore, while following the guidelines will benefit all population groups, the effect will be greater for some population groups*
- *As a full-time working parent of a child who is about to start school next year, I question how much control I really will have over their activity level when they are not with me (i.e. she has to go before and after school care and I do not control what happens there). We'll have a 2-hour window between coming home and bedtime, and while I think we'll definitely fit in some physical activity because I value it, I would not have a clue if she got 60 minutes a day. All this to say there will be some groups more able to apply the guidelines than others. I have the privilege of being highly educated, physically able and fit, have a high income and the funds to enrol my kids in sports, place high value on physical activity, yet still face barriers. Awareness of what we all should aim for is of course great, equitable ability to implement due to finances and time, neighbourhood infrastructure and school programs, parental physical and mental ability and capacity is a different story.*

Individual comments regarding suggested **intermediaries to implement and activate the *24-Hour Guidelines***

Suggested intermediaries included:

- Teachers
- Parents
- Sport Australia
- Educational academics
- Health care professionals
- Community health nurses
- National curriculum developers
- Various health Foundations eg National Heart Foundation
- Sports clubs
- Health promotion experts
- Young people themselves
- Aunty and Uncles for the ATSI community
- Personal trainers
- Anyone involved in the care of young people
- Psychologists
- Scholl leaders
- Social media commentators
- Government through Sport Australia
- Exercise physiologist
- Teachers in schools Educators in Universities Professional Associations for educators such as ACHPER including its state branches NfP Health organisations such as the NHF

What does the research say are the successful implementers of guidelines such as these. What evidence of success can you draw on to identify the key people and organisations ... in the above question the obvious "go tos" are identified, but does past experience and the evidence demonstrate any success with these? In education, teachers will play a significant role. As will parents. School communities in effect. If school principals saw this as a priority it would make for the greatest change. But that requires direction from Education Ministers and Chief Executives. Which requires the profile of movement to lift to the level of STEM and Numeracy and Literacy. And this requires considerable lobbying and resources. It requires the Australian population to value health as much as wealth. Schools are very much focused on producing employable students. Health and wellbeing are not the primary objective of schools. Education is. And education is skewed towards employment.

Individual comments regarding suggested **supports the intermediaries need** to implement and activate the *24-Hour Guidelines* (e.g., materials, training)?

- Could include case studies with “benefit statement”
- Tip sheets on how to do each of these things e.g. how to establish consistent bed time, how to keep screens out of the bedroom.
- Apps, social media packages
- Children need to drive this themselves to ensure ownership
- Information and advice via video; images and key messages that can be shared on social media; sample teaching and learning activities

- Advice and guidance on how to change health behaviours and associated habits. Removal of perceived barriers that are too often used as poor excuses not to engage in health behaviour
- Educational bombardment like the anti- smoking campaign.
- Increased time at school for movement and physical activity
- PE trained teachers in primary school
- Visuals showing a 24-hour clock with various “sample days” that meet the guidelines
- Smart phone app where children can record how they are doing for screen time, sleep and MVPA each day
- Awareness including all the benefits of meeting the guidelines eg cognitive benefits and academic outcomes for physical activity (even when replacing time studying

Organisations such as Life Education work in a unique context in supporting schools. They would need support (financial and expertise) to develop relevant content to integrate into their educational program and training for the educators working with children and young people to ensure consistent messaging. Other print and digital Resources: Accessible engaging Video content targeted at children and parents and carers, web accessible content. Posters, fridge magnets, brochures

References

1. Trost S. Discussion paper for the development of recommendations for children's and youth's participation in health promoting physical activity. 2005. Commonwealth Department of Health and Ageing, Canberra, pp. 1–141.
2. Okely AD, Salmon J, Vella S, Cliff D, Timperio A, Tremblay M, et al. A systematic review to update the Australian physical activity guidelines for children and young people. 2012. Report prepared for the Australian Government Department of Health.
3. Okely AD, Salmon J, Vella S, Cliff D, Timperio A, Tremblay M, et al. A Systematic Review to inform the Australian Sedentary Behaviour Guidelines for Children and Young People. Report prepared for the Australian Government Department of Health. 2012.
4. Tremblay MS, Carson V, Chaput J-P, Connor Gorber S, Dinh T, Duggan M, et al. Canadian 24-hour movement guidelines for children and youth: an integration of physical activity, sedentary behaviour, and sleep. Applied Physiology, Nutrition, and Metabolism. 2016;41(6):S311-S27.
5. Carson V, Chaput J-P, Janssen I, Tremblay MS. Health associations with meeting new 24-hour movement guidelines for Canadian children and youth. Preventive Medicine. 2017;95:7-13.
6. Janssen I, Roberts KC, Thompson W. Is adherence to the Canadian 24-Hour Movement Behaviour Guidelines for Children and Youth associated with improved indicators of physical, mental, and social health? Applied Physiology, Nutrition, and Metabolism. 2017(999):1-7.
7. Roman-Viñas B, Chaput J-P, Katzmarzyk PT, Fogelholm M, Lambert EV, Maher C, et al. Proportion of children meeting recommendations for 24-hour movement guidelines and associations with adiposity in a 12-country study. International Journal of Behavioral Nutrition and Physical Activity. 2016;13(1):123.
8. Okely AD, Ghersi D, Hesketh KD, Santos R, Loughran SP, Cliff DP, et al. A collaborative approach to adopting/adapting guidelines-The Australian 24-Hour Movement Guidelines for the early years (Birth to 5 years): an integration of physical activity, sedentary behavior, and sleep. BMC Public Health. 2017;17(5):869.
9. Schünemann HJ, Wiercioch W, Brozek J, Etxeandia-Ikobaltzeta I, Mustafa RA, Manja V, et al. GRADE Evidence to Decision (EtD) frameworks for adoption, adaptation, and de novo development of trustworthy recommendations: GRADE-ADOLOPMENT. Journal of Clinical Epidemiology. 2017;81:101-10.
10. Colley RC, Garriguet D, Janssen I, Craig CL, Clarke J, Tremblay MS. Physical activity of Canadian children and youth: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. Health reports. 2011;22(1):15.
11. Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. Medicine & Science in Sports & Exercise. 2008;40(1):181-8.
12. Matricciani L, Olds T, Petkov J. In search of lost sleep: secular trends in the sleep time of school-aged children and adolescents. Sleep Medicine Reviews. 2012;16(3):203-11.
13. Roberts KC, Shields M, de Groh M, Aziz A, Gilbert J-A. Overweight and obesity in children and adolescents: results from the 2009 to 2011 Canadian Health Measures Survey. Health rep. 2012;23(3):37-41.
14. Tremblay M, Katzmarzyk P, Willms J. Temporal trends in overweight and obesity in Canada, 1981–1 996. International Journal of Obesity. 2002;26(4):538.
15. Jones RA, Hinkley T, Okely AD, Salmon J. Tracking physical activity and sedentary behavior in childhood: a systematic review. American Journal of Preventive Medicine. 2013;44(6):651-8.
16. WHO. Commission's final report calls for high-level action to address major health challenge Commission on Ending Childhood Obesity Geneva. 2016.
17. Carson V, Lee EY, Hewitt L, Jennings C, Hunter S, Kuzik N, et al. Systematic review of the relationships between physical activity and health indicators in the early years (0-4 years). BMC Public Health. 2017;17(Suppl 5):854.

18. Poitras VJ, Gray CE, Janssen X, Aubert S, Carson V, Faulkner G, et al. Systematic review of the relationships between sedentary behaviour and health indicators in the early years (0-4 years). BMC Public Health. 2017;17(Suppl 5):868.
19. Chaput JP, Gray CE, Poitras VJ, Carson V, Gruber R, Birken CS, et al. Systematic review of the relationships between sleep duration and health indicators in the early years (0-4 years). BMC Public Health. 2017;17(Suppl 5):855.
20. Kuzik N, Poitras VJ, Tremblay MS, Lee EY, Hunter S, Carson V. Systematic review of the relationships between combinations of movement behaviours and health indicators in the early years (0-4 years). BMC Public Health. 2017;17(Suppl 5):849.
21. Okely AD, Ghersi D, Hesketh KD, Santos R, Loughran SP, Cliff DP, et al. A collaborative approach to adopting/adapting guidelines - The Australian 24-Hour Movement Guidelines for the early years (Birth to 5 years): an integration of physical activity, sedentary behavior, and sleep. BMC Public Health. 2017;17(Suppl 5):869.
22. Poitras VJ, Gray CE, Borghese MM, Carson V, Chaput J-P, Janssen I, et al. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. Applied Physiology, Nutrition, and Metabolism. 2016;41(6):S197-S239.
23. Saunders TJ, Gray CE, Poitras VJ, Chaput J-P, Janssen I, Katzmarzyk PT, et al. Combinations of physical activity, sedentary behaviour and sleep: relationships with health indicators in school-aged children and youth. Applied Physiology, Nutrition, and Metabolism. 2016;41(6):S283-S93.
24. Riazi N, Ramanathan S, O'Neill M, Tremblay MS, Faulkner G. Canadian 24-hour movement guidelines for the early years (0-4 years): exploring the perceptions of stakeholders and end users regarding their acceptability, barriers to uptake, and dissemination. BMC Public Health. 2017;17(Suppl 5):841.
25. Carson V, Hunter S, Kuzik N, Gray CE, Poitras VJ, Chaput J-P, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth: an update 1. Applied Physiology, Nutrition, and Metabolism. 2016;41(6):S240-S65.
26. Tremblay MS, LeBlanc AG, CArson V, et al. Canadian sedentary behavious guidelines for the early years (aged 0-4 years). Applied Physiology Nutrition and Metabolism. 2012;37:370-91.
27. Chaput J-P, Gray CE, Poitras VJ, Carson V, Gruber R, Olds T, et al. Systematic review of the relationships between sleep duration and health indicators in school-aged children and youth. Applied Physiology, Nutrition, and Metabolism. 2016;41(6):S266-S82.
28. Hirshkowitz M, Whiton K, Albert SM, Alessi C, Bruni O, DonCarlos L, et al. National Sleep Foundation's updated sleep duration recommendations: final report. Sleep Health. 2015;1(4):233-43.
29. Paruthi S, Brooks LJ, D'Ambrosio C, Hall WA, Kotagal S, Lloyd RM, et al. Consensus Statement of the American Academy of Sleep Medicine on the Recommended Amount of Sleep for Healthy Children: Methodology and Discussion. Journal of Clinical Sleep Medicine. 2016;12(11):1549-61.
30. Faulkner G, White L, Riazi N, Latimer-Cheung AE, Tremblay MS. Canadian 24-Hour Movement Guidelines for Children and Youth: Exploring the perceptions of stakeholders regarding their acceptability, barriers to uptake, and dissemination. Applied Physiology, Nutrition, and Metabolism. 2016;41(6):S303-S10.
31. Stanley R, Jones R, Swann C, Christian H, Sherring J, Shilton T, et al. Exploring stakeholders' perceptions of the acceptability, usability and dissemination of the Australian 24-hour Movement Guidelines for the early years. . Submitted to Journal of Physical Activity and Health
32. Tremblay MS, Chaput JP, Adamo KB, Aubert S, Barnes JD, Choquette L, et al. Canadian 24-Hour Movement Guidelines for the Early Years (0-4 years): An Integration of Physical Activity, Sedentary Behaviour, and Sleep. BMC Public Health. 2017;17(Suppl 5):874.

Annex 1: GRADE Tables

1.1 Physical Activity

Research Question: In children 5-17 years of age what dose (i.e., volumes, durations, frequencies, patterns, types, and intensities) of physical activity, as measured by objective and subjective methods, is associated with favourable health indicators?

Table 1.1.1. The relationship between physical activity and body composition.
Note: Text in blue is the number after the Australian update.

No. of studies	Design	Quality Assessment				No. of participants	Absolute effect[a]	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision			
The range of mean ages was 6.9 to 12 years. Data were collected by RCT, non-randomized intervention trial, cross-sectionally and up to 3 years of follow-up. Body composition markers were: BMI (absolute, percentile, Z-score, conditional Z-score velocity), weight status (CDC, IOTF or WHO cut-points), sum of SF, body mass, WC, %BF, FM, FM index, FFM, FFM index, ponderal index, and trunk fat. Outcomes were measured objectively in all but one instance.								
~~7~~9	Randomized Trials[b]	Serious Risk of Bias[c]	No serious inconsistency	Serious indirectness[d]	No serious imprecision	~~2,085~~ 3,957	**~~2/7~~9 studies** reported improved adiposity for intervention vs control at post-test (Gutin et al. 1999; Eather et al. 2013); **~~3/7~~ 4/9 studies** reported mixed favourable and null findings (Verstraete et al. 2007; Kriemler et al. 2010; Ford et al. 2013, Harrington et al 2018). **~~1/7~~ 2/9 studies** had no intervention effects (Finkelstein et al. 2013, Drummy et al. 2016); **1/~~7~~9 studies** reported that significant favourable effects in Kriemler et al. 2010 were null at 3 year follow up (Meyer et al. 2014). Favourable effects for %BF, but not FM, remained at 15 week follow up for Ford et al. 2013.[e]	LOW[f]
~~6~~11	NRT[g]	Serious risk of bias[h]	No serious inconsistency	Serious of indirectness[i]	No serious imprecision	~~1,174~~ 4,552	**~~5/6~~ 6/11studies** reported null effects of PA intervention on adiposity outcomes (Rowland et al. 1996; Pangrazi et al. 2003; Williams and Warrington 2011; Huang et al. 2012; Duncan et al. 2012, Aires et al. 2015). **4/11 studies** reported significant effects of PA intervention on adiposity outcomes (Benjamin Neelon et al. 2015, Postler et al. 2017, Brusseau et al. 2016) **1/6~~11~~ studies** reported lower odds of overweight/obesity half way through (1 year) a school/afterschool-based **total PA** intervention program, at post-test (2 years) and at 2 year follow-up (Sigmundova and Sigmund 2012).	VERY LOW[j]
~~14~~19	Longitudinal [k]	Risk of bias[l]	No serious inconsistency	No serious indirectness	No serious imprecision	~~11,629~~ 28,141	***Total PA:*** **1/~~7~~8 studies** reported favourable associations (Janz et al. 2005); **~~2/7~~3/8 studies** reported mixed favourable and null associations (Riddoch et al. 2009; White and Jago 2012, Griffiths et al. 2016); **4/~~7~~8 studies** reported null associations (Butte et al. 2007a; Basterfield et al. 2012; Hjorth et al. 2014a; Hjorth et al. 2014b). ***VPA:*** **~~2/3~~ 3/4 studies** reported favourable associations (total and bouts, Janz et al. 2005; dose-response trend, Carson et al. 2014, Hamer et al 2018); **1/~~3~~4 studies** reported null associations (Butte et al. 2007a). ***MVPA:*** **~~2/7~~5/10 studies** reported favourable associations (Janz et al. 2009; Mitchell et al. 2013, Augustin et al 2017,Chinapaw et al. 2018, Henderson et al. 2016);	VERY LOW[m]

							2/~~7~~10 studies reported mixed favourable and null associations (Riddoch et al. 2009; Hjorth et al. 2014b); **3/~~7~~10 studies** reported null associations (Stevens et al. 2007; Hallal et al. 2012; Hjorth et al. 2014a). ***MPA:*** **2/2 studies** reported null associations (total and bouts, Janz et al. 2005; Butte et al. 2007a). ***LPA:*** **2/3 studies** reported null associations (Butte et al. 2007a; Treuth et al. 2009); **1/3 studies** reported an unfavourable association, with evidence of dose-response gradient (Carson et al. 2014). **FFM** ***Total PA:* 1/1 studies** reported mixed favourable and null associations (Stevens et al. 2004).	
48	Cross-sectional[n]	Serious risk of bias[o]	Serious inconsistency[p]	No serious indirectness	No serious imprecision	57,696	***Meeting/Not Meeting Guidelines (≥60 min/day MVPA):*** **2/3 studies** reported favourable associations (Steele et al. 2009; Martinez-Gomez et al. 2010b); **1/3 studies** reported null associations (Mendoza et al. 2012). ***Total PA:*** **9/22 studies** reported favourable associations (Duncan et al. 2008; Riddoch et al. 2009; Steele et al. 2009; Ferrar and Olds 2010; Owen et al. 2010; Belcher et al. 2010; Mark and Janssen 2011; Ekstedt et al. 2013; Manios et al. 2013). **8/22 studies** reported mixed favourable and null associations (Andersen et al. 2006; Duncan et al. 2006; Ness et al. 2007; Ortega et al. 2007; Dollman et al. 2010; Ruiz et al. 2011; Tudor-Locke et al. 2011; Jimenez-Pavon et al. 2013c). **3/22 studies** reported null associations (Ekelund et al. 2006; Hands et al. 2009; Martinez-Gomez et al. 2012). **1/22 studies** reported mixed favourable, null, and unfavourable associations (Jimenez-Pavon et al. 2013a). **1/22 studies** reported mixed null and unfavourable associations (Hands and Parker 2008). ***VPA:*** **10/15 studies** reported favourable associations (Ekelund et al. 2004; Lohman et al. 2006; Steele et al. 2009; Martinez-Gomez et al. 2010b; Mark and Janssen 2011; Sayers et al. 2011; Chung et al. 2012; Martinez-Gomez et al. 2012; Jimenez-Pavon et al. 2013a; Katzmarzyk et al. 2015b). **4/15 studies** reported mixed favourable and null associations (Ortega et al. 2007; Kelly et al. 2010; Belcher et al. 2010; Jimenez-Pavon et al. 2013c). **1/15 studies** reported mixed null and unfavourable associations (Ortega et al. 2010).	VERY LOW[q]

							MVPA: **20/30 studies** reported favourable associations (Ekelund et al. 2004; Lohman et al. 2006; Ness et al. 2007; Stevens et al. 2007; Mark and Janssen 2009; Riddoch et al. 2009; Steele et al. 2009; Belcher et al. 2010; Martinez-Gomez et al. 2010b; Holman et al. 2011; Grydeland et al. 2012; Lawman et al. 2012; Carson et al. 2013; Ekstedt et al. 2013; Jimenez-Pavon et al. 2013a; Taverno Ross et al. 2013; daSilva et al. 2014; Young et al. 2014; Katzmarzyk et al. 2015a; Katzmarzyk et al. 2015b). **6/30 studies** reported mixed favourable and null associations (Kelly et al. 2010; Peart et al. 2011; Ruiz et al. 2011; Mendoza et al. 2012; St George et al. 2013; Jimenez-Pavon et al. 2013c). **3/30 studies** reported null associations (Hurtig-Wennlof et al. 2007; Ortega et al. 2007; Martinez-Gomez et al. 2012). **1/30 studies** reported mixed null and unfavourable associations (Ortega et al. 2010). **2 studies** examined *sporadic MVPA* (i.e. 1-4 min bouts) and associations were favourable (Mark and Janssen 2009; Holman et al. 2011). **3 studies** examined *bouts of MVPA* and associations were favourable (**2/3 studies;** Holman et al. 2011; da Silva et al. 2014) or mixed (favourable and null; **1/3 studies;** Mark and Janssen 2009). ***MPA:*** **2/10 studies** reported favourable associations (Mark and Janssen 2011; Chung et al. 2012). **2/10 studies** reported mixed favourable and null associations (Belcher et al. 2010; Jimenez-Pavon et al. 2013c). **5/10 studies** reported null associations (Ortega et al. 2007; Steele et al. 2009; Sayers et al. 2011; Martinez-Gomez et al. 2012; Jimenez-Pavon et al. 2013a). **1/10 studies** reported mixed null and unfavourable associations (Ortega et al. 2010). **No studies** reported only unfavourable associations. ***LPA :*** **1/9 studies** reported favourable associations (Mark and Janssen 2011). **2/9 studies** reported mixed favourable and null associations (Treuth et al. 2009; Kwon et al. 2011). **3/9 studies** reported null associations (Ekelund et al. 2004; Sayers et al. 2011; Carson et al. 2013). **3/9 studies** reported mixed null and unfavourable associations (Steele et al. 2009; Jimenez-Pavon et al. 2013a; Jimenez-Pavon et al. 2013c). **<u>FFM</u>** **Total PA:** **1/2 studies** reported favourable associations (Ness et al. 2007); **1/2 studies** reported mixed favourable and null associations (Jimenez-Pavon et al. 2013a).	

							VPA : **2/4 studies** reported favourable associations (Jimenez-Pavon et al. 2013a; Sayers et al. 2011); **2/4 studies** reported mixed null and unfavourable associations (Lohman et al. 2006; Lohman et al. 2008). **MVPA:** **1/4 studies** reported null associations (Jimenez-Pavon et al. 2013a); **3/4 studies** reported mixed null and unfavourable associations (Lohman et al. 2006; Lohman et al. 2008; Taverno Ross et al. 2013). **MPA:** **2/2 studies** reported null associations (Jimenez-Pavon et al. 2013a; Sayers et al. 2011). **LPA:** **1/2 studies** reported favourable associations (Sayers et al. 2011); **1/2 studies** reported mixed unfavourable (boys) and null (girls) associations (Jimenez-Pavon et al. 2013a).	

Note: %BF = percent body fat; BMI = body mass index; CTRL = control group; FFM = fat free mass; FM = fat mass; INT = intervention group; LPA = light physical activity; MPA = moderate physical activity; MVPA = moderate-to-vigorous physical activity; RCT = randomized controlled trial; SF = skinfold; WC = waist circumference.

[a] Absolute effects are in relation to adiposity-specific indicators unless otherwise stated (i.e. in relation to FFM).

[b] Includes **6 RCT studies** (Verstraete et al. 2007; Kriemler et al. 2010; Finkelstein et al. 2013; Eather et al. 2013; Ford et al. 2013; Meyer et al. 2014) from **5** unique samples, and **1 modified randomized crossover study** (Gutin et al. 1999). Kriemler et al. 2010 and Meyer et al. 2014 both report data from the KISS study. Results are reported separately and participants are only counted once.

[c] Serious risk of bias. Performance bias: Randomization was reported, but the method by which sibling pairs were further randomized beyond the initial randomization was not described and it is plausible that siblings discussed and detected group assignment (Finkelstein et al. 2013). Detection bias: 6 min walk test assessors were not blinded to group assignment; pedometers were open for INT, but sealed for CTRL, which could have influenced the outcome; missing pedometer data were disproportionately high in controls relative to intervention group (18.1% vs 6.1%), likely due to incentives for wear time offered to the intervention group only (Finkelstein et al. 2013). Selective reporting: %BF from BodPod was not available at follow up and reasons were not described. Many analyses were only reported for sub-samples with no explanation. Sequence generation: unclear how the subsample of children who had objective PA measures was selected (Ford et al. 2013).

[d] Serious indirectness. Differences in intervention: studies examined various types of physical activity programs and provided indirect evidence bearing on the potential effectiveness of different intensities and durations of physical activity. Indirect comparisons: different durations and intensities of physical activity were not compared within individual studies.

[e] MVPA (but not total PA) was significantly greater in the intervention vs control group at post-intervention (post 9-month intervention group difference of ~11 min/day) (Kriemler et al. 2010); there was a trend toward higher levels of total PA (but not MVPA) in the intervention vs control group at 3-yr follow-up (Cohen's d = 0.35, p=0.06; not significant) (Meyer et al. 2014).

[f] The quality of the evidence from randomized studies was downgraded from "high" to "low" due to: (1) a serious risk of bias in two studies that diminished the level of confidence in the observed effects, and (2) serious indirectness of the interventions and the comparisons being assessed.

[g] Includes **3 non-randomized controlled intervention studies** (Pangrazi et al. 2003; Williams and Warrington 2011; Sigmundova and Sigmund 2012) and **3 single group intervention studies** (Rowland et al. 1996; Duncan et al. 2012; Huang et al. 2012).

[h] Serious risk of bias. Allocation concealment: Group assignment was based on completion of intervention or drop-out, with drop-outs serving as CTRL. Attrition bias: the large amount of missing data was likely related to the outcome of interest (Williams and Warrington 2011). Other source of bias: there was no CTRL group (Duncan et al. 2012; Huang et al. 2012). Attrition bias: Analysis did not control for clustering by class order/number and change scores were not compared with a reference group (Huang et al. 2012). Allocation concealment was not described. Performance bias: no blinding attempted. Other sources of bias: The authors reported implausibly large effect sizes for the intervention (i.e., a reduction in the proportion of obesity to 0% in INT, while the proportion doubled in CTRL) (Sigmundova and Sigmund 2012). Incomplete outcome data: dietary analysis showed there was a small increase in caloric intake in INT compared to CTRL that was not controlled for in analysis (Rowland et al. 1996).

[i] Serious indirectness. Differences in intervention: Studies examined various types of physical activity programs and provided indirect evidence bearing on the potential effectiveness of different intensities and durations of physical activity. Indirect comparisons: different durations and intensities of physical activity were not compared within individual studies.
[j] The quality of evidence from non-randomized intervention studies was downgraded from "low" to "very low" due to: (1) a serious risk of bias in four studies that diminished the level of confidence in the observed effects, and (2) serious indirectness of the interventions and the comparisons being assessed.
[k] Includes **14 longitudinal studies** (Stevens et al. 2004; Janz et al. 2005; Stevens et al. 2007; Butte et al. 2007a; Janz et al. 2009; Riddoch et al. 2009; Treuth et al. 2009; Basterfield et al. 2012; Hallal et al. 2012; White and Jago 2012; Mitchell et al. 2013; Carson et al. 2014; Hjorth et al. 2014a; Hjorth et al. 2014b) from **11 unique samples**; Janz et al. 2005 and 2009 reported data from the Iowa Bone Development Study; Stevens et al. 2007 and Treuth et al. 2009 reported data from the TAAG study; Hjorth et al. 2014a and 2014b reported data from the OPUS study. Results are presented separately and participants are only counted once.
[l] Serious risk of bias. Authors reported significance at $p<0.10$. It is unclear if data from the univariate or multivariate models are reported. Loss to follow-up not examined by fat mass index (Basterfield et al. 2012). Enrollment protocol was not adequately described. Adiposity outcomes were reportedly estimated using a "previously validated equation", however in the validation study BMI was a better predictor of BF than the new equation. In the overweight group, baseline PA was a significant predictor of fat mass and fat-free mass, but not %BF; this is concerning as %BF is a function of fat mass and fat-free mass (Stevens et al. 2004). Sixty-eight percent of participants did not provide valid baseline accelerometer data or did not have complete cardiometabolic risk factor data (which included WC) at baseline and/or follow-up; reasons for missing data were not provided. Those lost to follow-up were older, heavier and displayed lower cardiorespiratory fitness levels than completers. Conditional BMI Z-score velocity was validated with infants as cited, however the validity and reliability with children and youth are unknown (Carson et al. 2014). Reasons for exclusions are not adequately reported (Hallal et al. 2012). Reasons for missing outcome data not clear (Riddoch et al. 2009). Only the subset that gained weight was included in the analysis (n=798 out of n=879), which may have affected the associations reported (Butte et al. 2007a).
[m] The quality of evidence from longitudinal studies was downgraded from "low" to "very low" due to serious risk of bias in six studies that diminished the level of confidence in the observed effects.
[n] Includes **48 studies** (Ekelund et al. 2004; Andersen et al. 2006; Duncan et al. 2006; Ekelund et al. 2006; Lohman et al. 2006; Ness et al. 2007; Ortega et al. 2007; Stevens et al. 2007; Hurtig-Wennlof et al. 2007; Duncan et al. 2008; Hands and Parker 2008; Lohman et al. 2008; Hands et al. 2009; Mark and Janssen 2009; Riddoch et al. 2009; Steele et al. 2009; Treuth et al. 2009; Ferrar and Olds 2010; Martinez-Gomez et al. 2010b; Owen et al. 2010; Ortega et al. 2010; Dollman et al. 2010; Kelly et al. 2010; Belcher et al. 2010; Peart et al. 2011; Holman et al. 2011; Kwon et al. 2011; Mark and Janssen 2011; Tudor-Locke et al. 2011; Ruiz et al. 2011; Sayers et al. 2011; Chung et al. 2012; Grydeland et al. 2012; Lawman et al. 2012; Martinez-Gomez et al. 2012; Mendoza et al. 2012; Barreira et al. 2013; Carson et al. 2013; Ekstedt et al. 2013; St George et al. 2013; Taverno Ross et al. 2013; Manios et al. 2013; Jimenez-Pavon et al. 2013a; Jimenez-Pavon et al. 2013c; da Silva et al. 2014; Young et al. 2014; Katzmarzyk et al. 2015a; Katzmarzyk et al. 2015b) from **19 unique samples**. **Two studies** reported data from the Western Australia Child and Adolescent PA and Nutrition Survey 2003 (Hands and Parker 2008 and Hands et al. 2009); **9 studies** reported data from NHANES (Belcher et al. 2010; Holman et al. 2011; Chung et al. 2012; Barreira et al. 2013; Carson et al. 2013; Mark and Janssen 2009 and 2011; Mendoza et al. 2012 and Peart et al. 2011); **2 studies** reported data from the ACT Trial (Lawman et al. 2012 and St George et al. 2013); **6 studies** reported data from the EYHS (Andersen et al. 2006; Ortega et al. 2007; Ortega et al. 2010; Ekelund et al. 2004 and 2006; and Hurtig-Wennlof et al. 2007); **2 studies** reported data from ISCOLE (Katzmarzyk et al. 2015a and 2015b); **3 studies** reported data from ALSPAC (Ness et al. 2007; Riddoch et al. 2009 and Sayers et al. 2011); **2 studies** reported data from the Australian National Children's Nutrition and PA survey (Ferrar and Olds 2010 and Dollman et al. 2010); **6 studies** reported data from TAAG (Stevens et al. 2007; Treuth et al. 2009; Kelly et al. 2010; Young et al. 2014; and Lohman et al. 2006 and 2008); **4 studies** reported data from HELENA (Ruiz et al. 2011; Martinez-Gomez et al. 2010b and 2012; and Jimenez-Pavon et al. 2013a); Duncan et al. 2006 and 2008 were from the same sample; results are reported separately and participants are only counted once.
[o] Serious risk of bias. Potential confounders were not controlled for (da Silva et al. 2014; Katzmarzyk et al. 2015b). Reasons for missing PA and BMI data were not reported (daSilva et al. 2014). The amount of missing data/exclusions and reasons were not reported (Hurtig-Wennlof et al. 2007; Duncan et al. 2008). Risk of detection bias as participants were retained if they provided PA data for at least 1 to 7 days; 68% provided at least 5 days of PA data and 32% provided 1-4 days. PA levels were slightly higher in those with fewer days of PA data. MVPA and LPA were recorded but not reported (Owen et al. 2010). Reasons for missing data were not explained (Steele et al. 2009). Participants with missing PA data differed on some outcome measures (Andersen et al. 2006). BMI z-score was measured and analyzed for males and females 5-12 yr, and collected but not reported for 13-16 yr olds (Dollman et al. 2010). Parent-estimated height and weight were used (Tudor-Locke et al. 2011). Thirty percent of adiposity data were missing without explanation (Jimenez-Pavon et al. 2013c). A large proportion of data were missing with no explanation (Ruiz et al. 2011; Sayers et al. 2011; Taverno Ross et al. 2013). FFM and FM were estimated using an equation developed specifically for the study, however a methods paper showed the equation did not perform satisfactorily or meet the criteria for cross-validation (Taverno Ross et al. 2013). Validity and reliability of outcome measure is unknown and a reference for the equation is not provided (Young et al. 2014).
[p] Serious inconsistency. Findings for LPA were highly inconsistent. Findings for other intensities of PA consistently reported null or favourable associations between PA and adiposity outcomes. Consistency for other measures was not an issue, with consistency and strength of findings explained by varied outcome measurement and intensity of PA (stronger associations for higher intensities of PA and more precise measures of adiposity).
[q] The quality of evidence from cross-sectional studies was downgraded from "low" to "very low" due to: (1) serious risk of bias in 14 studies that diminished the level of confidence in the observed effects and (2) serious unexplained inconsistency in the findings for LPA.

Table 1.1.2. The relationship between physical activity and cardiometabolic biomarkers.
Note: Text in blue is the number after the Australian update

No. of studies	Design	Quality Assessment					No. of participants	Absolute Effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
The range of mean ages was 5.1 to 17.0 years. Data were collected by RCT, non-randomized intervention trial, cross-sectionally and up to 4 years of follow-up. Cardiometabolic biomarkers assessed were: blood pressure (systolic BP, diastolic BP, mean arterial BP, pre-high BP, high BP, hypertension), blood lipids (TG, HDL, LDL, total cholesterol), insulin sensitivity/resistance (HOMA, HOMA-%S; QUICKI, Matsuda index), fasting insulin and glucose, oral glucose tolerance test results (2-hr plasma glucose, AUC I/$G_{t30\ min}$, AUC I/$G_{t120min}$), HbA1c, RPP, inflammatory markers (CRP, IL-6, TNF-α, C3, C4), artery properties (PWV, carotid intima-media thickness, carotid compliance, Young's elastic modules, stiffness index), ALT, cardiac sympathetic-parasympathetic modulation, homocysteine, liver fat & GGT (γ-glutamyl transferase) and composite cardiometabolic risk scores. All outcomes were measured objectively.									
2	Randomized Trials[a]	No serious risk of bias	No serious inconsistency	Serious indirectness[b]	No serious imprecision	None	502	The intervention group had larger reductions in **TGs**, **glucose**, and **cardiometabolic disease risk score** and a greater increase in **HDL** vs the control group. **Systolic BP** and **diastolic BP** were not different between groups (Kriemler et al. 2010).[c] There were no differences in **glucose, HDL**, **TG,** or **systolic BP** or **diastolic BP** between the control and intervention groups 3-yr post-intervention (Meyer et al. 2014).[c]	MODERATE[d]
~~1~~2	NRT[e]	Serious risk of bias[f]	No serious inconsistency	Serious indirectness[g]	No serious imprecision	None	~~31~~71	There were significant intervention effects on **systolic BP**, **total cholesterol & fasting glucose** (Aires et al. 2015). Aerobic training had no effect on **total cholesterol**, **HDL** or **TG**. In boys, **LDL** decreased during the control weeks prior to the intervention (Rowland et al. 1996).[h]	VERY LOW[i]
~~7~~15	Longitudinal[j]	Serious risk of bias[k]	No serious inconsistency	No serious indirectness	No serious imprecision	None	~~7,918~~ 21,255	***Meeting/Not Meeting Guidelines:*** Changes in *PA guideline adherence* over 2-yr did not influence incidence of **pre-high BP** or **high-BP** (de Moraes et al. 2015).[l] 1 study showed favourable effect with meeting the PA guidelines on BP (deMoraes et al. 2014). ***Total PA:*** **Systolic BP:** null association (**2/2 studies;** Hallal et al. 2011; Knowles et al. 2013); **Diastolic BP:** associations were favourable (**1/2 studies;** Knowles et al. 2013), or mixed (favourable and null; compared with the *least active tercile*, children in the *most active tercile* of PA at age 12 yr had lower diastolic BP at age 14; no difference between least active and intermediate terciles; **1/1 studies;** Hallal et al. 2011); **Mean arterial BP:** null association (2/2 **studies;** Hjorth et al. 2014a; Macdonald-Wallis et al. 2017); **TG:** null association (**1/1 studies;** Hjorth et al. 2014a); **HDL cholesterol:** favourable association (**1/1 studies;** Hjorth et al. 2014a); 1/1 showed a null association with Blood Lipids (Telford et al. 2015) **HOMA:** associations were null (**1/1 studies;** Hjorth et al. 2014a), or mixed favourable (in boys but not girls at 4-yr follow-up) and null (2-yr	VERY LOW[m]

								follow-up) (Telford et al. 2009); 1/1 showed favourable association with IR (Peplies et al. 2016); **Cardiometabolic disease risk score:** null association (**1/1 studies;** Hjorth et al. 2014a). ***VPA:*** null associations with **systolic BP** (Carson et al. 2014). ***MVPA:*** **Systolic BP:** null association (**1/1 studies;** Knowles et al. 2013); **Diastolic BP:** null association (**1/1 studies;** Knowles et al. 2013); **Mean arterial BP:** null association (**1/1 studies;** Hjorth et al. 2014a); **TG:** null association (**2/2 studies;** Hjorth et al. 2014a, Chinapaw et al. 2018); **HDL cholesterol:** favourable association (**1/1 studies;** Hjorth et al. 2014a); TC:HDLC ratio and composite cardiometabolic risk 1/1 study showed favourable associations (Chinapaw et al. 2018) **HOMA:** null association (**3/3studies;** Hjorth et al. 2014a, Henderson et al. 2016, Chinapaw et al. 2018); **Cardiometabolic disease risk score:** null association (**1/1 studies;** Hjorth et al. 2014a). Liver fat & GGT: favourable association (1/1 Anderson et al. 2016) ***MPA:*** null associations with **systolic BP** (Carson et al. 2014). TG and HOMA-IR favourable association (1/1 Skrede et al.2017) ***LPA:*** null associations with **systolic BP** (Carson et al. 2014).	
47	Cross-sectional[n]	Serious risk of bias[o]	No serious inconsistency	No serious indirectness	No serious imprecision	Exposure /outcome gradient[p]	27,571	<u>Blood Pressure (Systolic BP, Diastolic BP, Mean Arterial BP):</u> ***Meeting/Not Meeting Guidelines:*** **1 study** found that *meeting PA guidelines*[q] was associated with reduced odds of having **high BP**, but no difference in odds of **pre-high BP** or **risk of high** BP (de Moraes et al. 2015). **1 study** found that *meeting PA guidelines*[q] was associated with lower **systolic BP** and **diastolic BP** (Janssen et al. 2013). **1 study** found that *meeting 10,000 steps/day* did not impact the odds of having **high BP** (Schofield et al. 2009). ***Total PA:*** **Hypertension:** favourable dose-response gradient (**1/1 studies;** Mark and Janssen 2008). **Diastolic hypertension:** favourable association (**1/1 studies;** Knowles et al. 2013). **Systolic hypertension:** no association (**1/1 studies;** Knowles et al. 2013).	VERY LOW[t]

								Systolic BP: associations were favourable (**3/8 studies;** Andersen et al. 2006; Ekelund et al. 2006; Mark and Janssen 2008), null (**4/8 studies;** Leary et al. 2008; Owen et al. 2010; Knowles et al. 2013; Chaput et al. 2013), or mixed (favourable and null; **1/8 studies;** Hurtig-Wennlof et al. 2007). Mark and Janssen (2008) found a favourable dose-response gradient. **Diastolic BP:** associations were favourable (**6/8 studies;** Andersen et al. 2006; Ekelund et al. 2006; Mark and Janssen 2008; Owen et al. 2010; Knowles et al. 2013; Chaput et al. 2013), null (**1/8 studies;** Leary et al. 2008), or mixed (favourable and null; **1/8 studies;** Hurtig-Wennlof et al. 2007). Mark and Janssen (2008) found an inverse dose-response gradient. **Mean arterial BP:** null association (**1/1 studies;** Hjorth et al. 2014a). ***VPA:*** **High-normal systolic BP %:** was greatest in the lowest tertile of *VPA* (**1/1 studies;** Hay et al. 2012). **BP Z-score:** no association (**1/1 studies;** Stabelini Neto et al. 2014). ***MVPA:*** **Hypertension:** the likelihood of **hypertension** decreased in a curvilinear manner with *MVPA* (**1/1 studies;** Hjorth et al. 2014a). **BP Z-score:** favourable association (**1/1 studies;** Stabelini Neto et al. 2014). **Systolic BP:** associations were favourable (**4/9 studies;** Holman et al. 2011; Colley et al. 2012; Mendoza et al. 2012; Carson et al. 2013); null (**4/9 studies;** Leary et al. 2008; Hearst et al. 2012; Knowles et al. 2013; Chaput et al. 2013); or mixed (favourable and null; **1/9 studies;** Hurtig-Wennlof et al. 2007). **1 study** found a favourable association between *sporadic MVPA* and **systolic BP** (Holman et al. 2011). **Diastolic BP:** associations were favourable (**1/8 studies;** Chaput et al. 2013); null (**5/8 studies;** Leary et al. 2008; Colley et al. 2012; Mendoza et al. 2012; Hearst et al. 2012; Carson et al. 2013);or mixed (favourable and null; **2/8 studies;** Hurtig-Wennlof et al. 2007; Knowles et al. 2013). **Mean arterial BP:** null association (**1/1 studies;** Hjorth et al. 2014a). ***MPA:*** **BP Z-score:** favourable association (**1/1 studies;** Stabelini Neto et al. 2014). **Systolic BP:** null association (**1/1 studies;** Hay et al. 2012). ***LPA:*** **BP Z-score:** favourable association (**1/1 studies;** Stabelini Neto et al. 2014).	

								Systolic BP: null associations (**2/2 studies;** Hay et al. 2012; Carson et al. 2013). **Diastolic BP:** favourable association (**1/1 studies;** Carson et al. 2013). <u>Triglycerides (TG):</u> ***Meeting/Not Meeting Guidelines:*** *meeting PA guidelines*[q] had a null association with fasting **TGs** (**1/1 studies;** Janssen et al. 2013). ***Total PA:*** associations were favourable (**3/7 studies;** Andersen et al. 2006; Ekelund et al. 2006; Owen et al. 2010), null (**2/7 studies;** Chaput et al. 2013; Hjorth et al. 2014a), or mixed (favourable and null; **2/7 studies;** Wennlof et al. 2005; Hurtig-Wennlof et al. 2007). ***VPA:*** null association (**1/1 studies;** Stabelini Neto et al. 2014). ***MVPA:*** associations were favourable (**1/7 studies;** LeBlanc and Janssen 2010) or null (**6/7 studies;** Hurtig-Wennlof et al. 2007; Mendoza et al. 2012; Carson et al. 2013; Chaput et al. 2013; Hjorth et al. 2014a; Stabelini Neto et al. 2014). ***MPA:*** null association (**1/1 studies;** Stabelini Neto et al. 2014). ***LPA:*** null associations (**2/2 studies;** Carson et al. 2013; Stabelini Neto et al. 2014). <u>Cholesterol:</u> ***Meeting/Not Meeting Guidelines:*** **HDL cholesterol:** *meeting PA guidelines*[q] was favourably associated with HDL (**1/1 studies;** Janssen et al. 2013). ***Total PA:*** **Total cholesterol:** associations were favourable (**1/2 studies;** Andersen et al. 2006), or mixed (favourable and null; **1/2 studies;** Hurtig-Wennlof et al. 2007). **HDL cholesterol:** associations were favourable (**2/5 studies;** Chaput et al. 2013; Hjorth et al. 2014a) or null (**3/5 studies;** Andersen et al. 2006; Hurtig-Wennlof et al. 2007; Owen et al. 2010). ***VPA:*** **HDL cholesterol:** null associations (**1/1 studies;** Stabelini Neto et al. 2014). ***MVPA:*** **"High risk" cholesterol:** increased *MVPA* was associated with reduced odds (**1/1 studies;** LeBlanc and Janssen 2010). **Total cholesterol:** associations were favourable (**1/3 studies;** Hurtig-Wennlof et al. 2007) or null (**2/3 studies;** Hurtig-Wennlof et al. 2007; Mendoza et al. 2012).	

								HDL cholesterol: associations were favourable (**3/7 studies;** Mendoza et al. 2012; Chaput et al. 2013; Hjorth et al. 2014a) or null (**4/7 studies;** Hurtig-Wennlof et al. 2007; Hearst et al. 2012; Carson et al. 2013; Stabelini Neto et al. 2014). **Non-HDL cholesterol:** *MVPA* (total, bouts, sporadic) was favourably associated (**1/1 studies;** Holman et al. 2011). **LDL cholesterol:** null associations (**3/3 studies;** LeBlanc and Janssen 2010; Mendoza et al. 2012; Carson et al. 2013). ***MPA:*** **HDL cholesterol:** null associations (**1/1 studies;** Stabelini Neto et al. 2014). ***LPA:*** **HDL cholesterol:** associations were null (**1/2 studies;** Stabelini Neto et al. 2014) or mixed (favourable and null; **1/2 studies;** Carson et al. 2013). <u>Insulin Resistance:</u> ***Meeting/Not Meeting Guidelines:*** **HOMA:** *meeting PA guidelines*[q] had no impact on **HOMA** (**1/1 studies;** Janssen et al. 2013). ***Total PA:*** **HOMA:** associations were favourable (**5/6 studies;** Andersen et al. 2006; Rizzo et al. 2008; Sardinha et al. 2008; Owen et al. 2010; Hjorth et al. 2014a), or null (**1/6 studies;** Jimenez-Pavon et al. 2013c). **QUICKI:** null association (**1/1 studies;** Jimenez-Pavon et al. 2013c). ***VPA:*** **HOMA:** associations were favourable (**1/2 studies;** Rizzo et al. 2008) or null (**1/2 studies;** Jimenez-Pavon et al. 2013c). **QUICKI:** null association (**1/1 studies;** Jimenez-Pavon et al. 2013c). ***MVPA:*** **HOMA:** associations were favourable (**4/7 studies;** Rizzo et al. 2008; Sardinha et al. 2008; Hjorth et al. 2014a; Henderson et al. 2014), null (**3/7 studies;** Henderson et al. 2012; Carson et al. 2013; Jimenez-Pavon et al. 2013c). **QUICKI:** null association (**1/1 studies;** Jimenez-Pavon et al. 2013c). **Matsuda score:** null association (**1/1 studies;** Henderson et al. 2012). **HOMA-%S:** favourable association (**1/1 studies;** Carson et al. 2013). **OGTT results (**AUC I/G_{t30min} or AUC I/$G_{t120min}$): null associations (**1/1 studies;** Henderson et al. 2014).	

								MPA: **HOMA:** associations were favourable (**1/2 studies;** Rizzo et al. 2008), or null (**1/2 studies;** Jimenez-Pavon et al. 2013c). **QUICKI:** null association (**1/1 studies;** Jimenez-Pavon et al. 2013c). ***LPA:*** **HOMA:** associations were null (**4/4 studies;** Rizzo et al. 2008; Sardinha et al. 2008; Carson et al. 2013; Jimenez-Pavon et al. 2013c). **QUICKI:** null association (**1/1 studies;** Jimenez-Pavon et al. 2013c). **HOMA-%S:** null association (**1/1 studies;** Carson et al. 2013). <u>Fasting Insulin</u> ***Total PA:*** associations were favourable (**8/11 studies;** Brage et al. 2004a; Andersen et al. 2006; Ekelund et al. 2006; Butte et al. 2007b; Rizzo et al. 2008; Sardinha et al. 2008; Owen et al. 2010; Jimenez-Pavon et al. 2012), null (**1/11 studies;** Jimenez-Pavon et al. 2013c), or mixed (favourable and null) (**2/11 studies;** Wennlof et al. 2005; Hurtig-Wennlof et al. 2007). ***VPA:*** associations were favourable (**2/4 studies;** Rizzo et al. 2008; Jimenez-Pavon et al. 2012), or null (**2/4 studies;** Butte et al. 2007b; Jimenez-Pavon et al. 2013c). ***MVPA:*** associations were favourable (**5/9 studies;** Rizzo et al. 2008; Sardinha et al. 2008; Henderson et al. 2012; Jimenez-Pavon et al. 2012; Carson et al. 2013), null (**2/9 studies;** Mendoza et al. 2012; Jimenez-Pavon et al. 2013c), or mixed (favourable and null **2/9 studies;** Hurtig-Wennlof et al. 2007; Butte et al. 2007b). Butte et al. 2007b found that *5-* but not *10-min bouts of MVPA* were favourably associated with fasting insulin. ***MPA:*** associations were favourable (**1/3 studies;** Butte et al. 2007b), null (**1/3 studies;** Jimenez-Pavon et al. 2013c), or mixed (favourable and null; **1/3 studies;** Rizzo et al. 2008). ***LPA:*** associations were favourable (**1/5 studies;** Butte et al. 2007b), or null (**4/5 studies;** Rizzo et al. 2008; Sardinha et al. 2008; Carson et al. 2013; Jimenez-Pavon et al. 2013c). <u>Fasting Glucose</u> ***Total PA:*** associations were favourable (**3/7 studies;** Andersen et al. 2006; Ekelund et al. 2006; Rizzo et al. 2008), null (**3/7 studies;** Brage et al. 2004a; Chaput et al. 2013; Jimenez-Pavon et al. 2013c), or mixed (favourable and null; **1/7 studies;** Hurtig-Wennlof et al. 2007). ***VPA:*** associations were favourable (**1/3 studies;** Rizzo et al. 2008), or null (**2/3 studies;** Jimenez-Pavon et al. 2013c; Stabelini Neto et al. 2014).	

								MVPA: associations were favourable (**1/8 studies;** Rizzo et al. 2008), null (**6/8 studies;** Owen et al. 2010; Mendoza et al. 2012; Carson et al. 2013; Chaput et al. 2013; Jimenez-Pavon et al. 2013c; Stabelini Neto et al. 2014), or mixed (favourable and null) (**1/8 studies;** Hurtig-Wennlof et al. 2007). **1/1 studies** found no association between *MVPA* and **2-hr plasma glucose** (Carson et al. 2013). ***MPA:*** associations were favourable (**1/3 studies;** Rizzo et al. 2008), or null (**2/3 studies;** Jimenez-Pavon et al. 2013c; Stabelini Neto et al. 2014). ***LPA:*** associations were null (**4/4 studies;** Rizzo et al. 2008; Carson et al. 2013; Jimenez-Pavon et al. 2013c; Stabelini Neto et al. 2014). **1/1 studies** found no association with **2-hr plasma glucose** (Carson et al. 2013). <u>HbA1c</u> ***Total PA:*** null association (**1/1 studies;** Owen et al. 2010). ***MVPA:*** null association (**1/1 studies;** Mendoza et al. 2012). <u>Inflammatory Markers (CRP, TNF-α, IL-6, C3, C4)</u> ***Meeting/Not Meeting Guidelines:*** null association between *meeting PA guidelines*[r] and **CRP** (**1/1 studies;** Loprinzi et al. 2013). ***Total PA:*** **CRP:** null associations (**3/3 studies;** Owen et al. 2010; Martinez-Gomez et al. 2012; Loprinzi et al. 2013). **IL-6, TNF-α, C3** or **C4:** null associations (**1/1 studies;** Martinez-Gomez et al. 2012). ***VPA:*** **CRP**, **IL-6, TNF-α, C3** or **C4:** null associations (**1/1 studies;** Martinez-Gomez et al. 2012). ***MVPA:*** **CRP:** associations were favourable [increasing quartiles of *MVPA (total, bouts, sporadic)* were associated with reduced **CRP** (**1/5 studies;** Holman et al. 2011)], or null (**4/5 studies;** Mendoza et al. 2012; Martinez-Gomez et al. 2012; Carson et al. 2013; Loprinzi et al. 2013). *Bouts of MVPA* did not differ across CRP quartiles (**1/1 studies;** Loprinzi et al. 2013). **IL-6, TNF-α, C3** or **C4:** null associations (**1/1 studies;** Martinez-Gomez et al. 2012). ***MPA:*** **CRP**, **IL-6, TNF-α, C3** or **C4:** null associations (**1/1 studies;** Martinez-Gomez et al. 2012).	

								LPA: **CRP:** null associations (**1/1 studies;** Carson et al. 2013). <u>Alanine amino transferase:</u> ***Total PA*** did not differ by **ALT** status, and % of awake time spent in ***VPA***, ***MPA*** or ***LPA*** did not differ by **ALT** status (**1/1 studies;** Quiros-Tejeira et al. 2007). <u>Artery properties:</u> ***Total PA:*** negative association with **PWV** (**1/1 studies;** Sakuragi et al. 2009); null association with carotid **IMT** (**1/1 studies;** Lamotte et al. 2013). ***VPA:*** null associations with **IMT, carotid compliance, Young's elastic modules,** or **stiffness index** (**1/1 studies;** Ried-Larsen et al. 2013). ***MVPA:*** null associations with **IMT, carotid compliance, Young's elastic modules,** or **stiffness index** (**1/1 studies;** Ried-Larsen et al. 2013). <u>Rate Pressure Product:</u> ***Total PA, VPA***, or ***MPA****:* null associations (**1/1 studies;** Mota et al. 2012). <u>Cardiac sympathetic/parasympathetic modulation:</u> ***MVPA:*** positively associated with one index of **cardiac parasympathetic modulation** (root mean square of successive differences) but not associated with another (high frequency power), and negatively associated with **sympathetic-parasympathetic balance** (**1/1 studies;** Gutin et al. 2005b). <u>Homocysteine</u> ***Total PA, MVPA, VPA*** or ***MPA:*** null associations (**1/1 studies;** Ruiz et al. 2007). <u>Composite Cardiometabolic Disease Risk Score</u> ***Meeting/Not Meeting Guidelines:*** *meeting PA guidelines*[q,s] was associated with reduced **cardiometabolic risk score** (**2/2 studies;** Mendoza et al. 2012; Janssen et al. 2013); achieving 10,000 steps/day was not associated with different odds of having any number of **cardiovascular risk factors** (**1/1 studies;** Schofield et al. 2009). ***Total PA:*** associations were favourable (**3/7 studies;** Brage et al. 2004b; Ekelund et al. 2009; Jimenez-Pavon et al. 2013b), or null (**4/7 studies;** Rizzo et al. 2007; Schofield et al. 2009; Moreira et al. 2011;	

								Hjorth et al. 2014a). **1/1 studies** found that *lower mean cadence values* were associated with larger accrued **numbers of risk factors** (Barreira et al. 2013). ***VPA:*** associations were favourable (**1/2 studies;** Jimenez-Pavon et al. 2013b), or null (**1/2 studies;** Stabelini Neto et al. 2014). ***MVPA:*** associations were favourable (**6/8 studies;** Ekelund et al. 2006; Nguyen et al. 2010; Holman et al. 2011; Carson and Janssen 2011; Jimenez-Pavon et al. 2013b; Stabelini Neto et al. 2014), null (**1/8 studies;** Hjorth et al. 2014a), or mixed (favourable and null; **1/8 studies;** Rey-Lopez et al. 2013). **1 study** found that the odds of a high cardiometabolic risk score decreased in a graded dose-response manner across quartiles of *sporadic MVPA* or *bout MVPA*, with similar associations for some individual cardiometabolic disease risk factors (non-HDL cholesterol, CRP, systolic BP) (Holman et al. 2011). ***MPA:*** favourable associations (**2/2 studies;** Jimenez-Pavon et al. 2013b; Stabelini Neto et al. 2014). ***LPA:*** null association (**1/1 studies;** Stabelini Neto et al. 2014**).**	

Note: ALT = alanine amino transferase; AUC I/G_{t30min} and AUC $I/G_{t120min}$ = area under the curve of the ratio of insulin to glucose at 30 and 120 min post-oral glucose tolerance test; BP = blood pressure; C3 and C4 = complement factors 3 and 4; CRP = C-reactive protein; HbA1c = glycosylated hemoglobin; HDL = high density lipoprotein cholesterol; HOMA = homeostatic model assessment insulin resistance; HOMA-%S = insulin sensitivity; IL-6 = interleukin-6; IMT = intima media thickness; LDL = low density lipoprotein cholesterol; LPA = light intensity physical activity; MPA = moderate intensity physical activity; MVPA = moderate-to-vigorous physical activity; OGTT = oral glucose tolerance test; PA = physical activity; PWV = pulse wave velocity; QUICKI = quantitative insulin sensitivity check index; RPP = rate-pressure product; sporadic MVPA = <5 consecutive minutes of moderate-to-vigorous physical activity; TG = triglycerides; TNF-α = tumor necrosis factor alpha; VPA = vigorous intensity physical activity.

[a] Includes **2 studies** (Kriemler et al. 2010; Meyer et al. 2014) from one cluster randomized controlled trial ("Kinder-und Jugendsportstudie''; KISS). Results are reported separately and participants are only counted once.
[b] Serious indirectness. Indirect comparisons: different durations and intensities of PA were not compared.
[c] MVPA (but not total PA) was significantly greater in the intervention vs control group at post-intervention (post 9-month intervention group difference of ~11 min/day) (Kriemler et al. 2010); there was a trend toward higher levels of total PA (but not MVPA) in the intervention vs control group at 3-yr follow-up (Cohen's d = 0.35, p=0.06; not significant) (Meyer et al. 2014).
[d] The quality of the evidence from the randomized study was downgraded from "high" to "moderate" due to serious indirectness of the interventions and the comparisons being assessed.
[e] Includes **1 non-randomized intervention study** (Rowland et al. 1996).
[f] Serious risk of bias. PA outside of prescribed intervention was not controlled (e.g. sports teams/recreational programs) or measured, and it is unclear whether activity external to the intervention changed over the course of the study and/or may have influenced the results. Dietary analysis in a subset of non-randomly selected subjects (n=11) showed a decrease in caloric intake in the intervention vs control period (potentially important confounder) (Rowland et al. 1996).
[g] Serious indirectness. Indirect comparisons: different durations and intensities of physical activity were not compared.
[h] Training intensity estimated by HR monitor; mean HR during the training sessions was 174.4, SD = 10 bpm (Rowland et al. 1996).
[i] The quality of the evidence from the non-randomized study was downgraded from "low" to "very low" due to: (1) serious risk of bias in the included study that diminished the level of confidence in the observed effects, and (2) serious indirectness of comparisons.
[j] Includes **7 longitudinal studies** (Telford et al. 2009; Hallal et al. 2011; Telford et al. 2012a; Knowles et al. 2013; Hjorth et al. 2014a; Carson et al. 2014; de Moraes et al. 2015) from **6 unique samples**. **Two studies** reported data from the LOOK study (Telford et al. 2009; Telford et al. 2012a); results are reported separately and participants are only counted once.
[k] Serious risk of bias. Participants were divided into intervention (community-based healthy lifestyle promotion) and control (no treatment) groups, but possible group-effects were not considered and all analysis was reported pooled across groups (de Moraes et al. 2015). Sixty-eight percent of participants did not provide valid baseline accelerometer data or did not have complete cardiometabolic risk factor data at baseline and/or follow-up; reasons for missing data were not reported; those lost to follow-up were older, heaver and displayed lower cardiorespiratory fitness than those included at follow-up (Carson et al. 2014). Those included in analysis represent only ~10% of the total cohort (Hallal et al. 2011).
[l] Cut-point for "meeting" PA guidelines was ≥60 min MVPA/day (de Moraes et al. 2015).

[m] The quality of the evidence from longitudinal studies was downgraded from "low" to "very low" due to serious risk of bias in three studies that diminished the level of confidence in the observed effects.

[n] Includes **47 cross-sectional studies** (Brage et al. 2004a; Brage et al. 2004b; Wennlof et al. 2005; Gutin et al. 2005b; Andersen et al. 2006; Ekelund et al. 2006; Hurtig-Wennlof et al. 2007; Rizzo et al. 2007; Ruiz et al. 2007; Quiros-Tejeira et al. 2007; Butte et al. 2007b; Rizzo et al. 2008; Sardinha et al. 2008; Leary et al. 2008; Mark and Janssen 2008; Sakuragi et al. 2009; Ekelund et al. 2009; Schofield et al. 2009; Owen et al. 2010; LeBlanc and Janssen 2010; Nguyen et al. 2010; Holman et al. 2011; Carson and Janssen 2011; Moreira et al. 2011; Hay et al. 2012; Mota et al. 2012; Colley et al. 2012; Henderson et al. 2012; Mendoza et al. 2012; Jimenez-Pavon et al. 2012; Martinez-Gomez et al. 2012; Hearst et al. 2012; Barreira et al. 2013; Rey-Lopez et al. 2013; Carson et al. 2013; Janssen et al. 2013; Lamotte et al. 2013; Knowles et al. 2013; Chaput et al. 2013; Ried-Larsen et al. 2013; Loprinzi et al. 2013; Jimenez-Pavon et al. 2013b; Jimenez-Pavon et al. 2013c; Hjorth et al. 2014a; Stabelini Neto et al. 2014; Henderson et al. 2014; de Moraes et al. 2015) from **20 unique samples**. **Two studies** reported data from the CHMS (Colley et al. 2012; Janssen et al. 2013); **12 studies** reported data from the EYHS (Brage et al. 2004a; Brage et al. 2004b; Wennlof et al. 2005; Andersen et al. 2006; Ekelund et al. 2006; Hurtig-Wennlof et al. 2007; Rizzo et al. 2007; Ruiz et al. 2007; Rizzo et al. 2008; Sardinha et al. 2008; Ekelund et al. 2009; Ried-Larsen et al. 2013); **5 studies** reported data from HELENA (Jimenez-Pavon et al. 2012; Martinez-Gomez et al. 2012; Rey-Lopez et al. 2013; Lamotte et al. 2013; Jimenez-Pavon et al. 2013c); **2 studies** reported data from IDEFICS (Jimenez-Pavon et al. 2013b; de Moraes et al. 2015); **8 studies** reported data from NHANES (Mark and Janssen 2008; LeBlanc and Janssen 2010; Holman et al. 2011; Carson and Janssen 2011; Mendoza et al. 2012; Barreira et al. 2013; Carson et al. 2013; Loprinzi et al. 2013); **3 studies** reported data from QUALITY (Henderson et al. 2012; Chaput et al. 2013; Henderson et al. 2014); **2 studies** reported data from Viva la Familia (Quiros-Tejeira et al. 2007; Butte et al. 2007b); results are reported separately and participants are only counted once.

[o] Serious risk of bias. Participants were divided into intervention (community-based healthy lifestyle promotion) and control (no treatment) groups, but possible group-effects were not considered and all analysis was reported pooled across groups (de Moraes et al. 2015). Many studies had a large amount of missing data, or did not report sufficient information to determine the proportion of missing data (Gutin et al. 2005b; Andersen et al. 2006; Hurtig-Wennlof et al. 2007; Rizzo et al. 2007; Rizzo et al. 2008; Mark and Janssen 2008; Ekelund et al. 2009; LeBlanc and Janssen 2010; Holman et al. 2011; Carson and Janssen 2011; Mota et al. 2012; Mendoza et al. 2012; Carson et al. 2013; Janssen et al. 2013; Ried-Larsen et al. 2013; Jimenez-Pavon et al. 2013b; Stabelini Neto et al. 2014). Possible detection bias as participants were retained if they provided PA data for at least 1-7 days; 68% provided at least 5 days of PA data and at 32% provided 1-4 days; PA levels were slightly higher in those with fewer days of PA data; MVPA and LPA were recorded but not reported (Owen et al. 2010). Participants with missing data differed from those included in the analysis on some outcome measures (Andersen et al. 2006; Jimenez-Pavon et al. 2013c). Potential failure to adjust for relevant confounders (Barreira et al. 2013). No information provided regarding criteria for valid exposure measurement; possible detection bias (Quiros-Tejeira et al. 2007). Possible selective reporting bias (systolic BP reported in absence of diastolic BP); not possible to discern which potentially important confounders were included in the analyses (Hay et al. 2012). Possible detection bias; participants were excluded from the study if they did not wear the pedometer for >4 hours in total over the full 4 days of data collection (Schofield et al. 2009).

[p] Exposure/outcome gradients were observed in **4 studies** (Andersen et al. 2006; Mark and Janssen 2008; Holman et al. 2011; Hay et al. 2012) from **3 unique samples**.

[q] Cut-point for "meeting" PA guidelines was ≥ 60 min MVPA/day (Janssen et al. 2013; de Moraes et al. 2015).

[r] Cut-point for "meeting" PA guidelines was ≥ 60 min of at least moderate intensity PA, daily (1 min bouts) (Loprinzi et al. 2013).

[s] Cut-point for "meeting" PA guidelines was ≥ 60 min MVPA/day on 5 of 7 days (Mendoza et al. 2012).

[t] The quality of evidence from cross-sectional studies was downgraded from "low" to "very low" due to serious risk of bias in 24 studies that diminished the level of confidence in the observed effects.

Table 1.1.3. The relationship between physical activity and physical fitness.
Note: Text in blue is the number after the Australian update

No. of studies	Design	Quality Assessment					No. of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
The range of mean ages was 6.9 to 16.0 years. Data were collected by RCT, non-randomized intervention trial, cross-sectionally and up to 3.75 years of follow-up. Fitness was assessed as: aerobic fitness (VO_2max, VO_2peak, CRF), muscular strength, coordination, shoulder mobility and endurance, and flexibility. All outcomes were measured objectively.									
~~6~~7	Randomized Trials[a]	Serious risk of bias[b]	No serious inconsistency	Serious indirectness[c]	No serious imprecision	None	~~1113~~ 1,483	**Aerobic fitness:** **~~2~~3 studies** reported a favourable effect of PA interventions on aerobic fitness at post-test (Kriemler et al. 2010; Cohen et al. 2015) and 6-month and 2-year follow-up (Eather et al. 2013; Meyer et al. 2014); **2 studies** reported no effect (Verstraete et al. 2007; Finkelstein et al. 2013).[d] **Muscular strength and endurance:** **1 study** reported a favourable effect of PA interventions on upper and lower-body muscular fitness at post-test; these differences were no longer significant after 3 months (Meinhardt et al. 2013); **1 study** reported no effect at post-test (Verstraete et al. 2007); **1 study** reported mixed favourable and null findings at 6-month follow up (Eather et al. 2013). **Flexibility:** **1 study** reported no effect at post-test (Verstraete et al. 2007); **1 study** reported a favourable effect of PA on flexibility at 6-month follow-up (Eather et al. 2013).	LOW[e]
~~3~~8	NRT[f]	Serious risk of bias[g]	No serious inconsistency	Serious indirectness[h]	No serious imprecision	None	~~242~~ 5,336	**Aerobic Fitness:** **1 study** reported no effect of PA intervention on aerobic fitness (Rowland et al. 1996); **~~1 study~~4 studies** reported a favourable effect of PA intervention for INT compared with CTRL (Dimitriou et al. 2011; Buchele 2018;Brusseau et al 2016, Chesham et al. 2018); **1 study** reported mixed effects of PA intervention on aerobic fitness across subsamples at post-test (favourable effect for Grade 6 children but not Grade 1 to 5) (Burns et al. 2017); and **1 study** reported no differential effect of PA intervention on aerobic fitness between INT and CTRL, however the intervention group decreased from baseline to post-test (Shore et al. 2014). **Muscular Strength and Endurance:** **1 study** reported a favourable effect of PA intervention on upper-body strength for INT compared with CTRL (Dimitriou et al. 2011); **1 study** reported a favourable effect of PA intervention on endurance, co-ordination and shoulder mobility (Postler et al 2017); and **1 study** reported no differential effect of PA intervention on muscular fitness, however the control group	VERY LOW[i]

								improved upper-body strength from baseline to post-test (Shore et al. 2014). **Flexibility:** **1 study** reported a favourable differential effect of PA intervention for INT compared with CTRL (Dimitriou et al. 2011). **1 study** reported no differential effect of a PA intervention on flexibility, and an increase from baseline to post-test for the intervention group (Shore et al. 2014).	
~~1~~2	Longitu-dinal[j]	No serious risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision[k]	Dose response gradient[l]	~~315~~630	**Aerobic fitness:** There was a favourable, dose-response gradient between **VPA** and aerobic fitness, and no association between **LPA** or **MPA** and aerobic fitness in ~~1~~ **2 longitudinal study** (Carson et al. 2014; Santos et al. 2018).	VERY LOW[m]
28	Cross-sectional[n]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	14,985	**Aerobic fitness:** **Meeting/Not Meeting PA Guidelines (≥60 min/day MVPA):** favourable associations (**3/3 studies;** Ortega et al. 2008; Martinez-Gomez et al. 2010a; Silva et al. 2013). **Total PA:** associations were favourable (**14/18 studies;** Eiberg et al. 2005; Andersen et al. 2006; Ruiz et al. 2006; Butte et al. 2007b; Hands et al. 2009; Schofield et al. 2009; Ruiz et al. 2011; Machado-Rodrigues et al. 2012; Martinez-Gomez et al. 2012; Hjorth et al. 2013; Lambourne et al. 2013; Larouche et al. 2014; Hansen et al. 2014; Saavedra et al. 2014), or mixed (favourable and null; **4/18 studies;** Rizzo et al. 2007; Dencker et al. 2010; Kristensen et al. 2010; Jimenez-Pavon et al. 2013c).[o] **VPA:** associations were favourable (**11/12 studies;** Gutin et al. 2005a; Ruiz et al. 2006; Rizzo et al. 2007; Butte et al. 2007b; Lohman et al. 2008; Martinez-Gomez et al. 2010a; Kristensen et al. 2010; Ottevaere et al. 2011; Hay et al. 2012; Martinez-Gomez et al. 2012; Jimenez-Pavon et al. 2013c), or mixed (favourable and null; **1/12 studies;** Dencker et al. 2010).[p] **MVPA:** associations were favourable (**14/16 studies;** Eiberg et al. 2005; Gutin et al. 2005a; Ruiz et al. 2006; Butte et al. 2007b; Ortega et al. 2008; Lohman et al. 2008; Martinez-Gomez et al. 2010a; Ruiz et al. 2011; Ottevaere et al. 2011; Machado-Rodrigues et al. 2012; Martinez-Gomez et al. 2012; Hjorth et al. 2013; Silva et al. 2013; Santos et al. 2014), or mixed (favourable in boys, null in girls; **2/16 studies;** Dencker et al. 2010; Jimenez-Pavon et al. 2013c).[q] *Bouts of MVPA* were favourably associated with aerobic fitness in **2/2 studies** (Eiberg et al. 2005; Butte et al. 2007b).	LOW[u]

								MPA: associations were favourable (**5/9 studies;** Gutin et al. 2005a; Ruiz et al. 2006; Martinez-Gomez et al. 2010; Dencker et al. 2010; Ottevaere et al. 2011), mixed favourable and null (**2/9 studies;** Rizzo et al. 2007; Butte et al. 2007b), or null (**2/9 studies;** Hay et al. 2012; Martinez-Gomez et al. 2012).[r] **LPA:** associations were favourable (**1/6 studies;** Martinez-Gomez et al. 2010a), mixed favourable and null (**1/6 studies;** Butte et al. 2007b), or null (**4/6 studies;** Dencker et al. 2010; Hay et al. 2012; Machado-Rodrigues et al. 2012; Jimenez-Pavon et al. 2013c). **Muscular Strength and Endurance** **Total PA:** associations were favourable (**2/4 studies;** Martinez-Gomez et al. 2012; Larouche et al. 2014), mixed favourable and null (**1/4 studies;** Hands et al. 2009), or null (**1/4 studies;** Moliner-Urdiales et al. 2010).[s] **VPA:** associations were favourable (**1/2 studies;** Martinez-Gomez et al. 2012), or mixed favourable and null (**1/2 studies;** Moliner-Urdiales et al. 2010). **MVPA:** associations were favourable (**1/3 studies;** Martinez-Gomez et al. 2012), or mixed favourable and null (**2/3 studies;** Moliner-Urdiales et al. 2010; Aggio et al. 2015).[t] **MPA:** null associations (**2/2 studies;** Moliner-Urdiales et al. 2010; Martinez-Gomez et al. 2012). **LPA:** associations were null (**1/2 studies;** Moliner-Urdiales et al. 2010), or mixed null and unfavourable (**1/2 studies;** Aggio et al. 2015). **Flexibility** **Total PA:** associations were mixed favourable and null (**1/2 studies;** Hands et al. 2009) or null (**1/2 studies;** Larouche et al. 2014). **MVPA:** favourable associations (**1/1 studies;** Aggio et al. 2015). **LPA:** null associations (**1/1 studies;** Aggio et al. 2015).	

Note: CRF = cardiorespiratory fitness; LPA = light physical activity; MVPA = moderate-to-vigorous physical activity; NRT = non-randomized trial; PA = physical activity; RCT = randomized controlled trial; VO_2max = maximal oxygen uptake; VO_2peak = peak oxygen uptake; VPA = vigorous physical activity.

[a] Includes **6 RCT studies** (Verstraete et al. 2007; Kriemler et al. 2010; Meinhardt et al. 2013; Finkelstein et al. 2013; Eather et al. 2013; Meyer et al. 2014) from **5 unique samples**. Kriemler et al. 2010 and Meyer et al. 2014 both report data from the KISS Study. Results are reported separately and participants are only counted once.

[b] Serious risk of bias. Unclear method of randomization for sibling pairs; allocation concealment unlikely; missing pedometer data disproportionately high in controls relative to intervention group (18.1% vs 6.1%), likely due to incentives for wear time offered to the intervention group only; control group wore sealed pedometers while intervention group wore unsealed pedometers; 6-min walk test assessors were not blinded to group assignment (Finkelstein et al. 2013). No allocation concealment, which was likely to contaminate the control group (Meinhardt et al. 2013). Teachers of control group classes were aware of intervention arm but not its content; drop-outs were older and had higher adiposity than adherers and differences likely to be related to outcome of interest (Meyer et al. 2014).

[c] Serious indirectness. Differences in intervention: randomized trials examined various types of physical activity programs and provided indirect evidence bearing on the potential effectiveness of different intensities and durations of physical activity. Indirect comparisons: different durations and intensities of physical activity were not compared.

[d] MVPA (but not total PA) was significantly greater in the intervention vs control group at post-intervention (post 9-month intervention group difference of ~11 min/day) (Kriemler et al. 2010); there was a trend toward higher levels of total PA (but not MVPA) in the intervention vs control group at 3-yr follow-up (Cohen's d = 0.35, p=0.06; not significant) (Meyer et al. 2014).

[e] The quality of evidence from randomized studies was downgraded from "high" to "low" due to: (1) a serious risk of bias in three studies that diminished the level of confidence in the observed effects, and (2) serious indirectness of the interventions and the comparisons being assessed.

[f] Includes **1 non-randomized controlled trial** (Shore et al. 2014), **1 community trial** (Dimitriou et al. 2011), and **1 uncontrolled trial** (Rowland et al. 1996).

[g] Serious risk of bias. No inclusion/exclusion criteria established; inadequate reporting of recruitment, allocation concealment, and blinding; large unexplained loss to follow-up (36.5% retention) and unknown if follow-up differed by group allocation (Shore et al. 2014); selective reporting bias: reported use of PACER to measure aerobic fitness but did not report in results (Dimitriou et al. 2011).

[h] Serious indirectness. Differences in intervention: non-randomized trials examined various types of physical activity programs and provided indirect evidence bearing on the potential effectiveness of different intensities and durations of physical activity. Indirect comparisons: different durations and intensities of physical activity were not compared.

[i] The quality of evidence from randomized studies was downgraded from "high" to "low" due to: (1) a serious risk of bias in two studies that diminished the level of confidence in the observed effects, and (2) serious indirectness of the interventions and the comparisons being assessed.

[j] Includes **1 longitudinal study** (Carson et al. 2014).

[k] Serious imprecision. Wide confidence intervals for dose-response trend (Carson et al. 2014).

[l] There was a positive, dose-response gradient between VPA and aerobic fitness (Carson et al. 2014).

[m] The quality of evidence from the longitudinal study was downgraded from "low" to "very low" due to imprecision (wide confidence intervals), and because of this limitation was not upgraded for the dose-response trend.

[n] Includes **28 cross-sectional studies** (Eiberg et al. 2005; Gutin et al. 2005a; Andersen et al. 2006; Ruiz et al. 2006; Rizzo et al. 2007; Butte et al. 2007b; Ortega et al. 2008; Lohman et al. 2008; Hands et al. 2009; Schofield et al. 2009; Martinez-Gomez et al. 2010a; Dencker et al. 2010; Kristensen et al. 2010; Moliner-Urdiales et al. 2010; Ruiz et al. 2011; Ottevaere et al. 2011; Hay et al. 2012; Machado-Rodrigues et al. 2012; Martinez-Gomez et al. 2012; Hjorth et al. 2013; Lambourne et al. 2013; Silva et al. 2013; Jimenez-Pavon et al. 2013c; Larouche et al. 2014; Santos et al. 2014; Hansen et al. 2014; Saavedra et al. 2014; Aggio et al. 2015) from **17 unique samples**. **Five studies** report data from the EYHS (Andersen et al. 2006, Ruiz et al. 2006; Ortega et al. 2008; Rizzo et al. 2008; Kristensen et al. 2010); **6 studies** report data from HELENA (Martinez-Gomez et al. 2010a; Moliner-Urdiales et al. 2010; Ottevaere et al. 2011; Ruiz et al. 2011; Martinez-Gomez et al. 2012; Jimenez-Pavon et al. 2013c); **2 studies** report data from the CoSCIS study (Eiberg et al. 2005; Dencker et al. 2010). Data are reported separately and participants are only counted once.

[o] Positive associations between Total PA and aerobic fitness were found in the total sample (Eiberg et al. 2005; Andersen et al. 2006; Ruiz et al. 2006; Rizzo et al. 2007; Ruiz et al. 2011; Martinez-Gomez et al. 2012), in boys but not girls (Dencker et al. 2010; Jimenez-Pavon et al. 2013c), and in 9 year olds but not 15 year olds (Kristensen et al. 2010).

[p] Dencker et al. (2010) reported a positive association between VPA and aerobic fitness for boys, but not girls.

[q] Positive associations were reported between MVPA and aerobic fitness in the total sample (Eiberg et al. 2005; Martinez-Gomez et al. 2010a; Ruiz et al. 2011; Ottevaere et al. 2011; Martinez-Gomez et al. 2012) , and in boys but not girls in subdivided samples (Dencker et al. 2010; Jimenez-Pavon et al. 2013b).

[r] From the HELENA cohort, Martinez-Gomez et al. (2010a) and Ottevaere et al. (2011) reported positive associations for MPA and aerobic fitness in total sample, Martinez-Gomez et al. (2012) reported a null association, and Jimenez Pavon et al. (2013c) reported a positive association for boys, not girls. From the Viva la Familia study, Butte et al. (2007b) reported positive associations when controlling for BMI z-score but not %FM.

[s] Total PA was positively associated with standing broad jump and not associated with upper body- and other lower body strength and endurance in boys, and not associated with any muscular fitness outcome in girls (Moliner-Urdiales et al. 2010); No correlation with abdominal muscle endurance (curl-ups) or upper body strength, but high tertiles of total PA had better upper body strength (grip strength) (Hands et al. 2009).

[t] MVPA was positively associated with lower body strength but not upper body strength in one study (Aggio et al. 2015), and not associated with upper and lower body strength in boys and girls, with the exception of a positive association for standing broad jump for boys (Moliner-Urdiales et al. 2010).

[u] The quality of evidence from randomized studies remained as "low" as there were no serious concerns about the quality of included cross-sectional studies or reasons to rate-up.

Table 1.1.4. The relationship between physical activity and behavioural conduct/pro-social behaviour.
Note: Text in blue is the number after the Australian update

No. of studies	Design	Quality Assessment					No. of participants	Absolute Effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
The range of mean age was 6.0 to 11.15 years; data were collected by RCT, non-randomized intervention trials, cross-sectionally and up to 4 years of follow-up. Prosocial behaviour, conduct problems and peer problems were assessed via the Strengths and Difficulties Questionnaire, Effort and time on task were assessed via the Classroom Behavior and Assets Scale, Social acceptance was assessed via Harter's Self-perception Profile for Children and time in play and social skills were assessed via The Social Skills Improvement System Rating Scale and The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children. All outcomes were measured objectively.									
1	Cross-sectional[a]	Serious risk of bias[b]	No serious inconsistency	No serious indirectness	No serious imprecision	None	652	There was no association between *total PA* and **prosocial behaviour**, **peer problems**, **social acceptance** or **conduct problems** for boys or girls (Sebire et al. 2011). *MVPA* was favourably correlated with **peer problems** and **social acceptance** (in boys, not girls). *MVPA* was favourably associated with **prosocial behaviour** (in girls, not boys). *MVPA* was not associated with **conduct problems** in boys or girls.	VERY LOW[c]
1	RCT[d]	Serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	226	There was no effect of MVPA on time in play and social skills (Bundy et al. 2017).	HIGH
1	NRT[e]	Serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	1,322	There were positive effects of MVPA on effort and time on task (Carlson et al. 2015)	VERY LOW
1	Longitudinal[f]	Serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	7,704	PA associated with fewer peer problems. MVPA– unfavourable association with conduct hyperactivity problems (boys & girls) & conduct problems (boys only) (Ahn et al. 2018)	VERY LOW

Note: MVPA = moderate-to-vigorous physical activity; PA = physical activity

[a] Includes **1 cross-sectional study** (Sebire et al. 2011).
[b] Serious risk of bias. Complete data for only 66% of participants; no indication that data were missing at random. Internal consistency of the scales was questionable (alpha = 0.60 to 0.66).
[c] The quality of evidence from this cross-sectional study was downgraded from "low" to "very low" due to a serious risk of bias that diminished the level of confidence in the observed effects.
[d] Includes **1 RCT study** (Bundy et al. 2017)
[e] Includes **1 NRT study** (Carlson et al. 2015)
[f] Includes **1 longitudinal study** (Ahn et al. 2018)

Table 1.1.5. The relationship between physical activity and cognition/academic achievement.
Note: Text in blue is the number after the Australian update

No. of studies	Design	Quality Assessment				No of participants	Absolute Effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision			
The range of mean ages was 7.8 to 16.9 years. Data were collected by RCT, non-randomized intervention trial, cross-sectionally and up to ~~5~~ 6 years of follow-up. Cognitive Development / Academic Achievement were assessed by: WIAT-III, TEA-Ch, CDR, computerized cognitive assessment system, d2 Test of Attention, Letter Digit Substitution Test, BAS, Trail Making Test, Stroop Color and Word Test, Verbal Fluency Test, WISC-IV, WAI, OSPAN, The Tower of London, school records and GPA, and state or national level standardized tests. Mathematics Engagement was assessed using School Engagement Measure. On-task Behaviour was assessed through systematic direct observation. All outcomes were measured objectively.								
4	RCT	Serious risk of bias	No serious inconsistency	Serious indirectness	No serious imprecision	2,847	**On-task behaviour** **3 studies** found positive effects of PA intervention on on-task behaviour (Bartholomew et al. 2018; Riley et al. 2016; Grieco et al. 2016). **Cognition** **1 study** found no difference between PA intervention and control groups for **content recall** (Norris et al. 2015). **Academic achievement** **1 study** found no change on **mathematical test performance** following the PA intervention (Riley et al. 2016).	MODERATE[m]
~~1~~5	NRT[a]	Serious risk of bias[b]	No serious inconsistency	Serious indirectness[c]	No serious imprecision	~~92~~547	**On-task behaviour** **2/3 studies** showed positive effects of PA intervention on **on-task behaviour** (Goh 2017; Mullender-Wijnsma et al. 2015); **1/3 studies** showed no effects of PA intervention **on on-task behaviour** (Wilson et al. 2016). **Cognition** **2 studies** showed no effects of PA intervention on **sustained attention** or executive function text performance (**processing speed, selective attention**) (Wilson et al. 2016; van den Berg et al. 2016). **Academic Achievement** **GPA** increased in both groups, but there were no between-group differences (Shore et al. 2014).[d]	VERY LOW[e]
~~3~~9	Longitudinal [f]	Serious risk of bias[g]	No serious inconsistency	No serious indirectness	No serious imprecision	~~5,440~~ 15,460	**Academic Achievement** **School Grades** *%MVPA* at age 11 yr was favourably associated with **English** (but not **Math** or **Science**), and with academic attainment at age 13 and 16 in boys and girls (association also significant for **Science** in girls at age 16 yr) (Booth et al. 2014). **1 study** found null association between *MVPA* and **Grade based points** (Corder et al. 2015). **Standardized tests** 1 study found *PA index* was favourably associated with **writing** score, but not **reading** or **numeracy** (Telford et al. 2012b).	VERY LOW[h]

							1 study found that changes in *MVPA* had mixed favourable (in girls) and null (in boys) associations with changes in **NAPLAN test scores** (Owen et al. 2018). **1 study** found null associations between *total PA (cpm)* or *% time in MVPA* with **numeracy, reading** and **English** (Aadland et al. 2017). **Cognition** **Executive function tests (CDR):** **1 study** found no association between *total PA* or *% time in MVPA* at age 11 yr and test speed or accuracy at age 13. In boys, *%MVPA* (adjusted for total PA) was favourably associated with accuracy, but not speed. In girls, no association with speed or accuracy (Booth et al. 2013). **1 study** found no associations between *total PA (cpm)* or *% time in MVPA* with **inhibition, working memory** and **cognitive flexibility** (Aadland et al. 2017). **1 study** found unfavourable associations between *LPA* and **verbal reasoning** and **verbal knowledge**, while mixed unfavourable and null associations for *MVPA* (Aggio et al. 2016). **1 study** found mixed unfavourable (in girls) and null (in boys) associations between *LPA* and **fluid intelligence**; and mixed unfavourable (in boys) and null (in girls) associations between *VPA* and **inhibitions** (Wickel et al. 2017). **1 study** found null associations between *LPA* with **inhibition** and **working memory**, between *MPA or MVPA* **with inhibition, working memory** and **fluid intelligence**; and between *VPA* with **working memory** and **intelligence** (Wickel et al. 2017) **Mathematics Engagement** **1 study** found that changes in *MVPA* had null association with changes in **mathematics engagement** (Owen et al. 2018a). **1 study** found null associations between *LPA, MPA, VPA* and *MVPA* with **mathematics engagement**. (Owen et al. 2018b) **1 study** found mixed favourable associations between *MPA* and **cognitive engagement**, and null associations with **behavioural, emotional and overall school engagement**. (Owen et al. 2018b)	
6	Cross-sectional[i]	Serious risk of bias[j]	Serious inconsistency[k]	No serious indirectness	No serious imprecision	11,996	**Academic Achievement** **Standardized tests** **Total PA** **2/2 studies** reported no association between *total PA* and WIAT-III (Lambourne et al. 2013; Hansen et al. 2014). **MPA, MVPA, VPA** **1/3 studies** reported mixed unfavourable and null associations between *MVPA* and **state Math test** performance with inconsistencies occurring across samples (Young et al. 2014).	VERY LOW[l]

							1/3 studies reported mixed favourable and null associations, with *%MVPA* favourably associated with **English** (but not **Math** or **Science**) scores in boys, and **English** and **Science** (but not **Math**) scores in girls (Booth et al. 2014). **School Grades** **1/3 studies** found *MPA, MVPA* and *VPA* were unfavourably associated with **Math** and **Language scores,** and **GPA** (Esteban-Cornejo et al. 2014). **<u>Cognition</u>** **Total PA and MVPA** **Executive function tests (TEA-Ch, CDR)** **1/1 studies** reported mixed null and favourable associations between *total PA* or *%MVPA* and **test speed and accuracy** (Booth et al. 2013).	

Note: CDR = Cognitive Drug Research; GPA = grade point average; MPA = moderate intensity physical activity; MVPA = moderate-to-vigorous physical activity; NRT = non-randomized trial; PA = physical activity; TEA-Ch = Test of Everyday Attention for Children; VPA = vigorous intensity physical activity; WIAT-III = Weschsler Individual Achievement Test of oral language, written language and mathematics-Third Edition.

[a] Includes **1 non-randomized trial** (Shore et al. 2014).
[b] Serious risk of bias. No inclusion/exclusion criteria established; inadequate reporting of recruitment, allocation concealment, and blinding; large unexplained loss to follow-up (36.5% retention) and unknown if follow-up differed by group allocation (Shore et al. 2014).
[c] Serious indirectness. Differences in intervention: studies examined PE class content and provided indirect evidence bearing on the potential effectiveness of different intensities and durations of PA. Indirect comparisons: different durations and intensities of PA were not compared within individual studies.
[d] The intervention group increased steps/day (baseline to post-intervention: 9692 to 12307) more than the control group (9420 to 10608) (Shore et al. 2014).
[e] The quality of evidence from the non-randomized study was downgraded from "low" to "very low" due to: (1) a serious risk of bias that diminished the level of confidence in the observed effects, and (2) serious indirectness of the intervention and the comparison being assessed.
[f] Includes **3 longitudinal studies** (Telford et al. 2012b; Booth et al. 2013; Booth et al. 2014) from **2 unique samples**. **Two studies** reported data from the ALSPAC sample (Booth et al. 2013; Booth et al. 2014); results are reported separately and participants are only counted once.
[g] Serious risk of bias. Validity and reliability of outcomes unknown (Telford et al. 2012b; Booth et al. 2013; Booth et al. 2014).
[h] The quality of evidence from the longitudinal studies was downgraded from "low" to "very low" due to a serious risk of bias that diminished the level of confidence in the observed effects.
[i] Includes **6 cross-sectional studies** (Lambourne et al. 2013; Booth et al. 2013; Esteban-Cornejo et al. 2014; Young et al. 2014; Booth et al. 2014; Hansen et al. 2014) from **5 unique samples**. **Two studies** reported data from the ALSPAC sample (Booth et al. 2013; Booth et al. 2014); results are reported separately and participants are only counted once.
[j] Serious risk of bias. Valid PA data missing for 41.5% of the sample (Hansen et al. 2014). Validity and reliability of outcomes unknown (Booth et al. 2013 and 2014; Esteban-Cornejo et al. 2014; Young et al. 2014).
[k] Serious inconsistency. **Two studies** found unfavourable associations [between PA (MPA, MVPA, VPA) and GPA (Esteban-Cornejo et al. 2014), and between MVPA and state Math test performance (Young et al. 2014)], **2 studies** found no associations [between total PA and WIAT-III (Lambourne et al. 2013; Hansen et al. 2014)], and **2 studies** found no or favourable associations [between PA (total, %MVPA) and executive function tests (Booth et al. 2013); and between %MVPA and national English, Math and Science test scores (Booth et al. 2014)].
[l] The quality of evidence from cross-sectional studies was downgraded from "low" to "very low" due to: (1) a serious risk of bias in five studies that diminished the level of confidence in the observed effects, and (2) large unexplained inconsistency among the findings.
[m] The quality of evidence from the RCT was downgraded from "high" to "moderate" due to: (1) a serious risk of bias that diminished the level of confidence in the observed effects, and (2) serious indirectness of the intervention and the comparison being assessed.

Table 1.1.6. The relationship between physical activity and quality of life/well-being.

No. of studies	Design	Quality Assessment					No. of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
The range of mean ages was 6.9 to 12.6 years. Data were collected by RCT and cross-sectionally. Quality of life was assessed by self-report with the Child Health Questionnaire, PedsQL 4.0 (Scores: physical health, psychosocial health, and aggregate; health-related quality of life composite score), and the question "In general, is your health excellent, mostly good, or not very good?".									
3	Randomized Trial[a]	Serious risk of bias[b]	No serious inconsistency	Serious indirectness[c]	No serious imprecision	None	687	**2 studies** reported no difference between intervention and control groups in physical and psychological quality of life post-intervention (Kriemler et al. 2010) or at 3-yr follow-up (Meyer et al. 2014). [d] **1 study** reported no differences between groups in PedsQL scores (physical, psychosocial health, aggregate) (Finkelstein et al. 2013). [e]	LOW[f]
2	Cross-sectional[g]	Serious risk of bias[h]	No serious inconsistency	No serious indirectness	No serious imprecision	None	1,021	***Meeting/Not Meeting Guidelines:*** **1/1 studies** reported that boys (but not girls) *not meeting PA guidelines* had higher odds of having less-than-excellent self-rated health compared to those *meeting PA guidelines* (Herman et al. 2014). ***Total PA:*** **1/1 studies** reported that *total PA* (steps/day) was positively correlated with quality of life (Standage et al. 2012). ***MVPA:*** **1/1 studies** reported that boys (but not girls) in the lowest tertile of *MVPA* had higher odds of having less-than-excellent self-rated health compared to those in the highest tertile of *MVPA* (Herman et al. 2014).	VERY LOW[i]

Note: MVPA = moderate to vigorous physical activity; PA = physical activity; PedsQL = Pediatric Quality of Life Questionnaire; RCT = randomized controlled trial.

[a] Includes **3 RCT studies** (Kriemler et al. 2010; Finkelstein et al. 2013; Meyer et al. 2014) from **2 unique samples**. Kriemler et al. 2010 and Meyer et al. 2014 report data from the KISS study; results are reported separately and participants are only counted once.

[b] Serious risk of bias. Unclear method of randomization for sibling pairs; allocation concealment unlikely; missing pedometer data disproportionately high in controls relative to intervention group (18.1% vs 6.1%), likely due to incentives for wear time offered to the intervention group only; control group wore sealed pedometers while intervention group wore unsealed pedometers; 6-min walk test assessors were not blinded to group assignment (Finkelstein et al. 2013).

[c] Serious indirectness. Indirect comparisons: different durations and intensities of physical activity were not compared.

[d] MVPA (but not total PA) was significantly greater in the intervention vs control group at post-intervention (post 9-month intervention group difference of ~11 min/day) (Kriemler et al. 2010); there was a trend toward higher levels of total PA (but not MVPA) in the intervention vs control group at 3-yr follow-up (Cohen's $d = 0.35$, p=0.06; not significant) (Meyer et al. 2014).

[e] The intervention group had greater total PA (steps/day) vs the control group at the end of the 9-month intervention (Finkelstein, 2013).

[f] The quality of evidence from randomized studies was downgraded from "high" to "low" due to: (1) a serious risk of bias in one study that diminished the level of confidence in the observed effects, and (2) serious indirectness of comparisons.

[g] Includes **2 cross-sectional studies** (Standage et al. 2012; Herman et al. 2014).

[h] Serious risk of bias. One of the measures of quality of life was not a validated tool, was only one question, and was dichotomized arbitrarily (excellent vs. not excellent) instead of using a supported (i.e. clinical) cut-point (Herman et al. 2014). Possible attrition bias: the final sample was only 58% of original sample (Standage et al. 2012).
[i] The quality of evidence from the cross-sectional studies was downgraded from "low" to "very low" due to a serious risk of bias in both studies that diminished the level of confidence in the observed effects.

Table 1.1.7. The relationship between physical activity and harm/injuries.

Note: Text in blue is the number after the Australian update

No of studies	Design	Quality Assessment					No. of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
The range of mean ages was 10 to 15 years. Data were collected longitudinally which up to 19 months of follow-up. Measures included spinal pain occurrences. Outcomes were measured subjectively (self-report) or objectively (clinical examination and audit of linked medical records).									
2	Longitudinal[a]	Serious risk of bias	Serious inconsistency	No serious indirectness	No serious imprecision	None	2,101	*Total PA* **1/2 studies** reported unfavourable association with **diagnosed** or **traumatic spinal pain** (Franz et al. 2017). **1/2 studies** reported null associations with **self-reported number of spinal pain sites** and **frequency of spinal pain** (Aartun et al. 2016). *LPA* **1 study** reported unfavourable association between *% time in LPA* with **self-reported spinal pain** (Franz et al. 2017) *MPA* **1 study** reported null associations between *% time in MPA* with **self-reported** or **diagnosed spinal pain** (Franz et al. 2017). *MVPA* 1 study reported null associations between *total MVPA* or *meeting at least 1 hour/d of MVPA* with **self-reported number of spinal pain sites** and **frequency of spinal pain** (Aartun et al. 2016). *VPA* **1/2 studies** reported unfavourable associations between *% time in VPA* with **diagnosed or traumatic spinal pain** (Franz et al. 2017); **1/2 studies** reported null associations between *total VPA* with **self-reported number of spinal pain sites** and **frequency of spinal pain** (Aartun et al. 2016).	VERY LOW[b]

Note: LPA = light intensity physical activity; MPA = moderate physical activity; MVPA = moderate-and-vigorous physical activity; PA = physical activity; VPA = vigorous physical activity.

[a] Includes **2 longitudinal studies** (Aartun et al. 2016; Franz et al. 2017).

[b] The quality of evidence from longitudinal studies were downgraded from "low" to "very low" due to serious risk of bias and inconsistency across studies.

Table 1.1.~~7~~8. The relationship between physical activity and bone health.

No of studies	Design	Quality Assessment					No. of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
The range of mean ages was 5.2 to 17.7 years. Data were collected by RCT, cross-sectionally, and up to 12 years of follow-up. Measures included: BMD, BMC, scanned area, cross-sectional area, total skeletal area, section modulus, bone stress index, femur and tibia bone strength index, strength-strain index, polar moment of inertia, cross-sectional moment of inertia, periosteal and endosteal circumference, cortical thickness, cortical BMC, cortical bone area, BMD ratios (femoral neck to trochanter, femoral neck to intertrochanter, trochanter to intertrochanter). All outcomes were measured objectively by DXA or peripheral quantitative CT.									
1	Randomized Trials[a]	No serious risk of bias	No serious inconsistency	Serious indirectness[b]	No serious imprecision	None	73	In both groups, **BMD** increased more during periods of physical training than during periods of no physical training (Gutin et al. 1999).	MODERATE[c]
7	Longitudinal[d]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	948	*Total PA* **1 study** reported that baseline *total PA* predicted follow-up **BMC** at the **hip, trochanter, spine** and **whole body** in *boys* and at the **trochanter** and **whole body** in *girls* (data not shown). **Total PA** explained 1-2% of the variability in **BMC** (Janz et al. 2006). Children who maintained **high levels of PA** over the 3-yr period (≥50th percentile) accrued, on average, 14% more **trochanteric BMC** and 5% more **whole-body BMC** relative to peers maintaining **low levels of PA** (<50th percentile) (Janz et al. 2006). **1 study** found that spending a higher proportion of total PA in MPA-VPA relative to LPA was favourably associated with **BMC, BMD** and **bone area** (Heidemann et al. 2013). *VPA* **Hip** and **spine BMC:** mixed (favourable and null) associations (**2/2 studies;** Janz et al. 2014a; Francis et al. 2014). *MVPA* **Whole body, spine** and **hip BMC:** mixed (favourable and null) associations (**3/3 studies;** Janz et al. 2010; Francis et al. 2014; Janz et al. 2014b); **Hip BMD:** mixed (favourable and null) associations (**1/1 studies;** Janz et al. 2014b). **Femoral neck cross-sectional area** and **section modulus:** mixed (favourable and null) associations (**2/2 studies;** Janz et al. 2007; Janz et al. 2014b); **Measures of bone strength** (**bone stress index** and **polar moment of inertia**): mixed (favourable and null) associations (**1/1 studies;** Janz et al. 2014b).	LOW[e]

14	Cross-sectional[f]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	6,520	<u>*Meeting/Not Meeting Guidelines (≥60 min/day MVPA)*</u> **1 study** reported that meeting guidelines had no association with **BMC** (whole body, hip, lumbar spine, trochanter, intertrochanter, femoral) (Gracia-Marco et al. 2011a). **1 study** reported that meeting guidelines had mixed favourable, null, and unfavourable associations with **BMC** of at least 1 anatomical region (**whole body, upper limb, lower limb)** (Gracia-Marco et al. 2011b). **1 study** reported that meeting guidelines had mixed favourable (girls) and null (boys) associations (**lumbar spine**) or null associations (**whole body, hip, trochanter, intertrochanter** or **femoral neck**) with **BMD** (Gracia-Marco et al. 2011a). <u>*Total PA*</u> *Total PA and BMC:* **Whole body BMC:** associations were favourable (**1/2 studies;** Gracia-Marco et al. 2012), or mixed (favourable in boys, null in girls; **1/2 studies**; Janz et al. 2001); **Hip BMC:** favourable associations (**2/2 studies;** Janz et al. 2001; Gracia-Marco et al. 2012); **Spine BMC:** favourable association (**1/1 studies;** Janz et al. 2001). *Total PA and BMD:* **Whole body BMD:** null associations (**1/1 studies;** Janz et al. 2001); **Hip BMD:** favourable associations (**1/1 studies;** Janz et al. 2001); **Spine BMD:** mixed (null in boys, favourable in girls) associations (**1/1 studies;** Janz et al. 2001); **Calcaneal** and **distal forearm BMD:** favourable associations (**1/1 studies;** Hasselstrom et al. 2007). *Total PA and Area and strength:* **Total skeletal area:** favourable associations (**1/1 studies;** Janz et al. 2001). **Femur** and **tibia strength index/strength-strain index:** mixed (favourable and null) associations (**1/1 studies;** Farr et al. 2011). <u>*VPA*</u> *VPA and BMC:* **Whole body BMC:** associations were favourable (**1/1 studies;** Tobias et al. 2007) or mixed (favourable in boys, null in girls; **1/1 studies;** Janz et al. 2001);	LOW[g]

								Whole body BMC adjusted for bone area: null associations (**1/1 studies;** Tobias et al. 2007); **Hip BMC:** favourable associations (**2/2 studies;** Janz et al. 2001 and 2014a); **Spine BMC:** associations were favourable (**2/3 studies;** Janz et al. 2001 and 2014a) or null (**1/3 studies;** Francis et al. 2014). **Upper limb *absolute* BMC:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Lower limb *absolute* BMC:** null associations (**1/1 studies;** Tobias et al. 2007); **Upper** and **lower limb *areal* BMC:** null associations (**1/1 studies;** Tobias et al. 2007); **Cortical BMC:** favourable associations (**1/1 studies**; Sayers et al. 2011). *VPA and BMD:* **Whole body BMD:** associations were favourable (**1/2 studies;** Tobias et al. 2007) or null (**1/2 studies**; Janz et al. 2001); **Whole body *areal* BMD:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Hip BMD:** favourable associations (**1/1 studies;** Janz et al. 2001); **Spine BMD:** mixed (null in boys, favourable in girls) associations (**1/1 studies;** Janz et al. 2001); **Calcaneal** and **distal forearm:** favourable associations (**1/1 studies;** Hasselstrom et al. 2007); **Upper limb *absolute*** or ***areal* BMD:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Lower limb *absolute*** or ***areal* BMD:** null associations (**1/1 studies;** Tobias et al. 2007); **Femoral neck, trochanter** and **intertrochanter BMD:** favourable associations (**1/1 studies;** Cardadeiro et al. 2012); **Cortical BMD:** unfavourable associations (**1/1 studies;** Sayers et al. 2011); **BMD ratios:** null (femoral neck to intertrochanter, trochanter to intertrochanter) or mixed (null in boys, negative in girls; femoral neck to intertrochanter) associations (**1/1 studies;** Cardadeiro et al. 2012). *VPA and Area and strength:* **Total skeletal area:** favourable association (**1/1 studies;** Janz et al. 2001); **Cortical bone area:** favourable association (**1/1 studies;** Sayers et al. 2011);	

								Periosteal circumference of the tibia: positive association (**1/1 studies;** Sayers et al. 2011); **Endosteal circumference of the tibia:** negative association (**1/1 studies;** Sayers et al. 2011); **Cross-sectional area** and **section modulus** of **narrow neck, intertrochantic** and **shaft** regions of **femur:** favourable associations (**1/1 studies;** Janz et al. 2004). <u>*MVPA*</u> *MVPA and BMC:* **Whole body BMC:** mixed (favourable and null) associations (**1/1 studies;** Janz et al. 2008); **Hip BMC:** favourable associations (**2/2 studies;** Janz et al. 2008; Janz et al. 2014a); **Spine BMC:** mixed (favourable in boys, null in girls) associations (**2/3 studies;** Janz et al. 2008; Janz et al. 2014a), or null associations (**1/3 study;** Francis et al. 2014). *MVPA and BMD:* **Femoral neck, trochanter** and **intertrochanter BMD:** null associations (**1/1 studies;** Cardadeiro et al. 2012); **BMD ratios:** null (femoral neck to trochanter, trochanter to intertrochanter) or mixed (null in boys, positive in girls; femoral neck to intertrochanter) associations (**1/1 studies;** Cardadeiro et al. 2012). <u>*MPA*</u> *MPA and BMC:* **Whole body *absolute* or *areal* BMC:** favourable associations (**1 /1 studies;** Tobias et al. 2007); **Upper limb *absolute* or *areal* BMC:** null associations (**1/1 studies;** Tobias et al. 2007); **Lower limb *absolute* or *areal* BMC:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Cortical BMC:** null associations (**1/1 studies**; Sayers et al. 2011). *MPA and BMD:* **Whole body *absolute* or *areal* BMD:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Upper limb *absolute* or *areal* BMD:** null associations (**1/1 studies;** Tobias et al. 2007); **Lower limb *absolute* or *areal* BMD:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Femoral neck, trochanter, intertrochanter BMD:** null associations (**1/1 studies;** Cardadeiro et al. 2012);	

								Cortical BMD: null associations (**1/1 studies;** Sayers et al. 2011); **BMD ratios:** null (femoral neck to trochanter, femoral neck to intertrochanter, trochanter to intertrochanter; **1/1 studies;** Cardadeiro et al. 2012). *MPA and Area and strength:* **Cortical bone area:** favourable association (**1/1 studies;** Sayers et al. 2011); **Periosteal** and **endosteal circumference of the tibia:** null associations (**1/1 studies;** Sayers et al. 2011); **Cross-sectional area** of **femoral shaft:** favourable associations (**1/1 studies;** Janz et al. 2004); **Section modulus** of **femoral shaft:** mixed (null in boys, favourable in girls) associations (**1/1 studies;** Janz et al. 2004); **Cross-sectional area** and **section modulus** of **narrow neck** and **intertrochantic** regions of **femur:** mixed (null in boys, favourable in girls) associations (**1/1 studies;** Janz et al. 2004). <u>*LPA*</u> *LPA and BMC:* **Whole body *absolute* or *areal* BMC:** null associations (**1/1 studies**; Tobias et al. 2007); **Upper** or **lower limb *absolute* BMC:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Upper** or **lower limb *areal* BMC:** null associations (**1/1 studies;** Tobias et al. 2007); **Cortical BMC:** null associations (**1/1 studies**; Sayers et al. 2011)**.** *LPA and BMD:* **Whole body BMD:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Whole body *areal* BMD:** null associations (**1/1 studies;** Tobias et al. 2007); **Upper** and **lower limb *absolute* or *areal* BMD:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Cortical BMD:** unfavourable association (**1/1 studies;** Sayers et al. 2011). *LPA and Area and strength:* **Cortical bone area:** null association (**1/1 studies**; Sayers et al. 2011); **Periosteal circumference of the tibia:** positive association (**1/1 studies;** Sayers et al. 2011);	

								Endosteal circumference of the tibia: null association (**1/1 studies;** Sayers et al. 2011). *Other (impact measured by g-band)* **1/1 studies** (Deere et al. 2012) found both favourable (higher impacts) and null (lower impacts) associations between impact and **BMD** (femoral neck, hip), **hip structure** (femoral neck width, cross-sectional area, cortical thickness) and **predicted strength** (cross-sectional moment of inertia). A dose-response gradient was found for higher impact activity and **BMD** (femoral neck, total hip).	

Note: BMC = bone mineral content; BMD = bone mineral density; CSA = cross sectional area; CT = computer tomography; DXA = dual-energy x-ray absorptiometry; LPA = light intensity physical activity; MPA = moderate physical activity; MVPA = moderate-and-vigorous physical activity; PA = physical activity; VPA = vigorous physical activity.

[a] Includes **1 randomized-controlled trial** (Gutin et al. 1999).
[b] Serious indirectness. Differences in intervention: the RCT examined a training program that provided indirect evidence bearing on the potential effectiveness of different intensities and durations of PA. Indirect comparisons: different durations and intensities of PA were not compared.
[c] The quality of the evidence from the randomized study was downgraded from "high" to "moderate" due to serious indirectness of the intervention being assessed.
[d] Includes **7 longitudinal studies** (Janz et al. 2006; Janz et al. 2007; Janz et al. 2010; Heidemann et al. 2013; Francis et al. 2014; Janz et al. 2014a; Janz et al. 2014b) from **2 unique samples**. **Six studies** reported data from the Iowa Bone Development Study (Janz et al. 2006; Janz et al. 2007; Janz et al. 2010; Francis et al. 2014; Janz et al. 2014a; Janz et al. 2014b) and **1 study** reported data from the CHAMPS study sample (Heidemann et al. 2013). Results are reported separately and participants are only counted once.
[e] The quality of evidence from longitudinal studies remained rated as "low" as there were no serious limitations across studies or reasons to upgrade.
[f] Includes **14 cross-sectional studies** (Janz et al. 2001; Janz et al. 2004; Hasselstrom et al. 2007; Tobias et al. 2007; Janz et al. 2008; Sayers et al. 2011; Farr et al. 2011; Gracia-Marco et al. 2011a; Gracia-Marco et al. 2011b; Cardadeiro et al. 2012; Gracia-Marco et al. 2012; Deere et al. 2012; Francis et al. 2014; Janz et al. 2014a), from **6 unique samples**. **Five** studies reported data from the Iowa Bone Development Study (Janz et al. 2001; Janz et al. 2004; Janz et al. 2008; Francis et al. 2014; Janz et al. 2014a), **3 studies** from the ALSPAC (Tobias et al. 2007; Sayers et al. 2011; Deere et al. 2012), **3 studies** from HELENA (Gracia-Marco et al. 2011a; Gracia-Marco et al. 2011b; Gracia-Marco et al. 2012), and **1 study** from each of CoSCIS (Hasselstrom et al. 2007), EYHS (Cardadeiro et al. 2012), and Jump-In: Building Better Bones (Farr et al. 2011). Results are reported separately and participants are only counted once.
[g] The quality of the evidence from cross-sectional studies remained rated as "low" as there were no serious limitations across studies or reasons to upgrade.

Table 1.1.8~~8~~9. The relationship between physical activity and motor skill development.

No. of studies	Design	Quality Assessment					No. of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
The range of mean ages was 6.7 to 14.8 years. Data were collected by RCT, cross-sectionally and up to 2 years of follow-up. Motor Skill Development was assessed by: flamingo balance test, plate tapping test, CAPL obstacle course, KTK test battery, AST throwing accuracy test, eye-hand coordination throw and wall-rebound catch test, a neuromuscular development index, and a 4x10 m and a 30 feet shuttle-run test of speed-of movement, agility and coordination. All outcomes were measured objectively.									
1	Randomized Trials[a]	Serious risk of bias[b]	No serious inconsistency	Serious indirectness[c]	No serious imprecision	None	111	**1/1 studies** found no between-group differences in motor skill development after a PA intervention (Verstraete et al. 2007).	LOW[d]
1	NRT[e]	Serious risk of bias [f]	No serious inconsistency	Serious indirectness[g]	No serious imprecision	None	92	**1/1 studies** found no between-group differences in motor skill development after a PA intervention, but there were significant decreases within both the INT and CTRL groups (Shore et al. 2014).	LOW[h]
1	Longitudinal[i]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	790	***Total PA:*** null associations (**1/1 studies;** Telford et al. 2013).	LOW[j]
5	Cross-sectional[k]	Serious risk of bias[l]	No serious inconsistency	No serious indirectness	No serious imprecision	None	4,389	***Total PA:*** associations were favourable (**3/5 studies;** Martinez-Gomez et al. 2012; Morrison et al. 2012; Larouche et al. 2014) or null (**2/5 studies;** Hands et al. 2009; Telford et al. 2013). ***VPA:*** favourable associations (**1/1 studies;** Martinez-Gomez et al. 2012). ***MVPA:*** favourable associations (**1/1 studies;** Martinez-Gomez et al. 2012). ***MPA:*** null associations (**1/1 studies;** Martinez-Gomez et al. 2012).	VERY LOW[m]

Note: AST = Allgemeiner sportmotorischer Test für Kinder; CAPL = Canadian Assessment of Physical Literacy; CTRL = control; INT = intervention; KTK = Koordinations Test für Kinder; MPA = moderate physical activity; MVPA = moderate-to-vigorous physical activity; NRT = non-randomized trial; PA = physical activity; Total PA = total physical activity; VPA = vigorous physical activity.

[a] Includes **1 clustered randomized controlled trial** (Verstraete et al. 2007).
[b] Serious risk of bias. Participants are a subset (with objective PA measurement) from a larger sample; only ~35% of those randomly selected to be in the subsample had parental consent and it is unclear whether they differed systematically from the rest of the participants. There was no mention of blinding, and it is possible that this could have influenced the outcome measurements (Verstraete et al. 2007).
[c] Serious indirectness. Differences in intervention: randomized trials examined various types of PA programs and provided indirect evidence bearing on the potential effectiveness of different intensities and durations of PA. Indirect comparisons: different durations and intensities of PA were not compared.
[d] The quality of evidence from randomized studies was downgraded from "high" to "low" due to: (1) a serious risk of bias that diminished the level of confidence in the observed effects, and (2) serious indirectness of comparisons.
[e] Includes **1 non-randomized intervention trial** (Shore et al. 2014).
[f] Serious risk of bias. No inclusion/exclusion criteria established; inadequate reporting of recruitment, allocation concealment, and blinding; large unexplained loss to follow-up (36.5% retention) and unknown if follow-up differed by group allocation (Shore et al. 2014).
[g] Serious indirectness. Indirect comparisons: different durations and intensities of PA were not compared.

[h] The quality of evidence from non-randomized intervention studies was downgraded from "high" to "low" due to: (1) a serious risk of bias that diminished the level of confidence in the observed effects, and (2) serious indirectness of comparisons.
[i] Includes **1 longitudinal study** (Telford et al. 2013).
[j] The quality of evidence remained rated as "low" as there were no concerns regarding study quality and no reasons to rate-up.
[k] Includes and **5 cross-sectional studies** (Hands et al. 2009; Martinez-Gomez et al. 2012; Morrison et al. 2012; Larouche et al. 2014) or cross-sectional analysis (Telford et al. 2013).
[l] Serious risk of bias. Participants were asked to report their step counts in a diary, which may have introduced a social desirability bias (Larouche et al. 2014). Participants who did not provide acceptable pedometer data performed more poorly on the obstacle course (Larouche et al. 2014). Validity and reliability of the AST throwing task is unknown (Morrison et al. 2012). No reported reliability/validity of neuromuscular development index (Hands et al. 2009). Insufficient information to permit judgment of attrition bias (Hands et al. 2009; Martinez-Gomez et al. 2012).
[m] The quality of evidence from the cross-sectional studies was downgraded from "low" to "very low" due to a serious risk of bias in four studies that diminished the level of confidence in the observed effects.

Table 1.1.910. The relationship between physical activity and psychological distress.

No. of studies	Design	Quality Assessment					No. of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
The range of mean ages was 12.0 to 16.9 years. Data were collected cross-sectionally and with 3-year follow-up. Psychological distress was assessed as depressed mood by self-reported MFQ, depressive symptoms by self-reported short-MFQ and CES-D and MDD by face-to-face interview using sections of the Schedule for Affective Disorders and Schizophrenia for School Age Children-Present and Lifetime Version.									
1	Longitudinal [a]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	736	No association between baseline **MVPA** or **PAEE** and **depressed mood** or **Major Depressive Disorder** at follow-up (Toseeb et al. 2014).	LOW[b]
4	Cross-sectional[c]	No serious risk of bias	Serious inconsistency[d]	No serious indirectness	No serious imprecision	None	10,641	***Total PA:*** associations were null (**2/3 studies;** Johnson et al. 2008; Toseeb et al. 2014), or mixed (null and favourable) depending on if assignment to tertiles adjusted for total PA or adjusted for %time in MVPA (**1/3 studies;** Wiles et al. 2012). ***VPA:*** null associations (**1/1 studies;** Johnson et al. 2008). ***MVPA:*** associations were favourable (**1/4 studies;** Wiles et al. 2012), null (**2/4 studies;** Johnson et al. 2008; Toseeb et al. 2014), or mixed (null and unfavourable; **1/4 studies;** Young et al. 2014). ***LPA:*** null associations (**1/1 studies;** Johnson et al. 2008).	VERY LOW[e]

Note: CES-D = Center for Epidemiological Studies-Depression Scale; MDD = Major Depressive Disorder; MFQ = Mood and Feelings Questionnaire; MVPA = moderate to vigorous physical activity; PA = physical activity; PAEE = physical activity energy expenditure.

[a] Includes **1 longitudinal study** (Toseeb et al. 2014).
[b] The overall quality of evidence remained rated as "low" for the longitudinal study since there were no serious limitations and no reasons to upgrade.
[c] Includes **4 cross-sectional studies** (Johnson et al. 2008; Wiles et al. 2012; Toseeb et al. 2014; Young et al. 2014) from **3 unique samples**. **Two studies** (Johnson et al. 2008; Young et al. 2014) report data from the TAAG study. Results are reported separately and participants are only counted once.
[d] Serious inconsistency. Inconsistency is related to the associations between MVPA and depressive symptoms/depressed mood; favourable, null and unfavourable associations were reported in four studies, with no clear reason for differences (Johnson et al. 2008; Wiles et al. 2012; Toseeb et al. 2014; Young et al. 2014).
[e] The quality of evidence from cross-sectional studies was downgraded from "low" to "very low" due to unexplained inconsistency among the findings.

Table 1.1.~~10~~11. The relationship between physical activity and self-esteem.

No. of studies	Design	Quality Assessment					No. of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Mean age was 16.9 years; data were collected cross-sectionally. Self-esteem was assessed by self-report "global esteem" scale from the Physical Self-Description Questionnaire.									
1	Cross-sectional [a]	No serious risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision [b]	None	589	***MVPA:*** null associations (**1/1 studies;** Young et al. 2014).	VERY LOW[c]

Note: MVPA = moderate-to-vigorous physical activity.

[a] Includes **1 cross-sectional study** (Young et al. 2014).
[b] Serious imprecision. The standard error (SE) and parameter were of similar magnitude (parameter = 0.16, SE = 0.11, p=0.14).
[c] The overall quality of evidence was downgraded from "low" to "very low" due to imprecision.

1.2 Sedentary Behaviour

Research Question: In children 5-17 years of age what dose [i.e., durations, patterns (frequency, interruptions), and type] of sedentary behaviour, as measured by objective and subjective methods, is associated with favourable health indicators?

Table 1.2.1. The Relationship between Sedentary Behaviour and Body Composition

No. of studies	Design	Quality Assessment					No. of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Mean baseline age ranged between 5.0 and 16.7 years; where mean age was not reported, baseline age ranged from 3 to 19 years and grades 5 to 12. Data were collected by longitudinal (n=32), case-control (n=5), and cross-sectional (n=125) design with up to 12 years follow-up. Body composition was assessed as BMI (objectively measured, self-report, parental-report), BMI z-score (objectively measured, self-reported), BMI percentiles (objectively measured, self-reported), overweight and obesity (objectively measured, self-report, parental-report; International Obesity Task Force, Centre for Disease Control and Prevention, World Health Organization, other country-specific percentiles), WHtR (objectively measured), WHR (objectively measured), fat mass (TANITA bioelectric impedance, duel-energy x-ray absorptiometry, Lunar Prodigy DEXA scanner), WC (objectively measured), WC z-score (objectively measured), sum of skinfolds (objectively measured), % body fat (objectively measured), and overfat (slaughter equation).									
~~32~~45	Longitudinal[a]	Serious risk of bias[b]	No serious inconsistency	No serious indirectness	No serious imprecision	Dose-response gradient[c]	102,934[d]	Among *prospective findings*, higher sedentary behaviour was associated with unfavourable body composition for: 1) Accelerometer-derived sedentary time – *~~3~~5/~~9~~18 studies* (1 study found higher waist circumference at follow-up was associated with higher sedentary time at baseline). 2) Accelerometer-derived breaks - *0/~~1~~2 study*. 3) Screen time - *~~11~~15/~~13~~17 studies* (only for 6 and 10 yr. old's in 1 study, only in males for 1 study, not for waist circumference in 1 study). 4) TV - *~~14~~15/~~16~~18 studies* (only for females in 1 study, not for movie viewing in 1 study, not for movie viewing in males in 1 study, only for males and not for body fatness, waist circumference and skinfold thickness for males in 1 study). 5) Computer - *3/~~4~~5 studies* (only for females in 1 study, not for waist circumference in 2 studies, not for body fatness, hip circumference, and BMI in 1 study). 6) Video game - *0/2 studies*. 7) Total sedentary behaviour - *0/1 study*. 8) Weekend internet use – 1/1 study Higher sedentary behavior was associated with better body composition 1) Accelerometer-derived sedentary time – *~~0~~1/~~9~~9 studies* (Higher total or uninterrupted SB (exposure and change) were associated with better body composition).	VERY LOW[e]

								2) Accelerometer-derived breaks - ~~*01/12 study*~~. (Fragmentation findings were inconsistent – less fragmentation was beneficial overall (7-15y), but more fragmentation was beneficial between 9-12y	
5	Case-control [f]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None.	4,748	Higher sedentary behaviour was associated with being overweight/obese (case group) for: 1) Screen time - *4/4 studies.* 2) TV - *2/2 studies (*only for weekends in 1 study). 3) Computer - *0/2 studies.*	LOW
125	Cross-sectional[g]	Serious risk of bias[h]	No serious inconsistency	No serious indirectness	No serious imprecision	Exposure/ outcome gradient[i]	1,386,706[j]	Higher sedentary behaviour was associated with unfavourable body composition for: 1) Accelerometer-derived sedentary time - *3/18* studies (only after 3pm on weekdays for males in 1 study). 2) Long accelerometer-derived sedentary bouts (≥5 min) - *3/4 studies* (Only 5-9 minute bouts on weekdays and weekends only and in low MVPA group for only 5-9 minute and 10-19 minute bout on total days and weekends only in 1 study, Only 10-14 minute bouts for only BMI z-score and in males only in 1 study, and only at least 40 minutes (waist circumference only) in 11-14 yr old males after 3pm on weekdays and only at least 80 minutes for males only in 1 study). 3) Short accelerometer-derived sedentary bouts (1-4 minute) - *1/2 studies* (only for the weekend in 1 study). 4) Screen time - *26/36 studies* (only for males in 3 studies, not for urban participants in 1 study, not for certain ethnic groups in 1 study). 5) TV - *58/71 studies* (only for participates aged 4-8 yr in 1 study, only for males in 4 studies, only for females in 3 studies, only for weekdays in 1 study, only 12-18 yr old males for 1 study, not for BMI z-score in 1 study). 6) Computer - 7*/30 studies* (only for females in 2 studies). 7) Video game - 3*/20 studies* (only for weekends in 1 study and only for females in 1 study). 8) Total sedentary behaviour -*3/4 studies* (not for WC in 1 study, only in 1 sample and only for 6-11 yr olds in 1 study). 9) Homework - *3/7 studies* (only for males in 1 study, only in 6-11 yr old males in 1 study) 10) Quiet time - *1/1 study* (only for males in 1 study) Higher sedentary behaviour was associated with favourable body composition for: 1) Accelerometer-derived sedentary time - *1/18 studies*. 2) Accelerometer-derived sedentary breaks - *2/4 studies (*only 11-14 yr old males after 3pm on weekdays in 1 study).	VERY LOW[k]

								3) Short accelerometer-derived sedentary bouts (1-4 min) - *1/2 studies* (1-4 minute bouts in 1 study). 4) Long accelerometer-derived sedentary bouts (≥5 min) - *1/4 studies* (only for girls and only for WC in 1 study). 5) Screen time - *1/36 studies* 6) Computer - *2/30* studies (only for 1hr/day in 1 study, not for sum of skinfolds in 1 study). 7) Reading - *1/2 studies* (only for low group in 1 study) 8) Non-screen time - *1/1 study*.	
1	Group Non-randomised controlled trial[l]	Serious risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision	None	41	No effect for total sitting (during class school or whole day). Effect for sitting in long bouts (>10 min) and number of sit-to-stand transitions. No effect for BMIz/WCz.	VERY LOW[e]

Note: WHtR = waist to height ratio; WHR = waist to hip ratio; WC = waist circumference; BMI = body mass index; min= minutes.

[a]Includes ~~32~~45 longitudinal studies (Van den Bulck and Hofman 2009; Barnett et al. 2010; Calamaro et al. 2010; Wijga et al. 2010; Creighton et al. 2011; Hands et al. 2011; Miller 2011; Altenburg et al. 2012; Augustin et al. 2012; Barlett et al. 2012; Basterfield et al. 2012a; Basterfield et al. 2012b; Dumith et al. 2012; Ekelund et al. 2012; Fuller-Tyszkiewicz et al. 2012; Veitch et al. 2012; Drenowatz et al. 2013; Falbe et al. 2013; Kwon et al. 2013; Magee et al. 2013; Mamun et al. 2013; Mitchell et al. 2013a; Mitchell et al. 2013b; Williams et al. 2013; Berentzen et al. 2014; Chen et al. 2014; Gilbert-Diamond et al. 2014; Grontved et al. 2014; Hjorth 2014; Hjorth et al. 2014; Lin et al. 2014; Olafsdottir et al. 2014; Allen et al. 2016; Barrense-Dias et al. 2016; Collings et al. 2015; Griffiths et al. 2016; Janz et al. 2017; Mann et al. 2017; Marques et al. 2016; Oellingrath et al. 2016; Sluijs et al. 2016; Tanaka et al. 2018; Wheaton et al. 2015; Skrede et al. 2017; Dong et al. 2017)

[b]Out of the 26 studies that used a subjective measure of sedentary behaviour, only 7 studies mention psychometric properties for the sedentary behaviour items (Barnett et al. 2010; Hands et al. 2011; Veitch et al. 2012; Falbe et al. 2013; Mitchell et al. 2013b; Chen et al. 2014; Lin et al. 2014).

[c]Dose response gradient was observed for higher TV, sedentary time, screen time, computer with unfavourable body composition in 14 studies (Barnett et al. 2010; Miller 2011; Altenburg et al. 2012; Basterfield et al. 2012b; Dumith et al. 2012; Veitch et al. 2012; Falbe et al. 2013; Magee et al. 2013; Mitchell et al. 2013a; Mitchell et al. 2013b; Williams et al. 2013; Berentzen et al. 2014; Grontved et al. 2014; Lin et al. 2014).

[d]Two studies used the Longitudinal Study of Australian Children (Fuller-Tyszkiewicz et al. 2012; Magee et al. 2013).

[e]The quality of evidence for longitudinal studies was downgraded to "very low" from "low" due to serious risk of bias.

[f]Includes 5 case-control studies (Xi et al. 2011; Zurriaga et al. 2011; Yi et al. 2012; Al-Ghamdi 2013; Huang et al. 2013).

[g]Includes 125 cross-sectional studies (Beets and Foley 2010; Bishwalata et al. 2010; Brown et al. 2010; Ferrar and Olds 2010; Hong et al. 2010; Ismailov and Leatherdale 2010; Jones et al. 2010; Kuhle et al. 2010; Legnani et al. 2010; Liou et al. 2010; Melkevik et al. 2010; Olds et al. 2010; Pitrou et al. 2010; Rivera et al. 2010; Ruiz et al. 2010; Shan et al. 2010; Thibault et al. 2010; Wilkosz et al. 2010; Yen et al. 2010; Zhang et al. 2010; Al-Hazzaa et al. 2011; Allender et al. 2011; Bener et al. 2011; Brown et al. 2011; Carson and Janssen 2011; Chen et al. 2011; Dupuy et al. 2011; Fernandes et al. 2011; Goyal et al. 2011; Hsu and Johnson 2011; Kimbro et al. 2011; Leatherdale and Papadakis 2011; Martinez-Gomez et al. 2011a; McConley et al. 2011; Mushtaq et al. 2011; Nigg et al. 2011; Peart et al. 2011; Peltzer and Pengpid 2011; Rajmil et al. 2011; Saab et al. 2011; Sisson et al. 2011; Al-Hazzaa et al. 2012; Al-Nakeeb et al. 2012; Carson and Janssen 2012; Casiano and Kinley 2012; Chaput et al. 2012; Colley et al. 2012; Drake et al. 2012; Dundar and Oz 2012; Ercan et al. 2012; Gregori et al. 2012; Grydeland et al. 2012; Hajian-Tilaki and Heidari 2012; Hardy et al. 2012; Hay et al. 2012; Inanc et al. 2012; Jahns et al. 2012; Kuriyan et al. 2012; Lissner et al. 2012; Machado-Rodrigues et al. 2012; Masse et al. 2012; Morley et al. 2012; Rey-Lopez et al. 2012; Taber et al. 2012; Tin et al. 2012; Vaezghasemi et al. 2012; Wang et al. 2012; Zhang et al. 2012; Atkin et al. 2013; Badawi et al. 2013; Bingham et al. 2013; Bracale et al. 2013; Braithwaite et al. 2013; Busch et al. 2013; Cameron et al. 2013; Carriere et al. 2013; Chahal et al. 2013; Colley et al. 2013; de et al. 2013; Ekstedt et al. 2013; Fernandez-Alvira et al. 2013; Ghavamzadeh et al. 2013; Giussani et al. 2013; Gonzalez Montero de et al. 2013; Govindan et al. 2013; Graff and North 2013; Kettner et al. 2013; Kristiansen et al. 2013; Magee et al. 2013; Mejia et al. 2013; Mungrue et al. 2013; Perez et al. 2013; Rani and Sathiyasekaran 2013; Saunders et al. 2013; Sluyter et al. 2013; Stamatakis et al.

2013a; Stroebele et al. 2013; Suglia et al. 2013; Tambalis et al. 2013; Thibault et al. 2013; Wang et al. 2013; Yako et al. 2013; Bozza et al. 2014; Carson et al. 2014; Chaput et al. 2014b; Chinapaw et al. 2014; Decelis et al. 2014; Drenowatz et al. 2014; Farajian et al. 2014; Garmy et al. 2014; Hatami et al. 2014; Herman et al. 2014; Januszek-Trzciakowska et al. 2014; Jayawardene et al. 2014; Kantanista and Osinski 2014; Lane et al. 2014; Lee et al. 2014; Marques and Gaspar De 2014; Seo and Niu 2014; Sigmundova et al. 2014; Tucker et al. 2014; Wijtzes et al. 2014; Aggio et al. 2015; Katzmarzyk et al. 2015a; Katzmarzyk et al. 2015b).

[h] Out of 108 studies that used a subjective measure of sedentary behaviour only 33 studies mentioned psychometric properties for the sedentary behaviour items (Barnett et al. 2010; Ferrar and Olds 2010; Liou et al. 2010; Melkevik et al. 2010; Olds et al. 2010; Hands et al. 2011; Peart et al. 2011; Xi et al. 2011; Al-Nakeeb et al. 2012; Carson and Janssen 2012; Grydeland et al. 2012; Lissner et al. 2012; Masse et al. 2012; Rey-Lopez et al. 2012; Veitch et al. 2012; Yi et al. 2012; Al-Ghamdi 2013; Cameron et al. 2013; Falbe et al. 2013; Fernandez-Alvira et al. 2013; Ghavamzadeh et al. 2013; Graff and North 2013; Huang et al. 2013; Mitchell et al. 2013b; Tambalis et al. 2013; Thibault et al. 2013; Bozza et al. 2014; Chen et al. 2014; Garmy et al. 2014; Lin et al. 2014; Marques and Gaspar De 2014; Tucker et al. 2014; Katzmarzyk et al. 2015a).

[i] A gradient for higher TV, video games, sedentary bouts, sedentary breaks, screen time, studying with unfavourable body composition was observed in 30 studies (Hong et al. 2010; Kuhle et al. 2010; Pitrou et al. 2010; Carson and Janssen 2011; Kimbro et al. 2011; Leatherdale and Papadakis 2011; Mushtaq et al. 2011; Sisson et al. 2011; Carson and Janssen 2012; Drake et al. 2012; Kuriyan et al. 2012; Masse et al. 2012; Rey-Lopez et al. 2012; Taber et al. 2012; Tin et al. 2012; Zhang et al. 2012; Braithwaite et al. 2013; Cameron et al. 2013; Colley et al. 2013; Gonzalez Montero de et al. 2013; Graff and North 2013; Mejia et al. 2013; Perez et al. 2013; Saunders et al. 2013; Sluyter et al. 2013; Stamatakis et al. 2013a; Carson et al. 2014; Hatami et al. 2014; Lane et al. 2014; Lee et al. 2014).

[j]Two studies used the Gateshead Millenium Study (Basterfield et al. 2012a; Basterfield et al. 2012b). Two studies used the optimal well-being, development and health for Danish children through a health New Nordic Diet school meal study (Hjorth 2014; Hjorth et al. 2014). Three studies used the Longitudinal Study of Australian Children (Brown et al. 2010; Brown et al. 2011; Magee et al. 2013). Three studies used the China Health and Nutrition Survey (Zhang et al. 2010; Zhang et al. 2012; Seo and Niu 2014). Three studies used the Quebec Adiposity and Lifestyle Investigator in Youth study (Chaput et al. 2012; Saunders et al. 2013; Herman et al. 2014). Two studies used the 2007-2009 Canadian Health Measures Survey (Colley et al. 2012; Colley et al. 2013). Three studies used the International Study of Childhood Obesity, Lifestyle and the Environment (Chaput et al. 2014b; Katzmarzyk et al. 2015a; Katzmarzyk et al. 2015b). Two studies used the 2003/04 and 2005/06 National Health and Nutrition Examination Survey (Carson and Janssen 2011; Peart et al. 2011). Two studies used the Alimentación y Valoración del Estado Nutricional de los Adolescentes study (Ruiz et al. 2010; Martinez-Gomez et al. 2011a)]. Two studies used the Arab Teens Lifestyle Study (Al-Hazzaa et al. 2011; Al-Hazzaa et al. 2012).

[k]The quality of evidence for cross-sectional studies was downgraded to “very low” from “low” due to serious risk of bias.

[l]Includes one non-RCT (Allen et al. 2016)

Table 1.2.2. The Relationship between Sedentary Behaviour and Metabolic Syndrome/Cardiovascular Disease Risk Factors

No. of studies	Design	Quality Assessment					No. of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Mean baseline age ranged between 6.7 and 16.7 years; where mean age was not reported, baseline age ranged from 5 to 19 years. Data were collected by longitudinal (n=6) and cross-sectional (n=25) study designs with up to 27 years follow up. Metabolic syndrome/cardiovascular disease risk factors were assessed as SBP, DBP, mean arterial BP, HbA1c, HOMA-IR, TG, HDL, TC/HDL ratio, metabolic syndrome risk score, insulin, glucose, non-HDL, resting heart rate, LDL, CRP, Matsuda insulin sensitivity, HOMA2-%B, OGTT-derived measures of insulin secretion (AUC I/$G_{t30\ min}$ and AUC I $G_{t120min}$), total cholesterol, apolipoprotein A1, apolipoprotein-B100, lipoprotein(a), adiponectin, leptin, VLDL TG, VLDL cholesterol, and HDL TG. All outcomes were measured objectively.									
~~6~~12	Longitudinal[a]	Serious risk of bias[b]	Serious inconsistency[c] (no serious inconsistency for screen time)	No serious indirectness	No serious imprecision	Dose-response gradient[d]	~~9,711~~23,834	**Clustered Risk Score** Higher sedentary behaviour was associated with a higher clustered risk score for: 1) Accelerometer-derived sedentary time - *~~0~~1/~~1~~3 study.* 2) Screen time - *~~1~~4/~~2~~5 studies.* 3) TV - 2/2 studies. 4) Computer - *0/1 study.* **BP** Higher sedentary behaviour was associated with higher blood pressure for: 1) Accelerometer-derived sedentary time - *0/1 study.* 2) Screen time - *2/5 studies.* 3) TV - *1/3 studies.* 4) Computer - *2/2 studies (not for SBP in 2 studies).* 5) Video games - *0/1 studies.* **Cholesterol** Higher sedentary behaviour was associated with lower cholesterol for: 1) Accelerometer-derived sedentary time - *1/1 study (for HDL in 1 study).* 2) Screen time - 0/3 *studies.* 3) TV - *1/2 studies (for HDL in 1 study).* 4) Computer - *0/1 study.* **Insulin** Higher sedentary behaviour was associated with higher insulin for: 1) Screen time - *1/1 study.* 2) TV - *1/1 study.* 3) Computer - *1/1 study.* **TG, HOMA-IR, Glucose, Other**	VERY LOW[e] (Low)

								Sedentary behaviour was not associated with other individual risk factors for the majority of studies.	
25	Cross-sectional[f]	Serious risk of bias[g]	Serious inconsistency[h]	No serious indirectness	No serious imprecision	Exposure/outcome gradient[i]	69,342[j]	**<u>Clustered Risk Score</u>** Higher sedentary behaviour was associated with a higher clustered risk score for: 1) <u>Accelerometer-derived sedentary time</u> - *1/3 studies*. 2) <u>Long accelerometer-derived sedentary bouts (≥5 min)</u> - *0/2 studies*. 3) <u>Screen time</u> - *3/3 studies* (only in females for 1 study). 4) <u>TV</u> - *6/10 studies* (only for females in 1 study). 5) <u>Computer</u> - *1/6 studies* (only for males in 1 study). 6) <u>Video game</u> - *1/3 studies* (only for males and weekends in 1 study). 7) <u>Total sedentary behaviour</u> – 0/2 studies. 8) <u>Resting</u> - *1/1 studies*. Higher sedentary behaviour was associated with a lower clustered risk score for: 1) <u>Accelerometer-derived sedentary breaks</u> - *1/2 studies.* 2) <u>Short accelerometer-derived sedentary bouts (1-4 min)</u> - *1/1 study*. **<u>BP</u>** Higher sedentary behaviour was associated with a higher BP for: 1) <u>Accelerometer-derived sedentary time</u> - *0/5 studies.* 2) <u>Accelerometer-derived sedentary bouts</u> - *0/2 studies.* 3) <u>Accelerometer-derived sedentary breaks</u> - 0/2 studies. 4) <u>Screen time</u> - *2/5 studies* (not for SBP in 1 study). 5) <u>TV</u> - *5/8 studies* (only males in 1 study and not for SBP in 1 study). 6) <u>Computer</u> - *1/6 studies.* 7) <u>Video games</u> - *1/3 studies* (not for SBP or mean atrial pressure in 1 study). 8) <u>Total sedentary time</u> - *0/2 studies.* Higher sedentary behaviour was associated with a lower BP for: 1) <u>Reading</u> - *1/2 studies*. 2) <u>Homework</u> - *1/1 study* (not for DBP or mean atrial pressure in 1 study). **<u>Cholesterol</u>** Higher sedentary behaviour was associated with a lower cholesterol for: 1) <u>Accelerometer-derived sedentary time</u> - *0/5 studies* 2) <u>Accelerometer-derived sedentary bouts and breaks</u> - *0/3 studies.*	VERY LOW[k]

								3) Screen time - *1/4 studies (for HDL in 1 study).* 4) TV - *3/7 studies* (1 study was for non-HDL and 2 studies were HDL, no association with LDL in 2 studies or total cholesterol in 1 study). 5) Computer - *1/4 studies* (for HDL in 1 study, only in males for 1 study) 6) Video games - *0/1 study* 7) Total sedentary behaviour – 0/2 studies Higher sedentary behaviour was associated with a higher cholesterol for: 1) Listening to music - *1/1 study* (for HDL in 1 study). **TG, HOMA-IR, Insulin, Glucose, CRP, Other** Sedentary behaviour was not associated with other individual risk factors for the majority of studies.	

TV; television viewing; HDL = high-density lipoprotein cholesterol; LDL = low-density lipoprotein cholesterol; VLDL, very low-density lipoprotein cholesterol, TG = triglycerides; SBP = systolic blood pressure; DBP = diastolic blood pressure; BP = blood pressure; HOMA-IR = homeostatic model assessment of insulin resistance; CRP = C-reactive protein; OGTT= Oral glucose tolerance test; HbA1c= glycated haemoglobin; TC=total cholesterol; AUC I = Area under the curve of insulin; min = minutes.

[a]Includes ~~6~~12 longitudinal studies (Dumith et al. 2012; Wennberg et al. 2013; Berentzen et al. 2014; Gopinath et al. 2014; Grontved et al. 2014; Hjorth et al. 2014; Ayala et al. 2016; Skrede et al. 2017; Dong et al. 2017; De Moraes et al. 2015; Chinapaw et al. 2018; Macdonal-Wallis et al. 2017; Peplies et al. 2016).
[b]Out of the 5 studies that used a subjective measure of sedentary behaviour, information on psychometric properties of the sedentary behaviour survey items were not provided.
[c]Mixed results observed.
[d]A dose response gradient for higher screen time, sedentary time with higher cardiometabolic risk was observed for ~~5~~8 studies (Wennberg et al. 2013; Berentzen et al. 2014; Gopinath et al. 2014; Grontved et al. 2014; Hjorth et al. 2014; De Moraes et al. 2015; Peplies et al. 2016; Dong et al. 2017).
[e]The quality of evidence for longitudinal studies was downgraded to "very low" from "low" due to serious risk of bias and serious inconsistency.

[f]Includes 25 cross-sectional studies (Hardy et al. 2010; Martinez-Gomez et al. 2010; Carson and Janssen 2011; Yoshinaga et al. 2011; Ekelund et al. 2012; Gopinath et al. 2012; Hay et al. 2012; Henderson et al. 2012; Pahkala et al. 2012; You and Son 2012; Atkin et al. 2013; Berendes et al. 2013; Chaput et al. 2013; Colley et al. 2013; Fang et al. 2013; Giussani et al. 2013; Lämmle et al. 2013; Rey-Lopez et al. 2013; Saunders et al. 2013; Sisson et al. 2013; Staiano et al. 2013; Stamatakis et al. 2013b; Chinapaw et al. 2014; Henderson et al. 2014; Vaisto et al. 2014).
[g]Out of the 21 studies that used a subjective measure of sedentary behaviour, information on psychometric properties of the sedentary behaviour items were only provided in 6 studies (Hardy et al. 2010; Lämmle et al. 2013; Saunders et al. 2013; Sisson et al. 2013; Staiano et al. 2013; Stamatakis et al. 2013b). One study did not report psychometric properties (Chaput et al. 2013) but used the same sample of another study where psychometric properties were reported (Saunders et al. 2013).
[h]Mixed results observed.
[i]A gradient for higher TV, screen time, video games, computer, sedentary bouts, sedentary breaks, sedentary time with higher cardiometabolic risk was observed for 6 studies (Carson and Janssen 2011; Gopinath et al. 2012; Atkin et al. 2013; Chaput et al. 2013; Stamatakis et al. 2013b; Vaisto et al. 2014) and lower risk for 2 studies (Saunders et al. 2013; Chinapaw et al. 2014).
[j]4 studies used data from the Quebec Adiposity and Lifestyle Investigation in Youth study (Henderson et al. 2012; Chaput et al. 2013; Saunders et al. 2013; Henderson et al. 2014) and 2 studies used data from the German Health Interview and Examination Survey for Children and Adolescents study (Berendes et al. 2013; Lämmle et al. 2013).
[k] The quality of evidence for cross-sectional studies was downgraded to "very low" from "low" due to serious risk of bias and serious inconsistency.

Table 1.2.3. The Relationship between Sedentary Behaviour and Behavioural Conduct/Pro-social Behaviour

No. of studies	Design	Quality Assessment					No. of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Mean baseline age ranged between 5 and 14 years; where mean age was not reported, baseline age ranged from 4 to 18 years and grades 6 to 10. One study did not report age or grade, rather that the sample was male guidance school students. Data were collected by randomized controlled trial (n=1), cross-over trial (n=1), longitudinal (n=10), and cross-sectional (n=12) study designs with up to 21 years follow up. Behavioural conduct/pro-social behaviour was assessed as ADHD symptoms (parent- and teacher-reported ADHD-IV Rating Scale, parental reported Strengths and Difficulties Questionnaire), time on task (direct observation), conduct problems (parent-reported Strength and Difficulties Questionnaire), peer relationship problems (parental-reported Strength and Difficulties Questionnaire), pro-social behaviour (parental-reported Strengths and Difficulties Questionnaire), criminal conviction (computer system), antisocial personality (modified Diagnostic Interview Schedule, self-reported Negative Life Events instrument), personality traits (self-reported Multidimensional Personality Questionnaire), behavioural problems (parental-reported Behavioural Problems Index, parental-reported 11-item symptomology checklist, self-reported Achenbach's Youth Questionnaire), aggression/violence (teacher-reported, self-report questionnaire, self-reported Buss and Perry's Aggression Questionnaire, parental-reported Child Behavior Checklist, self-reported State-Trait Anger and the Anger Expression Scale), attention/inattention/hyperactivity problems (teacher-reported questionnaire, self- and parental-reported Child Behavior Checklist, parental-reported Strength and Difficulties Questionnaire, self-reported ADHD symptoms scale, parental-reported ADHD Rating Scale-IV and parent and child attention symptomology checklist), impulsiveness (self-reported Barratt Impulsiveness Scale - II), serious and covert conduct (self-report questionnaire), bullying perpetration (self-reported Kidscape Questionnaire), social problem/withdrawn/delinquent behaviour (parental reported Child Behavior Checklist).									
1	Randomized controlled Trial[a]	No serious risk of bias	No serious inconsistency	Serious indirectness[b]	No serious imprecision	None	202	Smaller decrease in unfavourable measures of behavioural conduct/pro-social behaviour for the sedentary art group compared to the physical activity group for: 1) Non-Screen time - *1/1 study* (not for parental- or teacher-reported hyperactivity/impulsivity, oppositional behaviour, moodiness, behaviour toward peers, and reputation with peers and not for teacher-reported inattention).	MODERATE[c]
1	Cross-over Trial[d]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	96	Unfavourable measures of behavioural conduct/pro-social behaviour for the sedentary group compared to the physical activity group for: 1) Non-Screen time - *1/1 study* (only for 10-minute exercise break group).	LOW
~~10~~14	Longitudinal[e]	Serious risk of bias[f]	No serious inconsistency	No serious indirectness	No serious imprecision	Dose-response gradient[g]	~~31,648~~ 43,784	For *longitudinal findings*, higher sedentary behaviour was associated with unfavourable measures of behavioural conduct/pro-social behaviour for: 1) Screen time - ~~2~~*4*/~~2~~*4 studies* (not for emotional symptoms, hyperactivity/inattention, peer relationship problems or pro-social behaviour in 1 study). 2) TV - ~~3~~*5*/~~5~~*6 studies* (not for violent conviction by age 26yr in 1 study, not for emotional symptoms, hyperactivity/ inattention, peer relationship problems, or pro-social behaviour for 1 study, only in females for 1 study). 3) Video games - ~~5~~*6*/~~8~~*9 studies* (not for serious or covert conduct problems in 1 study).	VERY LOW[h] (LOW)

								For longitudinal findings, higher sedentary behaviour was associated with favourable measures of behavioural conduct/pro-social behaviour for: 1) Computer - *1/2 studies* (only in females for 1 study).	
12	Cross-sectional[i]	Serious risk of bias[j]	No serious inconsistency	No serious indirectness	No serious imprecision	None	95,287[k]	Higher sedentary behaviour was associated with unfavourable measures of behavioural conduct/pro-social behaviour for: 1) Screen time - *1/3 studies*. 2) TV - *4/6 studies* (not for withdrawn in 1 study, not for parental-reported attention problems, or antisocial personality in 1 study). 3) Computer - *3/5 studies* (not for anger in and anger control in 1 study). 4) Video game - *3/4 studies* (not for behavioural problems or attention problems in 4 to 8 and 13 to 18 yr olds in 1 study, not for parental-reported attention problems, or antisocial personality in 1 study). 5) Higher tech time - *1/1 study each* (not for behavioural problems in 4 to 8 yr olds or attention and behavioural problems for 9 to 12 yr olds).	VERY LOW[l]

Note: ADHD = attention deficit/hyperactivity disorder; TV = television viewing.

[a]Includes 1 randomized controlled trial (Hoza et al. 2014).
[b]It is unclear if children were engaging in sedentary time during the whole before school period and whether the art class was just replacing other sedentary time.
[c]The quality of evidence for the randomized controlled trial was downgraded to "moderate" from "high" due to serious indirectness.
[d]Includes 1 cross-over trial (Howie et al. 2014).
[e]Includes ~~10~~14 longitudinal studies (Hofferth 2010; Swing et al. 2010; Lemmens et al. 2011; Barlett et al. 2012; Gentile et al. 2012; Janssen et al. 2012; Willoughby et al. 2012; Parkes et al. 2013; Robertson et al. 2013; Brunborg et al. 2014; Allen et al. 2015; Roser et al. 2016; Chaelin et al. 2018; Wu et al. 2018).
[f]Apart from 2 studies (Gentile et al. 2012; Janssen et al. 2012) information on psychometric properties of the sedentary behaviour items were not provided.
[g]A dose-response gradient was for higher TV, screen time, computer, and video games with unfavourable behavioural conduct/pro-social behaviour was observed in ~~6~~9 studies (Swing et al. 2010; Lemmens et al. 2011; Janssen et al. 2012; Parkes et al. 2013; Robertson et al. 2013; Brunborg et al. 2014; Allen et al. 2015; Wu et al. 2018; Chaeli et al. 2018).
[h] The quality of evidence for the longitudinal studies was downgraded to "very low" from "low" due to serious risk of bias.
[i]Includes 12 cross-sectional studies (Griffiths et al. 2010; Ferguson 2011; Ozmert et al. 2011; Demirok et al. 2012; Singh and Yu 2012; van Egmond-Frohlich et al. 2012; Busch et al. 2013; Lämmle et al. 2013; Rech et al. 2013; Shokouhi-Moqhaddam et al. 2013; Przybylski 2014; Rosen 2014).
[j]Apart from 4 studies (Ferguson 2011; Ozmert et al. 2011; Lämmle et al. 2013; Shokouhi-Moqhaddam et al. 2013) information on psychometric properties of the sedentary behaviour items were not provided.
[k]Two studies used the German Health Interview and Examination Survey for Children and Adolescents (van Egmond-Frohlich et al. 2012; Lämmle et al. 2013).
[l] The quality of evidence for cross-sectional studies was downgraded to "very low" from "low" due to serious risk of bias.

Table 1.2.4. The Relationship between Sedentary Behaviour and Academic Achievement

No. of studies	Design	Quality Assessment					No. of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Mean baseline age ranged between 12.0 and 16.9 years; where mean age was not reported, baseline age ranged from 6 to 18 years and grades 9 to 12. Data were collected by longitudinal (n=4) and cross-sectional (n=12) study designs with up to 2 years follow up. Academic achievement was assessed as school/academic performance (self- and proxy-report by interview, questionnaire and Child Behaviour Checklist); grades/grade point average (self- and proxy-report by interview or questionnaire, objectively measured) standardized test scores (National Center for Education Statistics, the National Assessment Program for Literacy and Numeracy); and Reading and Mathematics skills (Wide Range Achievement Test, Revision 3).									
~~4~~10	Longitudinal[a]	Serious risk of bias[b]	No serious inconsistency (Serious inconsistency)	No serious indirectness	No serious imprecision	Dose response gradient[c]	~~23,093~~ 33,703	Among *longitudinal findings*, higher sedentary behaviour was associated with lower academic achievement for: 1) Total screen time – 2/2 studies 2) TV - *3/6 studies* (weekdays only for one study). 3) Video games - *~~1~~2/~~3~~6 studies*. 4) Computer - *~~0~~1/~~1~~2 study*. 5) Non-school sedentary time excluding TV – 1/1 studies 6) Mobile Phone – 0/1 study Among longitudinal findings, higher sedentary behaviour was associated with higher academic achievement for: - Accelerometer – derived sedentary time – 2/2 studies 1) Reading - *2/~~2~~3 studies*. 2) Homework outside of school *~~1~~2/~~1~~2 study*.	VERY LOW[d]
12	Cross-sectional[e]	Serious risk of bias[f]	Serious inconsistency	No serious indirectness	No serious imprecision	Exposure/ outcome gradient[h]	14,887	Higher sedentary behaviour was associated with lower academic achievement for: 1) TV - *1/6 studies* (only for males in 1 study). 2) Video games - *3/6 studies (for GPA only in 1 study)*. 3) Computer - *1/4 study*. 4) Total sedentary behaviour - 1/2 studies 5) Cell phone - *0/2 studies* Higher sedentary behaviour was associated with higher academic achievement for: 1) Computer - *1/4 studies*. 2) Total sedentary behaviour - *1/2 studies* (before school only for 1 study). Due to heterogeneity in the measurement of sedentary behaviour and academic achievement a meta-analysis was not possible.	VERY LOW[i]

[a]Includes ~~4~~10 longitudinal studies (Sharif et al. 2010; Bowers and Berland 2013; Romer et al. 2013; Brunborg et al. 2014; Nigg et al. 2015; Aggio et al. 2016; Roser et al. 2016; Lopez-Vicente et al. 2017; Wickel et al. 2017; Poulain et al. 2018).

[b]No studies provided information on psychometric properties of the sedentary behaviour items.

[c]A dose-response gradient for higher TV/accelerometer derived sedentary time and lower academic achievement or reading and homework with higher academic achievement was observed in ~~2~~ 4 studies (Bowers and Berland 2013; Romer et al. 2013; Aggio et al. 2016; Wickel et al. 2017).
[d]The quality of evidence for longitudinal studies was downgraded to "very low" from "low" due to serious risk of bias.
[e]Includes 12 cross-sectional study (Sanchez-Martinez and Otero 2010; Ferguson 2011; Jackson et al. 2011; Jeong and Kim 2011; Ozmert et al. 2011; Martinez-Gomez et al. 2012; O'Dea and Mugridge 2012; Esmaeilzadeh and Kalantari 2013; Shashi Kumar et al. 2013; Kiatrungrit and Hongsanguansri 2014; Munoz-Miralles et al. 2014; Vassiloudis et al. 2014).
[f]Apart from 3 studies (Ferguson 2011; Ozmert et al. 2011; Shashi Kumar et al. 2013) information on psychometric properties of the sedentary behaviour items were not provided.
[g]Mixed findings were observed.
[h]A gradient for higher video games and computer use with lower academic achievement was observed in 2 studies (Jackson et al. 2011; Munoz-Miralles et al. 2014).
[i]The quality of evidence for cross-sectional studies was downgraded to "very low" from "low" due to serious risk of bias and serious inconsistency.

Table 1.2.5. The Relationship between Sedentary Behaviour and Fitness

No. of studies	Design	Quality Assessment					No. of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Mean baseline age ranged between 6.7 and 17.7 years; where mean age was not reported, baseline age ranged from 6 to 18.5 years. Data were collected from longitudinal (n=3) and cross-sectional (n=18) study designs with up to 2 year follow up. Fitness was assessed as CFR (Andersen test, PACER, AMIS 2001 Cardiopulmonary Function test, FITNESSGRAM 20 m shuttle-run, submaximal cycle ergometer test, 3 minute step test, Leger shuttle run, Physical Work Capacity 170 test); flexibility (EUROFIT test, Dordel-Koch test, Motorik-Modeule, FITNESSGRAM); muscular strength/endurance (EUROFIT test, Dordel-Koch test, hand grip strength, Motorik-Modeule, FITNESSGRAM); power (EUROFIT test, Dordel-Koch test). All outcomes were measured objectively.									
3	Longitudinal[a]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	Dose-response gradient[b]	4,327	**CRF** For prospective findings, higher sedentary behaviour was associated with lower fitness for: 1) Accelerometer-derived sedentary time - *1/1 study*. 2) Screen time - *3/3 studies*.	LOW
18	Cross-sectional[c]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	Exposure/ outcome gradient[d]	55,636[e]	**CRF** Higher sedentary behaviour was associated with lower fitness for: 1) Accelerometer-derived sedentary time - *2/5 studies* (only in females for 1 study). 2) Screen time - *3/3 studies.* 3) TV - 3/3 studies (only in females for 1 study). 4) Video game - *2/2 studies* (only for males on weekdays in 1 study). 5) Computer - *0/1 study.* *6) Total sedentary behaviour – 1/1 study.* **Muscular Strength/Endurance** Higher sedentary behaviour was associated with lower fitness for: 1) Accelerometer-derived sedentary time - *0/1 study.* 2) Screen time - *2/2 studies.* 3) TV - *1/3 studies* (not for grip strength in 1 study). 4) Computer - *2/2 studies* (not for strength of arm in 1 study). 5) Video game - *0/2 studies.* **Flexibility** Higher sedentary behaviour was associated with lower fitness for: 1) Accelerometer-derived sedentary time - *0/1 study.* 2) Screen time - *1/1 study.* 3) Computer - *1/1 study.* **Other**	MODERATE[f]

								Higher sedentary behaviour was associated with lower fitness for: 1) Accelerometer-derived sedentary time and peak expiratory flow - *0/1 study.* 2) Screen time and overall fitness score - *1/1 study.* 3) TV and overall fitness score - *1/1 study.* 4) TV and higher resting HR - *1/1 study.*	

Note: CRF = cardiorespiratory fitness; HR = heart rate; TV = television viewing.

[a]Includes 3 longitudinal studies (Aggio et al. 2012; Mitchell et al. 2012; Hjorth et al. 2013).
[b]A dose-response gradient of higher screen time with lower fitness was observed in 1 longitudinal study (Mitchell et al. 2012).
[c]Includes 18 cross sectional study (Dencker et al. 2010; Ruiz et al. 2010; Aires et al. 2011; Martinez-Gomez et al. 2011b; Dowda et al. 2012; Hay et al. 2012; Machado-Rodrigues et al. 2012; Grontved et al. 2013; Lämmle et al. 2013; Sandercock and Ogunleye 2013; Simhaee et al. 2013; Ciesla et al. 2014; Drenowatz et al. 2014; Filho et al. 2014; Poethko-Muller and Krug 2014; Santos et al. 2014; Tucker et al. 2014; Aggio et al. 2015).
[d]A gradient of higher accelerometer-derived sedentary time, screen time, or TV with lower fitness was observed in 7 cross-sectional studies (Aires et al. 2011; Dowda et al. 2012; Grontved et al. 2013; Lämmle et al. 2013; Sandercock and Ogunleye 2013; Poethko-Muller and Krug 2014; Santos et al. 2014).
[e]Two studies used the German Health Interview and Examination Survey for Children and Adolescents (Lämmle et al. 2013; Poethko-Muller and Krug 2014).
[f]The quality of evidence for cross-sectional studies was upgraded to "moderate" from "low" due to an exposure/outcome gradient.

Table 1.2.6. The Relationship between Sedentary Behaviour and Self-Esteem

No. of studies	Design	Quality Assessment					No. of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Mean age ranged between 9.87 and 16.4 years; where mean age was not reported, age ranged from 12 to 19 years and grades 3 to 5. Data were collected by cross-sectional design (n=10). Self-esteem was assessed as overall/global/general and social self-esteem (Rosenberg Self-Esteem scale, Culture Free Self Esteem Inventories for Children, Marsh's Physical Self-Description questionnaire; Harter Self-Perception Profile for Children questionnaire, Harter's Self-Competence scale); general self-efficacy (Rosenberg's Self-Efficacy scale and Schwarzer's Generalized Self-Efficacy scale); offline and online social self-efficacy (Self-Efficacy Questionnaire for Children and Self-Efficacy scale); academic, social, physical appearance, athletic, and behavioural self-concept (Harter's Self-Competence scale, Rosenberg's Self-Esteem scale, Marsh's Physical Self-Description questionnaire). All measures were assessed through a self-reported questionnaire. Some studies modified the scales.									
10	Cross-ectional[a]	Serious risk of bias[b]	Serious inconsistency[c]	No serious indirectness	No serious imprecision	Exposure/Outcome Gradient[d]	82,919	Higher sedentary behavior was associated with lower self-esteem for: 1) Accelerometer-derived sedentary time – *0/2 studies.* 2) Accelerometer-derived sedentary bouts – *0/1 study.* 3) Accelerometer-derived sedentary breaks – *0/1 study.* 4) Screen time – *2/2 studies* (not physical self-concept in 1 study). 5) TV – *2/4 studies.* 6) Computer – *3/5 studies* (one for females only in 1 study, not for online game in 1 study, not for physical concept in 1 study. 7) Video games – *¼ studies* (only in self-concept and self-esteem in 1 study). Higher sedentary behavior was associated with higher self-esteem for: 1) Computer – *1/5 studies* (only for self-concept in 1 study) 2) Video games – *¼ studies* (only for online self-efficacy for 1 study) 3) cell phone – *2/2 studies* (not for global self-esteem in 1 study and only for social self-concept in 1 study).	VERY LOW[e]
1	Longitudinal[f]	Serious risk of bias	Serious inconsistency	No serious indirectness	No serious imprecision	Non	519	In boys, higher sedentary behaviour is associated with lower self-esteem (0/1) 1) Other Screen time (computers, video game consoles mobile devices) (1/1) 2) TV (0/1) In girls, higher sedentary behavior was associated with higher self-esteem. 1) Other Screen time (computers, video game consoles mobile devices) (0/1) 2) TV (1/1)	Very low

[a]Includes 10 cross-sectional studies (Jackson et al. 2010; McClure et al. 2010; Jackson et al. 2011; Jeong and Kim 2011; Racine et al. 2011; Tin et al. 2012; Busch et al. 2013; Nihill et al. 2013; Faulkner et al. 2014; Kiraly et al. 2014).
[b]Of the nine studies that used a subjective measure of sedentary behaviour, only one study (Nihill et al. 2013) reported psychometric properties for the items.
[c]Mixed findings were observed.
[d]A gradient for higher screen time and TV with lower self-esteem was observed in 3 studies (McClure et al. 2010; Racine et al. 2011; Tin et al. 2012).
[e] The quality of evidence for cross-sectional studies was downgraded to "very low" from "low" due to serious risk of bias and serious inconsistent
[f] Includes one longitudinal study (Braig et al. 2018).

Table 1.2.6. The Relationship between Sedentary Behaviour and Psychological Distress

No. of studies	Design	Quality Assessment					No. of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Mean age ranged between 13.54 and 18.43 years; where mean age was not reported, age ranged from 6 to 15 years. Data were collected by longitudinal design (n=6). Psychological Distress was assessed using different methods. Anxiety was assessed using the Self-Rating Anxiety Scale (SAS). Depression was assessed using the Center for Epidemiologic Studies Depression Scale (CES-D) and the Mood and Feelings Questionnaire (MFQ). Psychopathological symptoms were measured using the Multidimensional Sub-health Questionnaire of Adolescents (MSQA). Psychopathological symptoms were measured using the Multidimensional Sub-health Questionnaire of Adolescents (MSQA).									
6	Longitudinal[a]	Serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	7,417	Higher sedentary behavior associated with higher levels of psychological distress 1) Accelerometer-derived sedentary time – 0/2 studies 2) Screen time – 4/4 studies 3) Computer use for homework – 0/1 study 4) TV – 0/1 study	VERY LOW[e]

[a] Includes 6 longitudinal studies (Sund et al. 2011; Hume et al. 2011; Gunnell et al. 2016; Wu et al. 2016; Zahl et al. 2017; Babic et al. 2017).

1.3 Sleep

PICO: In children 5-17 years of age what duration of sleep, as measured by objective and subjective methods, is associated with favourable health indicators?

Table 1.3.1 Association between sleep duration and adiposity in children and youth.
Note: Text in blue is the number after the Australian update

No of studies	Design	Quality Assessment					No of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Mean age ranged between 5 and 17.7 years. Intervention study was 1 week long and up to 6 years for longitudinal studies. Sleep duration was assessed by actigraphy, polysomnography, parent report or self-report. Adiposity was assessed as body weight, body mass index (absolute, z-score or percentile), fat mass index, waist circumference, waist-to-height ratio, weight status (different definitions for underweight, normal weight, overweight, obese) or % body fat (bioelectrical impedance, dual-energy X-ray absorptiometry, skinfolds), either objectively or subjectively.									
1	Randomized trial[a]	No serious risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision[b]	None	37	Compared with decreased sleep, increased sleep duration resulted in lower weight after a week (mean difference in weight of 0.24 kg, $p<0.001$, Cohen's $d = 0.93$). There was a 2.4 h sleep duration difference between conditions (8.1 h vs. 10.5 h for the decreased and increased sleep, respectively).	MODERATE
~~12~~ 13	Longitudinal study[c]	Serious risk of bias[d]	No serious inconsistency	No serious indirectness	No serious imprecision	None	~~40,726~~ 54,815	Out of ~~12~~ 13 longitudinal analyses, ~~7~~ 8 reported a significant association between short sleep duration and adiposity gain while 5 reported no association.	VERY LOW
~~58~~ 71	Cross-sectional study[e]	Serious risk of bias[f]	No serious inconsistency	No serious indirectness	No serious imprecision	Large effect and evidence of a dose-response gradient (i.e. longer sleep associated with lower adiposity)	~~470,303~~ 542,457	Out of ~~58~~ 71 cross-sectional analyses, ~~50~~ 57 reported a significant association between short sleep duration and adiposity, 3 reported a significant association between longer sleep duration and reduced risk of adiposity, 1 reported an association between irregular sleep duration and increased risk of adiposity, while ~~8~~ 10 reported no association.	LOW

								Due to heterogeneity in the measurement of sleep and adiposity, a meta-analysis was not possible.	

[a]Randomized cross-over study (Hart et al. 2013).
[b]Only one study was published so the risk of imprecision is high (the quality of evidence was downgraded from high to moderate).
[c]Includes ~~12~~ 13 longitudinal studies (Magee et al. 2013b; Bartlett et al. 2012; Chang et al. 2013; Lytle et al. 2013; Mitchell et al. 2013; Hjorth et al. 2014a; Hjorth et al. 2014b; Hiscock et al. 2011; Silva et al. 2011; Araujo et al. 2012; Calamaro et al. 2010; Suglia et al. 2014; Cao et al. 2018).
[d]Only ~~2~~ 3 studies used an objective assessment of sleep duration (the quality of evidence was downgraded from low to very low).
[e]Includes ~~58~~ 71 cross-sectional studies (Hjorth et al. 2014a; Hjorth et al. 2014b; Hiscock et al. 2011; Silva et al. 2011; Araujo et al. 2012; Calamaro et al. 2010; Suglia et al. 2014; Butte et al. 2007; Chaput et al. 2014; Colley et al. 2012; Ekstedt et al. 2013; Katzmarzyk et al. 2015; Wong et al. 2013; Chaput et al. 2011; de Jong et al. 2012; Guo et al. 2012; Hense et al. 2011; Magee et al. 2013a; Padez et al. 2009; Park et al. 2012; Scharf et al. 2015; Sekine et al. 2002; Suglia et al. 2013; Von Kries et al. 2002; Wing et al. 2009; Bawazeer et al. 2009; Berentzen et al. 2014; Eisenmann et al. 2006; Ozturk et al. 2009; Peach et al. 2015; Shan et al. 2010; Stroebele et al. 2013; Awad et al. 2013; Martinez et al. 2014; Gupta et al. 2002; Al-Hazzaa et al. 2014; Al-Hazzaa et al. 2012; Bel et al. 2013; Culnan et al. 2013; Danielsen et al. 2010; Do et al. 2013; Garaulet et al. 2011; Huang et al. 2010; Knutson and Lauderdale 2007; Knutson 2005; Kuciene and Dulskiene 2014; Kong et al. 2011; Lee and Park 2014; Liou et al. 2010; Lowry et al. 2012; Martinez-Gomez et al. 2011; Meldrum and Restivo 2014; Morley et al. 2012; Pallesen et al. 2011; Park 2011; Sivertsen et al. 2014a; Stea et al. 2014; ~~Vaezghasemi et al. 2012;~~ Ferranti et al. 2016; Gong et al. 2018; Jiang et al. 2015; Duran Aguero et al. 2016; Lee et al. 2016; Lim et al. 2018; Macahdo-Rodrigues et al. 2018; Nuutinen et al. 2017; Rudnicka et al. 2017; Sakamoto et al. 2017; Seo et al. 2017; Zhang B et al. 2017; Zhang J et al. 2017).
[f]Most studies used a subjective assessment of sleep with no psychometric properties reported (the quality of evidence was downgraded from low to very low). However, the quality of evidence for the cross-sectional studies was upgraded to "low" because of the large effect observed and the evidence of a dose-response gradient between sleep duration and adiposity (i.e. longer sleep is associated with lower adiposity indicators).

Table 1.3.2. Association between sleep duration and emotional regulation in children and youth.
Note: Text in blue is the number after the Australian update

No of studies	Design	Quality Assessment					No of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Mean age ranged between 7 and 17.3 years. Intervention studies were between 2 days and 9 months, and longitudinal studies were up to 8 years. Sleep duration was assessed by actigraphy, polysomnography, parent report or self-report. Emotional regulation was assessed through various self-reported instruments.									
4 9	Randomized trial[a]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	~~277~~ 1433	After the treatment, participants in the sleep education group showed significant improvements in irritability and mood in the morning compared to the control group (Tamura and Tanaka 2014). Participants showed impaired functioning in the short (mean: 8.1 h) relative to the long (mean: 9.3 h) sleep condition on measures of positive affective response and emotion regulation (Vriend et al. 2013). Compared with healthy sleep (control; 10 h in bed per night for 5 nights), participants rated themselves as significantly more tense/anxious, angry/hostile, confused, fatigued, and less vigorous during sleep restriction (6.5 h in bed per night for 5 nights). Parents and adolescents also reported greater oppositionality/irritability and poorer emotional regulation during sleep restriction compared to control. There were no differences in depression or hyperactivity/impulsivity (Baum et al. 2014). Participants reported more positive affect (but no difference in negative affect) when rested (8.5	HIGH

								h/night for 2 nights) relative to when sleep deprived (6.5 h the first night then 2 h the 2nd night) (Dagys et al. 2012). No effects of time in bed on mood were reported (Diaz-Morales et al. 2015b). Increase in TIB on weekdays was related to a decrease in depressive symptoms and increase in positive mood ($p<0.04$). Increase in weekday TST was not associated with any changes ($p>0.19$)(Lo et al. 2018). Negative affect was increased following sleep restriction both in terms of subjective affective experience ($p<0.01$) and pupillary response ($p=0.04$)(McMakin et al. 2016). Sleep duration was not analysed in relation to the outcome category, however, after the intervention TST and TIB were both increased ($p<0.004$) and perceived stress and anxiety decreased significantly ($p<0.001$) (Paavonen et al. 2016). Participants in the sleep restricted sleep condition reported significantly less positive affect ($p = 0.002$) higher state anxiety ($p < 0.001$) and higher trait anxiety ($p = 0.01$) relative to those in the idealized sleep condition (Reddy et al. 2017).	
~~11~~ 13	Longitudinal study[b]	Serious risk of bias[c]	No serious inconsistency	No serious indirectness	No serious imprecision	None	~~25,271~~ 27,801	Out of ~~11~~ 13 longitudinal analyses, ~~8~~ 9 reported that longer sleep was related to better emotional	VERY LOW

								regulation at follow-up, 1 reported that daily variability in sleep duration predicted greater symptomatology, while 3 reported no association.	
~~47~~ 67	Cross-sectional study[d]	Serious risk of bias[e]	No serious inconsistency	No serious indirectness	No serious imprecision	None	~~480,925~~ 684,315	Out of ~~47~~ 67 cross-sectional analyses, ~~37~~ 39 reported that longer sleep was related to better emotional regulation, 13 that shorter sleep was associated with worse emotional regulation, ~~8~~ 12 reported null findings, and ~~2~~ 3 reported opposite/mixed associations. Due to heterogeneity in the measurement of sleep and emotional regulation, a meta-analysis was not possible.	VERY LOW

[a]Includes ~~3~~ 7 randomized cross-over/repeated measures studies (Vriend et al. 2013; Baum et al. 2014; Dagys et al. 2012; Paavonen et al. 2016; McMakin et al. 2016; Lo et al. 2018; Diaz-Morales et al. 2015b) and ~~one~~ two randomized controlled trials (Tamura and Tanaka 2014; Reddy et al. 2017).

[b]Includes ~~11~~ 13 longitudinal studies (Asarnow et al. 2014; Barlett et al. 2012; Chang and Gable 2013; Frederiksen et al. 2004; Roberts and Duong 2014; Roberts et al. 2009; Kalak et al. 2014; Pasch et al. 2012; Lin and Yi 2015; Lumeng et al. 2007; Silva et al. 2011; Fuligni et al.2018; James and Hale 2017).

[c]Only one study used an objective assessment of sleep (the quality of evidence was downgraded from low to very low).

[d]Includes ~~47~~ 67 cross-sectional studies (Lin and Yi 2015; Lumeng et al. 2007; Silva et al. 2011; Arman et al. 2011; Biggs et al. 2011; Bos et al. 2009; Nixon et al. 2008; Ievers-Landis et al. 2008; Lin et al. 2011; van der Heijden et al. 2013; Wang et al. 2013; Lehto and Uusitalo-Malmivaara 2014; Barnes 2015; Chen et al. 2006; de Souza and Hidalgo 2014; Dewald et al. 2012; Dewald-Kaufmann et al. 2013; Do et al. 2013; Fitzgerald et al. 2011; Gangwish et al. 2010; Gupta et al. 2002; Kang et al. 2014; Kubiszewski et al. 2014; Lam and Yang 2008; Lee et al. 2012; Lemola et al. 2015; Liu 2004; Liu and Zhou 2002; Lowry et al. 2012; McClure et al. 2014; McHale et al. 2011; Knight-Eily et al. 2011; Meijer et al. 2010; Paciencia et al. 2013; Pallesen et al. 2011; Perfect et al. 2014; Perkinson-Gloor et al. 2013; Park et al. 2013; Sarchiapone et al. 2014; Sivertsen et al. 2014b; Short et al. 2013a; Short et al. 2013b; Stea et al. 2014; Suzuki et al. 2011; Winsler et al. 2015; Wolfson and Carskadon 1998; Yen et al. 2010; Bauducco et al. 2016; Calhoun et al. 2017; Chaing et al. 2017; Daly et al. 2015; Diaz-Morales et al. 2015b; Fernandez-Mendoza et al. 2016; Fuligni et al. 2018; Hysing et al. 2015; Hysing et al. 2016b; Liu et al. 2017; Ojio et al. 2016; Owens et al. 2016; Owens et al. 2017; Park et al. 2017; Poulou et al. 2017; Seo et al. 2017; Shen et al. 2018; Wang et al. 2017; Wheaton et al 2016; Zhang et al. 2017).

[e]Most studies used a subjective assessment of sleep with no psychometric properties reported (the quality of evidence was downgraded from low to very low).

Table 1.3.3 Association between sleep duration and cognition in children and youth.
Note: Text in blue is the number after the Australian update

No of studies	Design	Quality Assessment					No of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Mean age ranged between 8 and 17 years. Data were collected cross-sectionally and up to 5 years of follow-up. Sleep duration was assessed by actigraphy, polysomnography, parent report or self-report. Cognition was measured by self- and parental-report, as well as numerous computer testing modalities, and other tests/questionnaires: the CBCL, the TEA test, the CCTT (versions 1-2), the WISC-III and the MFT, the PVT, the n-back Task, Behavioral Rating Inventory of Executive Function-Self-Report, Thurstone's Primary Mental Abilities (PMA) test, the Penn Computerized Neurocognitive Battery, the Developmental Neuropsychological Assessment for Children II, the Conners Continuous Performance Test II/Wisconsin Card Sorting Task/Trail Making Task, ImPACT, and PCSS.								
~~1~~ 6	Randomized trial[a]	No serious risk of bias	No serious inconsistency	No serious indirectness	~~Serious imprecision[b]~~ No serious imprecision	None	~~32~~ 326	Short term memory, working memory, divided attention (CCTT-2) and math fluency scores were lower in children in the short sleep condition (1 h later in bed for 4 nights) compared to long sleep (1 h earlier for 4 nights relative to their typical bedtime). No differences were found for reaction time on alerting, orienting, sustained (CCTT-1) or executive attention tasks between long and short sleep conditions. Those who began in the short sleep condition had greater working memory and sustained attention (CCTT-1) than those who began in the long sleep condition (Vriend et al. 2013). Longer sleep was associated with better performance on the classroom quiz. Greater inattention and eye closure was seen during short sleep compared to long sleep episodes. Parents and adolescents alike reported that the adolescents showed significantly greater inattention and daytime sleepiness during short sleep than during long sleep (Beebe et al. 2017)	~~MODERATE~~ HIGH

								During encoding in the picture encoding and recognition test, accuracy was significantly lower in the SR group who were also significantly slower than controls. At retrieval, recognition was poorer in the SR group compared to controls. Prior to encoding, vigilance was impaired significantly for the SR group compared to controls, with a greater number of lapses and slower response speed (Cousins et al. 2018). A significant reduction in sleep duration was seen in the post daylight savings time (DST) condition. A decline in psychomotor vigilance (mean reaction time, number of lapses, and reciprocal reaction time) was seen during the week post-DST (Medina et al. 2015). Participants who had a nap opportunity had faster RT ($p<0.008$), while participants in the no-nap group tended to have steeper TOT declines. The results suggest that napping may partially reverse detrimental effects of sleep restriction (Lim et al. 2017). No sleep duration effects were seen on memory performance. Benefits of prioritization on memory was greater one week after encoding only for the control group but not the SR group (Lo et al. 2016).	

~~1~~ 2	Longitudinal study[c]	No serious risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision[d]	None	~~304~~ 1013	At 5-year follow-up, there were no increased odds of having learning problems across sleep duration categories. There were significant associations between average nightly sleep duration, EF and sedentary behaviour were identified (Warren, 2015)	VERY LOW
4 9	Cross-sectional study[e]	Serious risk of bias[f]	Serious inconsistency[g]	No serious indirectness	No serious imprecision	None	~~8,221~~ 34653	Kim et al. (2011) found no association between sleep duration and attention. However, increased weekend (but not weekday) sleep duration was associated with more omission errors on sustained and divided attention tasks ($\beta = 0.40$, $p<0.01$ and. $\beta = 0.26$, $p<0.05$ respectively). McClure et al. (2014) found that verbal and visual memory scores were lower in the short sleep group (<7 h) compared to the intermediate sleep group (≥7 h to <9 h), but found no associations between sleep duration and visual motor processing. Ortega et al. (2010) found better overall cognitive performance and reasoning abilities in males who slept longer (>8 h) compared to the short sleep group (<8 h). No associations were observed for verbal or numeric ability in males and no associations altogether were found in females. van der Heijden et al. (2013) found no association between sleep duration and reaction time,	VERY LOW

								information processing, or focused attention. Working memory errors were positively correlated with sleep duration, but working reaction time was not. Verbal and nonverbal intellectual ability were negatively correlated with sleep duration during weekdays, but not on weekends. Time in bed on weekdays and weekends were not related to PMA (Diaz-Morales et al. 2015a) Participants with higher frequencies or longer durations of midday napping reported significantly better nighttime sleep quality. Frequent nappers (5–7d/week) were significantly associated with heightened accuracy on tasks that measured sustained attention and nonverbal reasoning and faster reaction times on spatial memory compared with other frequency groups (Ji et al. 2018) In girls, longer catch-up sleep was associated with longer reaction times, and higher scores in the similarities test. In boys, shorter sleep duration was associated with faster reaction times in CPT, lower D prime scores, and larger number of commission errors in the CPT, reflecting poorer executive functioning (Kuula et al. 2015) Greater amounts of sleep during the week were associated with lower odds of being restless, or distractible; and more sleep was associated with higher odds of being	

								persistent on tasks (Sakamoto et al. 2017). The typical sleep (5.5-8.5hrs) group had higher neurocognitive scores and were less symptomatic than the sleep restricted (<5hrs) group. The optimal sleep group (>9hrs) had had higher neurocognitive scores on verbal and visual memory, visual motor speed, and PCSS, than the sleep restricted group (<5hrs) (Sufrinko et al. 2016). Due to heterogeneity in the measurement of sleep and cognition, a meta-analysis was not possible.	

CBCL = Child Behaviour Checklist; TEA = Test of Educational Ability; CCTT = Children's Colour Trails Test; WISC III = Wechsler Intelligence Scale for Children-Third Edition; MFT = Math Fluency Task; ImPACT = Baseline Immediate Post-Concussion Assessment and Cognitive Testing; PCSS = Post-concussion Symptom Scale; PVT = Psychomotor Vigilance Test. [a]Includes 6 randomized cross-over studies/randomized control trials (Vriend et al. 2013; Medina et al. 2015; Lo et al. 2016; Lim et al. 2017; Cousins et al. 2018; Beebe et al. 2017). [b]Large standard deviations, small effect sizes and only one study was published so the risk of imprecision is high (the quality of evidence was downgraded from high to moderate). [c]Includes ~~1~~2 longitudinal studies (Silva et al. 2011; Warren et al. 2015). [d]Only one study was published so the risk of imprecision is high (the quality of evidence was downgraded from low to very low). [e]Includes 4 9 cross-sectional studies (Kim et al. 2011; McClure et al. 2014; Ortega et al. 2010; van der Heijden et al. 2013; Sufrinko et al. 2016; Sakamoto et al. 2017; Kuula et al. 2015; Ji et al. 2018; Diaz-Morales et al. 2015a). [f]All studies used a subjective assessment of sleep with no psychometric properties reported. [g]Studies reported either positive, negative, or null findings. Therefore, the quality of evidence was downgraded from low to very low.

Table 1.3.4. Association between sleep duration and academic achievement in children and youth.
Note: Text in blue is the number after the Australian update

No of studies	Design	Quality Assessment					No of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Mean age ranged between ~~12~~ 8.46 and 17.3 years. Data were collected cross-sectionally and up to 6 years of follow-up. Sleep duration was assessed by parent report, self-report, or actigraphy. Academic achievement metrics were assessed by official school transcripts, report cards, school engagement, attendance, GPA, self-report questionnaire, WJ-R, and NAPLAN.									
~~4~~ 6	Longitudinal study[a]	Serious risk of bias[b]	No serious inconsistency	No serious indirectness	No serious imprecision	None	~~10,286~~ 11017	~~3 out of 4~~ 3 out of 6 studies reported poorer grades with short sleep duration (Fredriksen et al. 2004; Roberts et al. 2009; Lin et al. 2015). ~~Asarnow et al. (2014)~~ Two studies reported that short sleep duration did not predict cumulative GPA at follow-up (Asarnow et al.2014; Dunbar et al. 2017), while one of these found a positive correlation between School engagement and sleep duration. Fuligni et al. (2018) reported nonlinear associations of sleep duration with GPA and English (but not Math) test scores.	VERY LOW
~~17~~ 27	Cross-sectional study[c]	Serious risk of bias[d]	No serious inconsistency	Serious indirectness[e]	No serious imprecision	None	~~30,249~~ 104529	~~11 of 17~~ 16 of 27 total studies showed associations for longer sleep duration and better academic achievement, or shorter sleep duration and poor academic achievement measured by self-report, official school grades, or standardized tests (Lin et al. 2015; Eide and Showalter 2012; Stroebele et al. 2013; Kang et al. 2014; Pallesen et al. 2011; Perkinson-Gloor et al. 2013; Quevedo-Blasco and Quevedo-Blasco 2011; Stea et al. 2014; Titova et al. 2015; van der Vinne et al. 2015; Wolfson and Carskadon 1998; Singh et al. 2018; Levin et al. 2017; Kolomeichuk et	VERY LOW

								al. 2016; Diaz-Morales et al. 2015a; Faught et al. 2017a). ~~5~~ 7 studies found no association between sleep duration and academic achievement (Arbabi et al. 2015; O'Dea and Mugridge 2012; Boschloo et al. 2013; McHale et al. 2011; Short et al. 2013a; Pecor et al. 2016; Matos et al. 2016). 1 study (Unalan et al. 2013) found that as sleeping span increased, academic achievement decreased. Fuligni et al. (2018) reported nonlinear associations of sleep duration with GPA and English (but not Math) test scores. 2 studies (Hysing et al. 2016a; Faught et al. 2017b) found sleeping too short, or too long, compared to recommendations, was negatively associated with academic achievement. Hysing et al. 2016a There was a dose–response association between GPA and sleep efficiency, with adolescents having a sleep efficiency of ≥90% having the highest GPA (4.0) compared to adolescents with a sleep efficiency of <75% having a GPA of 3.5. 1 study found that sleep deprivation had a negative correlation with attendance (Singh et al. 2018) Due to heterogeneity in the measurement of sleep and academic	

								achievement, a meta-analysis was not possible.	
1	Randomized trial[f]	No serious risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision	None	71	In the intervention group, sleep was extended by 18.2 min per night, sleep efficiency improved by 2.3%, and sleep latency was shortened by 2.3 min, while report card grades in mathematics and English improved significantly. No changes were noted in the control group	Moderate

Note: GPA = Grade Point Average; WJ-R = Woodcock-Johnson Psycho-Educational Battery-Revised test; NAPLAN = National Assessment Program for Literacy and Numeracy.
[a]Includes ~~4~~ 6 longitudinal studies (Asarmow et al. 2014; Fredriksen et al. 2004; Roberts et al. 2009; Lin et al. 2005; Dunbar et al. 2017; Fuligni et al. 2018).
[b]All studies used a subjective assessment of sleep with no psychometric properties reported (the quality of evidence was downgraded from low to very low).
[c]Includes ~~17~~ 27 cross-sectional studies (Lin et al. 2015; Arbabi et al. 2015; Eide and Showalter 2012; O'Dea and Mugridge 2012; Stroebele et al. 2013; Boschloo et al. 2013; Kang et al. 2014; McHale et al. 2011; Pallesen et al. 2011; Perkinson-Gloor et al. 2013; Quevedo-Blasco and Quevedo-Blasco 2011; Short et al. 2013a; Stea et al. 2014; Titova et al. 2015; Unalan et al. 2013; van der Vinne et al. 2015; Wolfson and Carskadon 1998; Diaz-Morales et al. 2015a; Faught et al. 2017a; Faught et al. 2017b; Fuligni et al. 2018; Hysing et al. 2016a; Kolomeichuk et al. 2016; Lewin et al. 2017; Matos et al. 2016; Pecor et al. 2016; Singh et al. 2018).
[d]Most studies used a subjective assessment of sleep with no psychometric properties reported.
[e]Of the ~~17~~ 27 studies, ~~8~~ 13 examined student's actual grades/test results while ~~9~~ 14 studies used self-report metrics (not all asked for students to report their grades; some questions referred to if students felt they feel behind in school, how well to perform relative to your peers academically, etc.). It may be reasonable to assume that the 'gold standard' would be to assess children/youth's actual grades. Since only half of the studies did this, downgrading has been decided (from low to very low).
[f]Randomized intervention trial (Gruber et al. 2016).
[g]Only one study was published so the risk of imprecision is high.

Table 1.3.5. Association between sleep duration and quality of life/well-being in children and youth.
Note: Text in blue is the number after the Australian update

No of studies	Design	Quality Assessment					No of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Mean age ranged between ~~11~~ 4 and 18 years. Data were collected cross-sectionally and up to 1 year. Sleep duration was assessed by self- and parent-report (Health Behaviour in School-aged Children questionnaire). Quality of life/well-being was assessed by self-report as life satisfaction (Mental Health Diagnostic Interview Schedule for Children, Version IV), positive attitude towards life (Berne Questionnaire on Adolescent Subjective Well-Being), self-rated health (single question), health related quality of life, health complaints, and psychological positive health (Pediatric Quality of Life Inventory; Health Behaviour in School-Aged Children questionnaire), and parent-reported mental health, and health related quality of life.									
~~1~~ 4	Longitudinal study[a]	Serious risk of bias[b]	~~No serious inconsistency~~ Serious inconsistency	No serious indirectness	~~Serious imprecision~~[c] No serious imprecision	None	~~2,855~~ 17009	Participants with short sleep duration (≤6 h) at baseline had increased odds of low life satisfaction (OR = 1.73, 95% CI: 1.17-1.54; p<0.05) (Roberts et al. 2009). Longer sleep duration was associated with better overall HRQL in 12-15 year olds, but no significant association in 10-year olds (Gustafsson, 2016). Long sleep duration was associated with a worsening in physical and school functioning subscales. Short sleep duration did not differ significantly from the good sleep duration on any measures of HRQL (Magee, 2017). Children with versus without psychosocial health-related quality of life problems slept slightly less at 6–7 years, but not 8–9 years. Children's physical health-related quality of life was not associated with sleep duration at age 6-7, or 8-9 years (Price, 2016)	VERY LOW
~~2~~ 5	Cross-sectional study[d]	Serious risk of bias[e]	No serious inconsistency	No serious indirectness	No serious imprecision	None	~~139,305~~ 153,077	~~Both~~ Four studies reported better quality of life/well-being/no health	VERY LOW

								complaints with longer sleep duration, or reduced health-related quality of life/increased health complaints with sleep deprivation (Perkinson-Gloor et al. 2013; Do et al. 2013; Segura-Jimenez, 2015; Paiva, 2015). One study found that children's physical health-related quality of life was not associated with sleep duration at age 6-7, or 8-9 years (Price, 2016). Children with versus without psychosocial health-related quality of life problems slept slightly less at 6–7 years, but not 8–9 years (Price, 2016). Due to heterogeneity in the measurement of sleep and quality of life/well-being, a meta-analysis was not possible.	

[a]Includes ~~1~~ 4 longitudinal studies (Roberts et al. 2009; Gustafsson et al. 2016; Magee et al. 2017; Price et al. 2016).
[b]Sleep duration was self-reported with no psychometric properties reported.
[c]~~Only one study was published so the risk of imprecision is high.~~ The studies report inconsistent results, therefore, the quality of evidence was downgraded from low to very low
[d]Includes ~~2~~ 5 cross-sectional studies (Perkinson-Gloor et al. 2013; Do et al. 2013; Paiva et al. 2015; Price et al. 2016; Segura-Jimenez et al. 2015).
[e]~~Both~~ All studies used a subjective assessment of sleep with no psychometric properties reported (the quality of evidence was downgraded from low to very low).

Table 1.3.6. Association between sleep duration and harms/injuries in children and youth.
Note: Text in blue is the number after the Australian update

No of studies	Design	Quality Assessment					No of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Mean age ranged between 8-14 years. Data were collected cross-sectionally and up to 4 years. Sleep duration was assessed by actigraphy, parent report or self-report. Harms/injuries were assessed by structured health interviews with parents, children and school nurses and by self-report questionnaires.									
1	Longitudinal study[a]	No serious risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision[b]	None	617	Children who slept <10 h at age 7 had greater odds of migraine (OR = 1.83, p<0.05), but not tension-type headache, at age 11.	VERY LOW
~~1~~ 4	Cross-sectional study[c]	Serious risk of bias[d]	No serious inconsistency	No serious indirectness	Serious imprecision[e]	None	~~1,429~~ 27,377	Adolescents who slept <7 h/weeknight did not have greater odds of single-injury vs. adolescents who slept ≥7 h/weeknight. Adolescents who slept <7 h/weeknight were more likely to have experienced multiple episodes of injury during the 3 months prior to the survey vs. those who slept ≥7 h/weeknight (OR = 2.2, 95% CI: 1.1-4.8; p<0.05). Bicycle riding accidents were increased in the groups with lower sleep durations (p=0.01). Participants with less sleep showed a higher OR for slips and falls (p<0.001). In school-age children, **short sleep duration** on weekdays was associated with **increased injury risk** (95% CI: 1.25–3.66). Among teens, paradoxically, **short sleep duration** on weekends appeared **protective against injury** (95% CI: 0.29-0.99).	VERY LOW

								Short sleeping time was significantly associated with lower back pain.	
2	Case-control study[f]	Serious risk of bias[g]	No serious inconsistency	No serious indirectness	No serious imprecision	None	789	Raffi et al. (2013) found that sleep duration was shorter in the injury group vs. the non-injury group (8.98 ± 1.36 vs. 9.91 ± 1.06 h/night, respectively, p<0.001). In contrast, Li et al. (2008) found no differences in sleep duration in the case vs. control groups. Due to heterogeneity in the measurement of sleep and harms/injuries, a meta-analysis was not possible.	VERY LOW

[a]Includes 1 longitudinal study (Waldie et al. 2014).
[b]Only one study was published so the risk of imprecision is high. Therefore, the quality of evidence was downgraded from low to very low.
[c]Includes ~~1~~ 4 cross-sectional studies (Lam and Yang 2007; Kim et al. 2015; Marlenga et al. 2017; Yabe et al. 2018).
[d]Sleep duration was self-reported in all studies with no psychometric properties reported.
[e]Only ~~one~~ ~~three~~ four studies published so the risk of imprecision is high. Therefore, the quality of evidence was downgraded from low to very low.
[f]Includes 2 case-control studies (Li et al. 2008; Rafii et al. 2013).
[g]Sleep duration was self-reported in both studies with no psychometric properties reported. Therefore, the quality of evidence was downgraded from low to very low.

Table 1.3.7. Association between sleep duration and cardiometabolic biomarkers in children and youth.
Note: Text in blue is the number after the Australian update

No of studies	Design	Quality Assessment					No of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Mean age ranged between 7.9 and 16.~~7~~ 9 years. Data were collected cross-sectionally and up to 5 years. Sleep duration was assessed by actigraphy, polysomnography, parent report or self-report. Cardiometabolic biomarkers were measured objectively using fasting and non-fasting blood samples, blood pressure devices, various assays, Holter monitors, elastic electrode belts, conventional lab methods, all performed by trained research staff or nurses.									
~~3~~ 4	Longitudinal study[a]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	~~1,900~~ 3302	Hjorth et al. (2014a) showed that changes in sleep duration were negatively associated with changes in HOMA-IR (β = -0.18, 95% CI: -0.36 to 0.01; p<0.05) over a 200-day follow-up period. Short sleep duration was also associated with an increased Metabolic Syndrome score after the follow-up period (r = -0.10, β = -0.46, 95% CI: -0.87 to -0.04; p=0.03). However, changes in sleep duration were not associated with mean arterial pressure, fasting plasma triglycerides or HDL cholesterol, over the follow-up period. Hancox and Landhuis (2012) showed that sleep duration was not associated with HbA1c or with greater odds of pre-diabetes at age 32 years. Archbold et al. (2012) reported that a decrease in sleep duration was associated with an increase in SBP (β = -0.008, SE = 0.004, p=0.042) over a 5-year follow-up period. However, the change in sleep duration was not associated with DBP (β = -0.006, SE=0.004, p=0.144). Paciencia et al. (2016) reported that females who had higher sleep duration had higher levels of SDP and DBP. Among males, an inverse association was found, where those who had higher	LOW

								sleep duration had lower levels of SBP and SDP.	
~~16~~ 25	Cross-sectional[b]	Serious risk of bias[c]	Serious inconsistency[d]	No serious indirectness	No serious imprecision	None	~~27,530~~ 67,137	Blood pressure (~~7~~ 9 studies): 1 study (Kuciene and Dulskiene 2014) showed short sleep (<7 h) was associated with higher SBP, DBP and likelihood of being hypertensive. 1 study (Paciencia et al. 2013) showed longer sleep duration (≥9.5 h) was associated with higher SBP. 1 study (Paciencia et al. 2016) observed higher levels of BP among those sleeping more hours per day, in both genders. ~~2~~ 3 studies (Peach et al. 2015; Rey-Lopez et al. 2014; Pulido-Arjona et al. 2018) showed no association between sleep duration and SBP or hypertension risk. 3 studies (Wells 2008; Lee and Park 2014; Meininger et al. 2014) showed mixed findings (null and expected) for short and/or long sleep duration and SBP/DBP. CV risk and function (~~5~~ 6~~–~~ studies): ~~4~~ 5 studies (Michels et al. 2013; Berentzen et al. 2014; Narang et al. 2012; Rey-Lopez et al. 2014; Pulido-Arjona et al. 2018) found no association between sleep duration and CV function or clustered CV risk. 1 study (Rodriguez-Colon et al. 2015) showed mixed findings (null and	VERY LOW

								expected) for HRV and increased sleep duration. Inflammatory markers (~~1~~ 4 studies): 1 study (Perez de Heredia et al. 2014) found mixed findings (null and expected) between sleep duration and inflammatory markers (CRP, IL-4, cortisol, TNF). 3 studies (Fernandez-Mendoza et al. 2017; Nielsen et al. 2016; Park et al. 2016) found significant associations between sleep duration and CRP Blood lipids (TGs, TC, HDL, LDL) (~~5~~ 7 studies): ~~3~~ 4 studies (Hjorth et al. 2014a; Hitze et al. 2009; Rey-Lopez et al. 2014; Pulido-Arjona et al. 2018) showed no associations between sleep duration and blood lipids. 2 studies (Kong et al. 2011; Lee and Park 2014) showed mixed findings (null and expected) for short, long, weekday, and weekend sleep duration and blood lipids 1 study (Lim 2018) found associations between shorter sleep duration and lower HDL-C. Metabolic markers (glucose, insulin, HOMA-IR, metabolic syndrome) (~~5~~ 9 studies): 2 studies (Lee and Park 2014; Rey-Lopez et al. 2014) showed no association between sleep duration and metabolic markers.	

								3 studies (Hjorth et al. 2014a; Javaheri et al. 2011; Hitze et al. 2009) showed mixed findings (null and expected) for short and long sleep duration and metabolic markers. 1 study (Cespedes-Feliciano et al. 2018) found an association between longer sleep duration and lower metabolic risk score. 1 study (Guedes et al. 2018) found a significant association between sleep duration longer than 12 h and HbA1c. 1 study (Lim 2018) showed an association between MetS and very short sleep duration. 1 study (Rudnicka et al. 2017) found 1 h longer sleep duration was associated with lower insulin resistance and lower fasting glucose. Due to heterogeneity in the measurement of sleep and cardiometabolic biomarkers, a meta-analysis was not possible.	

Note: SBP = systolic blood pressure; DBP = diastolic blood pressure; TGs = triglycerides; TC = total cholesterol; LDL = low density lipoprotein; HDL = high density lipoprotein; CV = cardiovascular; HRV = heart rate variability; CRP = C-reactive protein; IL-4 = interleukin-4; TNF = tumor necrosis factor; HOMA-IR = homeostasis model assessment of insulin resistance; MetS = Metabolic Syndrome.

[a]Includes ~~3~~ 4 longitudinal studies (Hjorth et al. 2014a; Hancox and Landhuis 2012; Archbold et al. 2012; Paciencia et al. 2016).
[b]Includes ~~16~~ 25 cross-sectional studies (Cespedes Feliciano et al. 2018; Fernandez-Mendoza et al. 2017; Guedes et al. 2018; Lim 2018; Nielsen et al. 2016; Paciencia et al. 2016; Park et al. 2016; Pulido-Arjona et al. 2018; Rudnicka et al. 2017; Hjorth et al. 2014a; Peach et al. 2015; Michels et al. 2013; Berentzen et al. 2014; Wells 2008; Javaheri et al. 2011; Rodriguez-Colon et al. 2015; Perez de Heredia et al. 2014; Hitze et al. 2009; Kong et al. 2011; Kuciene and Dulskiene 2014; Lee and Park 2014; Meininger et al. 2014; Narang et al. 2012; Paciencia et al. 2013; Rey-Lopez et al. 2014).
[c]Most studies used a subjective assessment of sleep with no psychometric properties reported. [d]Mixed findings observed. Therefore, the quality of evidence was downgraded from low to very low.

1.4 Integrated

PICO: In children 5-17 years of age what are the relationships between each of the following combinations of movement behaviours and health indicators?
Sleep & Sedentary Behaviour; Sleep & Physical Activity; Sedentary Behaviour & Physical Activity; Sleep & Sedentary Behaviour & Physical Activity?

Table 1.4.1. GRADE table showing association between combinations of movement behaviours and body composition in school-aged children and youth.

No. of studies	Design	Quality Assessment					No of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Mean ages ranged from 7.6 -14.4 years. Sedentary behaviour assessed via accelerometer and self-reported screen time. Physical activity was assessed via accelerometer and pedometer. Sleep was assessed via self-report questionnaire and accelerometer. Adiposity was assessed via measured height and weight, waist circumference, waist-to-height ratio, body fat % (bio-electrical impedance and DEXA scans) and skinfolds.									
3	Prospective [a]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	6,588 [b]	PA+SB+SLEEP In 1/1 study, reallocation of time to MVPA from Sleep, SB (Screen, Academic, Other) or LPA was associated with lower adiposity. Reallocation of time to "Other SB" from either Screen SB or Academic SB was association with lower adiposity. No associations for reallocations between any type of SB and LPA or Sleep, or between LPA and Sleep. PA+SB In 1/2 studies, reallocation of time to MVPA from SB was associated with lower adiposity. No associations reported for reallocations to LPA from SB.	Low
10	Cross-sectional [c]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	70, 673	MEETING GUIDELINES Lower adiposity was reported in: 3/3 studies for children meeting all three guidelines (PA, Screen and Sleep) compared with children meeting none, one or two of these guidelines; 2/3 studies for children meeting Sleep and PA guidelines; 1/2 studies for children meeting Screen and PA guidelines;	Low

								2/2 studies for children meeting Sleep and Screen guidelines, all compared to children not meeting either of them. <u>Combinations of PA+SB+SLEEP</u> Lower adiposity was reported among groups of children with *High PA/Low SB/High Sleep* compared to *Low PA/High SB/Low Sleep* (3/3 studies) and compared to *Low PA/Low SB/High Sleep* (1/3 studies). 1/1 study found a group characterized by High PA had lower adiposity than groups characterized by: *Low PA/High Sleep; High Screen/Low Sleep; High Non-Screen SB/Low Sleep.* <u>Combinations of PA + SB</u> 9/9 studies reported lower adiposity in groups of children with *High PA/Low SB* compared to those with *Low PA/High SB*. 3 of these studies found that categories with *High PA* tended to have lower levels of adiposity when compared to those with *Low* PA, irrespective of *SB.* <u>Combinations of PA + SLEEP</u> 1/1 study reported lower adiposity in the *High Sleep/High MVPA* group compared to *Low Sleep/Low MVPA.* <u>Combinations of SB + SLEEP</u> 1/1 study reported no differences for *Low Sleep/High Screen Time* vs *High Sleep/Low Screen Time*, or *Low Sleep/High Sedentary Time* vs *High Sleep/Low Sedentary Time*. COMPOSITIONAL AND TRADITIONAL ISOTEMPORAL SUBSTITUTION <u>PA+SB+SLEEP</u> 2/2 studies reported lower adiposity when time was reallocated to MVPA from	

								either Sleep, SB or LPA. For reallocation of time to LPA from SB, 1/2 studies reported lower adiposity. Reallocations to Sleep from SB or LPA were associated with lower adiposity in some age/sex groups (2/2 studies) <u>ISOTEMPORAL SUBSTITUTION OF PA+SB</u> Lower adiposity was reported when time was reallocated: To VPA from SB (2/3 studies), LPA (2/3 studies) or MPA (1/3 studies); To MPA from SB (2/3 studies) or LPA (1/3 studies); To MVPA from SB (4/4 studies); To LPA from SB (1/4 studies). No associations for other reallocations. <u>COMPOSITIONAL ANALYSIS PA + SB + Sleep</u> Lower adiposity was associated with: higher MVPA relative to remaining behaviours (2/2 studies); lower LPA relative to remaining behaviours (2/2 studies); lower SB relative to remaining behaviours (1/2 studies); and higher Sleep relative to remaining behaviours (1/2 studies). Due to heterogeneity in study design, presentation of data, and measures of body composition, a meta-analysis was not possible.	

Note: LPA = light intensity physical activity; MVPA = moderate-and-vigorous intensity physical activity; PA= physical activity; SB = sedentary behaviour LPA = light intensity physical activity; MVPA = moderate-and-vigorous intensity physical activity; VPA= vigorous physical activity; MPA= moderate physical activity; PA= physical activity; SB = sedentary behavior.
[a]Participants from overlapping datasets only counted once.[a] Includes three prospective studies (Huang et al. 2016; Dalene et al. 2017; Sardinha et al. 2016)
[b] Two studies (Laurson et al. 2008, 2014) used data from the SWITCH intervention. two studies used data from the ISCOLE study, although one (Chaput et al. 2014b) used only the Canadian data, while one (Katzmarzyk et al. 2015) used data from 12 countries. Two studies used the NHANES survey, although one (Loprinzi et al. 2015) used only the NHANES, while another (Ekelund et al. 2012) combined the NHANES with other data from the ICAD database. Participants in Loprinzi et al. (2015) Chaput et al. (2014b), and Laurson et al. (2014) have not been included in "Number of Participants" column to avoid double-counting of the same individuals.
[c] Includes 10 cross-sectional studies: (Laurson et al. 2008, 2014, Ekelund et al. 2012, De Bourdeaudhuij et al. 2013, Herman et al. 2014, Chaput et al. 2014b, Hjorth et al. 2014b, Loprinzi et al. 2015, Aggio et al. 2015, Katzmarzyk et al. 2015).

Table 1.4.2. GRADE table showing association between combinations of movement behaviours and cardiometabolic health in school-aged children and youth.

No. of studies	Design	Quality Assessment					No of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Ages ranging from 4-18 years, data collection cross-sectionally and longitudinally. Sedentary behaviour assessed via accelerometer and self-reported screen time. Physical activity was assessed via accelerometer and pedometer. Sleep was assessed via self-report questionnaire and accelerometer. Systolic, diastolic and mean arterial blood pressure, fasting insulin, triglycerides, HDL-cholesterol and homeostatic model assessment of insulin resistance was directly measured.									
1	Longitudinal	No serious risk of bias	No serious inconsistency.	No serious indirectness	No serious imprecision	None	632	PA + SB + SLEEP 1/1 study reported reduced metabolic syndrome score in children with *Decreased SB/Increased Sleep/Increased MVPA* compared to those with *Increased SB/Decreased Sleep/Decreased MVPA* The same study reported reduced metabolic syndrome score among the following combinations of behaviours (compared to the opposite combinations): *Decreased SB/Increased MVPA*; *Increased Sleep/Increased MVPA;* and *Increased Sleep/Decreased SB.*	Low
~~2~~6	Cross-sectional	No serious risk of bias	No serious inconsistency.	No serious indirectness	No serious imprecision	None	~~24,179~~ 47,317[a]	MEETING GUIDELINES Better cardiometabolic health was reported in 1/1 study for children meeting all three guidelines (PA, Screen and Sleep) compared with children meeting none, one or two of these guidelines; and children meeting both PA and Screen guidelines, compared to those not meeting these two guidelines. Combinations of PA + SB 1/3 studies found better cardiometabolic health among children with higher MVPA, regardless of SB. 1/3 studies reported higher systolic blood pressure in females with *High MVPA/High SB* vs *Low MVPA/High SB.*	Low

								1/3 studies found better cholesterol markers among children with *High VPA/High SB* vs *Low VPA/High SB*; ISOTEMPORAL SUBSTITUTION PA+SB Better cardiometabolic health was reported for the reallocation of time to VPA from LPA (1/1 study) Better cardiometabolic health was reported for the reallocation of time to MVPA from SB or LPA (1/1 study). No associations for other reallocations COMPOSITIONAL DATA ANALYSIS PA+SB+Sleep 1/1 study reported better cardiometabolic health among children with higher MVPA, relative to remaining behaviours. No associations reported for other behaviours (relative to remaining behaviours). Due to heterogeneity in study design, presentation of data, and measures of risk factors, a meta-analysis was not possible.	

Note: LPA = light intensity physical activity; MVPA = moderate-and-vigorous intensity physical activity; VPA= vigorous physical activity; MPA= moderate physical activity; PA= physical activity; SB = sedentary behavior. [a]Participants from overlapping datasets only counted once.

[a] Includes 1 longitudinal study: (Hjorth et al. 2014a)
[b] Includes ~~2~~6 cross sectional studies: (Ekelund et al. 2012, de Moraes et al. 2013; Rendo-Urtuega et al. 2015; Carson et al. 2016; Moore et al. 2017; Hansen et al. 2018)

Table 1.4.3. GRADE table showing association between combinations of movement behaviours and fitness in school-aged children and youth.

No. of studies	Design	Quality Assessment					No of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Range of mean ages 7.6-14.7 years. Data collection was cross-sectional and longitudinal. Sedentary behaviour assessed via accelerometer and self-reported screen time. Physical activity was assessed via accelerometer and pedometer. Sleep was assessed via self-report questionnaire and accelerometer. Fitness assessments include shuttle run, horizontal jump, sit-and-reach test, hand grip, and tests such as PACER and FITNESSGRAM).									
1	Prospective [a]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	315	ISOTEMPORAL SUBSTITUTION PA + SB In 1/1 study the reallocation of time to VPA from SB or LPA was associated with better fitness. No association for other reallocations.	Low
~~3~~8	Cross-sectional [b]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	~~4,667~~ 14,033	MEETING GUIDELINES Better fitness was reported in: 1/1 study for children meeting all three guidelines (PA, Screen and Sleep) compared with children meeting none, one or two of these guidelines; and for children meeting both PA and Screen guidelines, compared to those not meeting these two guidelines. Combinations of PA + SB Better fitness was reported in children with the combination of : *High MVPA/Low SB* (3/3 studies) and *Low MVPA/Low SB* (2/3 studies) and *High MVPA/High SB* (1/3 studies), when compared to children with the combination of *Low MVPA/High SB* (in 1 study this was observed in females only). 1/1 study found children characterized by high PA had better fitness than groups characterized by: *Low PA/High Sleep; High Screen/Low Sleep; High Non-Screen SB/Low Sleep.* ISOTEMPORAL SUBSTITUTION PA + SB	Low

								Better fitness was associated with the reallocation of time: to VPA from SB (2/2 studies), LPA (1/2 studies) or MPA (1/2 studies); to MPA from SB and LPA (1/2 studies); to MVPA from SB or LPA (1/1 study) COMPOSITIONAL DATA ANALYSIS PA + SB + Sleep Better fitness was reported for children with higher MVPA (relative to remaining behaviours), and lower SB (relative to remaining behaviours) in 1/1 study. No associations for LPA or Sleep (relative to remaining behaviours). Due to heterogeneity in study design, presentation of data, and measures of fitness, a meta-analysis was not possible.	

Note: LPA = light intensity physical activity; MVPA = moderate-and-vigorous intensity physical activity; VPA= vigorous physical activity; MPA= moderate physical activity; PA= physical activity; SB = sedentary behavior.

[a] Includes 1 prospective study (Santos et al. 2018)
[b]Includes ~~3~~ 8 cross-sectional studies: (Martinez-Gomez et al. 2011, Santos et al. 2013, Aggio et al. 2015; Carson et al. 2016; Carson et al. 2017; Collings et al. 2017; Cabanas-Sanchez et al. 2018; Santos et al. 2018)
[c]Participants from overlapping datasets only counted once.

Table 1.4.4. GRADE table showing association between combinations of movement behaviours and HRQoL in school-aged children and youth

No. of studies	Design	Quality Assessment					No of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Range of ages 9-11 years. Data collection was cross-sectional. All studies used the same dataset. Behaviours assessed via accelerometer. HRQoL assessed via questionnaire (KIDSCREEN10).									
2	Cross-sectional[a]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	6,106[b]	MEETING GUIDELINES Better HRQoL was reported in: 1/1 study for children meeting all three guidelines (PA, Screen and Sleep) compared with children meeting none, one or two of these guidelines; and for children meeting both Sleep and Screen guidelines, compared to those not meeting these two guidelines. COMPOSITIONAL DATA ANALYSIS PA + SB + Sleep Better HRQoL was reported for children with higher MVPA (relative to remaining behaviours) in 1/1 study. No associations for LPA, SB or Sleep (each relative to remaining behaviours). Both studies used the same dataset. Due to heterogeneity in study design, presentation of data, and measures of fitness, a meta-analysis was not possible.	Low

Note: HRQoL= Health-related quality of life; LPA = light intensity physical activity; MVPA = moderate-and-vigorous intensity physical activity; VPA= vigorous physical activity; MPA= moderate physical activity; PA= physical activity; SB = sedentary behavior.

[a]Includes two cross-sectional studies (Sampasa-Kanyinga et al. 2017; Dumuid et al. 2018)
[b]Participants from overlapping datasets only counted once.

Table 1.4.5. GRADE table showing association between combinations of movement behaviours and behavioural outcomes in school-aged children and youth

No. of studies	Design	Quality Assessment					No of participants	Absolute effect	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Range of ages 6-17 years. Data collection was cross-sectional. Sedentary behaviour and physical activity assessed via accelerometer. Sleep was assessed via self-report questionnaire. Behavioural outcome assessed by Strengths and Difficulties Questionnaire. Both studies used the same dataset.									
2	Cross-sectional[a]	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	4,169[b]	MEETING GUIDELINES Better behavioural outcomes were reported in: 1/1 study for children meeting all three guidelines (PA, Screen and Sleep) compared with children meeting none, one or two of these guidelines; and for children meeting both PA and Screen guidelines, compared to those not meeting these two guidelines. COMPOSITIONAL DATA ANALYSIS PA + SB + Sleep Better behavioural outcomes were reported for children with higher Sleep (relative to remaining behaviours) in 1/1 study. No associations for MVPA, LPA or SB, each relative to remaining behaviours. Due to heterogeneity in study design, presentation of data, and measures of fitness, a meta-analysis was not possible.	Low

Note: LPA = light intensity physical activity; MVPA = moderate-and-vigorous intensity physical activity; VPA= vigorous physical activity; MPA= moderate physical activity; PA= physical activity; SB = sedentary behavior.

[a]Includes two cross-sectional studies (Carson et al. 2016; Carson et al. 2017)
[b]Participants from overlapping datasets only counted once.

Annex 2: Guideline Leadership group

	Name	Organisation	State	Expertise
1	Tony Okely	University of Wollongong	NSW	Chair, Content expert Physical Activity, Sedentary Behaviour
2	Sarah Loughran	University of Wollongong	NSW	Content expert Sleep
3	Dylan Cliff	University of Wollongong	NSW	Content expert Sedentary Behaviour
4	Anne-Maree Parrish	University of Wollongong	NSW	Content expert Physical Activity
5	Tim Olds	University of South Australia	SA	Content expert Integrated Behaviour
6	Lisa Kervin	University of Wollongong	NSW	Digital Literacy
7	Simon Eckermann	University of Wollongong	NSW	Health Economist
8	Rachel Jones	University of Wollongong	Vic	Stakeholder Consultation
9	Rebecca Stanley#	University of Wollongong	NSW	Stakeholder consultation
10	Trevor Shilton	Director of Cardiovascular Health, Heart Foundation of Western Australia	WA	Stakeholder
11	Davina Ghersi	Senior Principal Research Scientist, National Health and Medical Research Council (NHMRC)	ACT	GRADE Methodology expert
12	Mark Tremblay	CHEO Research Institute, Canada	Canada	Content expert Physical Activity, Sedentary Behaviour, international
13	Sandra Downie	Preventive Programs, Commonwealth Department of Health	ACT	Stakeholder, End user, government
14	Julie Sherring	University of Wollongong	NSW	Project Manager
15	Natalie Toms	Preventive Programs, Commonwealth Department of Health	ACT	Stakeholder, End user

Annex 3: Guideline Development Group

	Name	Organisation	State	Expertise
1	Tony Okely	University of Wollongong	NSW	Chair, Content expert Physical Activity, Sedentary Behaviour
2	Sarah Loughran	University of Wollongong	NSW	Content expert Sleep
3	Dylan Cliff	University of Wollongong	NSW	Content expert Sedentary Behaviour
4	Anne-Maree Parrish	University of Wollongong	NSW	Content expert Physical Activity
5	Tim Olds	University of South Australia	SA	Content expert Integrated Behaviour
6	Lisa Kervin	University of Wollongong	NSW	Digital Literacy
7	Simon Eckermann	University of Wollongong	NSW	Health Economist
8	Rachel Jones	University of Wollongong	Vic	Stakeholder Consultation
9	Rebecca Stanley#	University of Wollongong	NSW	Stakeholder consultation
10	Trevor Shilton	Director of Cardiovascular Health, Heart Foundation of Western Australia	WA	Stakeholder
11	Davina Ghersi	Senior Principal Research Scientist, National Health and Medical Research Council (NHMRC)	ACT	GRADE Methodology expert
12	Mark Tremblay	CHEO Research Institute, Canada	Canada	Content expert Physical Activity, Sedentary Behaviour, international
13	Sandra Downie	Preventive Programs, Commonwealth Department of Health	ACT	Stakeholder, End user, government
14	Julie Sherring	University of Wollongong	NSW	Project Manager
15	Jo Salmon	Deakin University	Vic	Content expert Physical Activity, Sedentary Behaviour
16	Clair Bannerman	Department of Education	ACT	Stakeholder
17	Tamie Needham	Department of Health	NT	Stakeholder
18	Elaine Marshall	Department of Health	Tas	Stakeholder
19	Jordy Kaufman	Swinburne University	Vic	Content expert Screen time
20	Layne Brown	University of Wollongong	UOW	Content expert Indigenous Health

	Name	Organisation	State	Expertise
21	Janecke Wille	Federation of Ethnic Communities' Council of Australia (FECCA)	ACT	Stakeholder
22	Greg Wood	Australian Sports Commission	WA	Stakeholder
23	David Lubans	University of Newcastle	NSW	Content expert Physical Activity, Sedentary Behaviour
24	Stuart Biddle	University of Southern Queensland	QLD	Content expert Physical Activity, Sedentary Behaviour, mental health
25	Shane Pill	The Australian Council for Health, Physical Education and Recreation (ACHPER) National	SA	Health and Physical Education Profession
26	Anthea Hargreaves	Cycling and Walking Australia New Zealand	Vic	Active Transportation
27	Natalie Jonas	Australian Curriculum, Assessment and Reporting Authority (ACARA)	SA	Australian Curriculum
28	Natasha Schranz	Active Healthy Kids Australia	SA	Physical Activity
29	Perry Campbell	Australian Children's Education and Care Quality Authority (ACECQA)	NSW	Education, Quality Assurance
30	Karen Ingram/Hayley Dean*	NSW Education Standards Authority (NESA)		Curriculum Expert
31	Zhiguang Zhang	University of Wollongong	NSW	PhD student, Sedentary Behaviour
32	Adam Verrender	University of Wollongong	NSW	PhD student, Sleep
33	John Kar-Hau Chong	University of Wollongong	NSW	PhD student, Physical Activity
34	Dorothea Dumuid	University of South Australia		Post Doc fellow, Integrated review of movement behaviours
35	Natalie Toms	Preventive Programs, Commonwealth Department of Health	ACT	Stakeholder, End user
36	Peter Katzmarzyk	Pennington Biomedical Research Center		Observer
37	Cathi Draper	University of the Witwatersrand		Observer
38	Rosa Virgara	University of South Australia		Observer

	Name	Organisation	State	Expertise
39	Hayley Lewthwaite	University of South Australia		Observer
40	Borja del Pozo-Cruz	Australian Catholic University		Observer

Annex 4: Summary of declaration of interest from Guideline Development Group members

Tony Okely	• Member of Consensus Committee for Canadian 24-hour integrated movement guidelines for the early years • Member of Consensus Committee for Canadian 24-hour integrated movement guidelines for children and youth • Member of Guideline Development Group, World Health Organization Physical Activity, Sedentary and Sleep Behaviour Guidelines for Children Birth to 5. • Member of Guideline Development Group, UK Chief Medical Officer's Physical Activity, Sedentary and Sleep Behaviour Guidelines for Children Birth to 5 • Member of Guideline Development Group, South African Physical Activity, Sedentary and Sleep Behaviour Guidelines for Children Birth to 5 • Paid consultancy from Foxtel on active interstitials for children's pay television channels. • Consultancy to Early Childhood Australia to deliver Munch & Move Professional Development for early childhood educators in NSW. • *Paid consultancy from Foxtel to advise on inclusion of physical activity interstitials (activity breaks during advertising periods) on children's pay television channels* • *My expenses were covered to attend meetings for Canadian 24-hr movement guidelines for children and youth in 2016 and 2017 (2 times)*
Sarah Loughran (sleep)	• Member of the leadership group for the Australian 24-Hour Movement Guidelines for the Early Years • I have received funding from the NHMRC for research studies focused on sleep, screen time, and mobile phone use in children • I have published journal articles and given presentations on sleep, screen time, and mobile phone use in children
Dylan Cliff	• I was a leadership group member for the Australian 24-Hour Movement Guidelines for the Early Years. • I have received funding from the ARC, NHMRC and National Heart Foundation for research studies focused on physical activity, sedentary behaviour, and electronic media use in children. • I have published journal articles and given presentations on physical activity, sedentary behaviour, electronic media use and sleep in children. • I have provided consultancy to Early Childhood Australia and NSW Health to deliver Munch & Move Professional Development for educators in NSW related to physical activity promotion for children.
Anne-Maree Parrish	• I have received funding from the National Heart Foundation for research focusing on physical activity and sedentary behaviour in children and youth • I have published journals and given conference presentations on physical activity and sedentary behaviour in children and youth • I was involved in an evaluation for the NSW Department of Education which assessed sedentary time in children and youth • I am a committee member of the Public Health Association of Australia's Health Promotion Special Interest group have revised the physical activity policy as part of this role • I was involved in the development of the existing Australian Physical Activity and Sedentary Behaviour Guidelines for Australian Children and youth

Tim Olds	• Grant: NHMRC Project Grant APP143379 (2018-2021). *Life On Holidays: Fitness lost, fatness regained?* • Grant: A Better Start National Science Challenge and Cure Kids (2017-2019). Childhood Obesity: Data to Action (CODA): Translation modeling to inform an evidence-based childhood intervention obesity agenda. • Grant: ARC Discovery Indigenous IN160100035 (2016-2018). *Participation in sport and its links to education attainment and health and wellbeing.* • Grant: NHMRC Project Grant APP1109355 (2016-2019). *Biological, phenotypic and public health costs of risk and protective pathways to non-communicable disease in children and adults: The national Longitudinal Study of Australian Children* • Grant: NHMRC Project Grant APP1080186 (2015-2018). *Active Team – Examining an online social networking intervention to increase physical activity in controlled (RCT) and ecological (ET) settings*

Lisa Kervin	• I have had funded research to investigate young children's use of digital technology:
	  • Verenikina, I., Kervin, L. & Murphy, C. Conceptualising digital play: The role of tablet technologies in the development of imaginative play of young children. ARC Discovery DP140100328
	  • Kervin, L. & Mantei, L. Examining digital reading practices of emerging readers URC Partnership Grant (with Catholic Education, Diocese of Wollongong) ($10, 000 URC funding, $22, 000 cash and in-kind CEO) 2012-2013
	• I have published journal articles and chapters reporting on young children's use of digital technology.
	• I am involved (as one of 6 CIs) on a current ARC Centre of Excellence bid.

Simon Eckermann	• Member of Consensus Committee for Australian 24-hour integrated movement guidelines for the early years • Member (health economics expert adviser) for Food Standards Australia New Zealand (FSANZ) Social Science Economics Advisory Group (SSEAG) • CI on National Health and Medical Research Council. Project Grant 1062433. **2014-2017.** Promoting physical activity among young children from disadvantaged communities. • Author of the Health Economics from Theory to Practice text (Eckermann 2017), where in particular: chapters 4 and 12 identify best practice methods and policy implications for health economic evaluation of community based health promotion activities such as integrated movement Guidelines and their integration into policy and practice;; and chapters 8--10 best method for joint evaluation of multiple effect domains and strategies in trail and practice evaluations. http://www.springer.com/gp/book/9783319506111 • Eckermann S, Dawber J, Yateman H, K Quinsey, Morris D. Evaluating return on investment in a school based health promotion and prevention program: the investment multiplier for the Stephanie Alexander Kitchen Garden National Program. ***Social Science and Medicine***. 2014; 114: 103-112. DOI: 10.1016/j.socscimed.2014.05.056.
Rachel Jones	• Member of Consensus Committee for Australian 24-hour integrated movement guidelines for the early years (Stakeholder Consultations and dissemination) • Consultancy to Early Childhood Australia to deliver Munch & Move Professional Development for early childhood educators in NSW.

	• I have received funding from the NHMRC and National Heart Foundation for research studies focused on physical activity and sedentary behaviour in children. • I have published journal articles and given presentations on physical activity and sedentary behaviour in children. • Co-lead – Special Interest Group Early Childhood and Care, ISBNPA
Bec Stanley	• Member of Consensus Committee for Australian 24-hour integrated movement guidelines for the early years (leadership of the Stakeholder Consultations) • Consultancy to Early Childhood Australia to deliver Munch & Move Professional Development for early childhood educators in NSW. • Funded by a NSW Health Early-Mid Career Research Fellowship to conduct research on physical activity and sedentary behaviours of Australian Indigenous children. • Grant - Early Start Research Institute - Okely, A, Rissel, C, Williams, M, Franco, L, Furber S, **Stanley RM**, Kelly, B, Feng X, F, Roberto Dos Santos, R, Cliff, D, Jones, R, Hammersley, M, Probst, Y & Morris, J, (2017-2020) "Obesity prevention", NSW Health Prevention Research Support Program Round 5. • Grant - **Stanley RM**, McKnight, A, Crowe, R, Probst, Phillipson, L, Okely AD. (2015-2018), "Stronger culture, healthier lifestyles: the development of an afterschool cultural and activity program for Aboriginal children living in the Shoalhaven", UOW Global Challenges Project Grant • Co-chair of the International Society of Behavioural Nutrition and Physical Activity Children and Families Special Interest Group.
Trevor Shilton	• Member of the Board. International Society for Physical Activity and Health (ISPAH) • Chairman of Global Advocacy for Physical Activity (GAPA), the advocacy Council of ISPAH • Member of the Board and Global Vice President for Partnerships, International Union for Health Promotion and Education (IUHPE) • Adjunct Professor, School of Public Health, Curtin University, Bentley Western Australia • Adjunct Associate Professor, School of Exercise Science and Health, University of Western Australia, Crawley, WA • Member of the World Health Organization, Civil Society Working Group for the United National High Level Meeting on Non-communicable Disease.
Davina Ghersi	• Employee of National Health and Medical Research Council as Senior Principal Research Scientists • Member of GRADE working group
Mark Tremblay	• I was involved in the development of the existing Australian Physical Activity and Sedentary Behaviour Guidelines for Australian Children and Youth • I led the development of the Canadian 24-Hour Movement Guidelines for Children and Youth, and it is possible these guidelines will be involved in the Australian adolopment process. • I have been involved in the development of many other physical activity, sedentary behavior and 24-hour movement guidelines for additional age groups (e.g., early years, adults, older adults, pregnancy) in Canada and in other countries • I was Chair of the Canadian Society for Exercise Physiology Canadian Guideline Committee for many years

	• I have held several grants for the development of the Canadian Guidelines from the Canadian Institutes of Health Research, the Public Health Agency of Canada, the Conference Board of Canada, ParticipACTION, the University of Alberta, and the Canadian Society for Exercise Physiology — no research monies were used to pay me directly
Sandra Downie	• Nothing to declare
Julie Sherring	• Julie Sherring was Project Manager of the Australian 24-Hour Movement Guidelines for Children in the Early Years
Jo Salmon	• My spouse manufactures height adjustable desks for schools.
Clair Bannerman	• Nothing to declare
Tamie Needham	• Nothing to declare
Elaine Marshall	• Contribute written content to state government reports, ministerial advice and submissions that contain information about children's physical activity and sedentary behaviour. • Working group member of a project funded through NHMRC partnership project grants scheme.
Jordy Kaufman	• I have published journal articles on children's use of screen-based media • I was the lead investigator on a project evaluating the ELLA apps created by the Department of Education and Training. • I led a literature review for the Department of Education and Training on the implications of technology use by children. The focus was on educational outcomes in the school setting, but it did touch on home use and health outcomes. • I gave feedback on a draft of the ECA statement being developed.
Janecke Wille	• Nothing to declare
Greg Wood	• Nothing to declare
David Lubans	• Nothing to declare
Stuart Biddle	• Funding was received in 2016 for consultancy work for Halpern PR Limited (for an international deodorant company) concerning light intensity physical activity, primarily in adults. • Member, International Advisory Panel, Get Britain Standing. • Member, Expert Working Group for 'Sedentary Behaviour', 2017-2018 update of the UK CMO physical activity guidelines. • Member, Expert Working Group for 'Physical Activity and Disability', 2017-2018update of the UK CMO physical activity guidelines.

Shane Pill	• Nothing to declare
Anthea Hargreaves	• Lobbying activities: In my role as Bicycle Network's General Manager, Public Affairs I am responsible for advocating for funding and bike infrastructure at all levels of government. • I am also the national spokesperson for Bicycle Network's Ride2School program. • I don't believe there are any other activities which may impact my impartiality.
Natalie Jonas	• ACARA Curriculum Specialist:Primary and Health and Physical Education • Vice President (volunteer role): Early Childhood Organisation of South Australia.
Natasha Schranz	• Nothing to declare
Perry Campbell	• Nothing to declare
Karen Ingram/Hayley Dean*	• Nothing to declare
Zhiguang Zhang	• Nothing to declare
Adam Verrender	• Member of the Consensus panel for the Australian 24 hour movement guidelines for children of the Early Years.
John Kar-Hau	• Nothing to declare
Dorothea Dumuid	• Travel grant: Healthy Development Adelaide • Catalyst grant: Royal Society of NZ • Travel scholarships: University of South Australia • Australian Government Research Training Program Scholarship • NHMRC Project Grant • Director and physiotherapist at Have a Ball Children's Physiotherapy Services
Natalie Toms	• Nothing to declare

Annex 5: Existing International Physical Activity Guidelines for Children and Young people

Criteria	USA 2018[a]	China 2017	Chile	Netherlands 2017	New Zealand 2017	Canada 2016	France 2016	Germany 2016	Norway 2016	Mexico 2015	Spain 2015	Australia 2014	Austria 2013	Denmark 2014	Paraguay 2014	Turkey 2014	Qatar 2014	Argentina 2013
Followed GRADE process	N	N	?	N	Y	Y	N	N	?	Y	Y	Y	N	N	Y	N	N	Y
Addresses clear questions (can identify PICO elements)	Y	N	?	N	Y	Y	Y	?	?	Y	Y	Y	N	?	Y	N	N	Y
Has benefits and harms assessments	Y	N	?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	?	Y	Y	Y	Y
Assessed using AGREE	N	N	?	N	Y	Y	N	N	?	N	N	Y	N	N	N	N	N	N
Allows for updating	?	N	?	Y	N	Y	Y	N	?	Y	Y		N	?	Y	N	N	Y
Has existing and accessible evidence tables/summaries	Y	N	?	Y	Y	Y	Y	Y	?	N	Y	Y	Y	?	Y	N	N	Y
Has risk of bias assessment	Y	N	?	Y	Y	Y	N	?	?	Y	Y	Y	N	?	Y	N	N	Y
Were integrated (24hr)	?	N	?	N	Y	Y	N	N	?	N	N	N	N	?	N	N	N	N
Costs associated with implementing guideline	N	?	?	?	N	Y	N	N	?	?	?	N	N	?	?	?	?	?
Acccompanying – how they are going to implement – disseminate the guidelines	N	N	?	?	N	Y	Y	N	?	?	?	N	Y	?	?	?	?	?

Reference: Appendix 1. GRADE-ADOLOPMENT (Schünemann et al., J Clin Epidemiol. 2017)
[a] under development during guideline development process but made available to Australian Consensus Panel
Key: Y=yes; N=no; ?=unsure

Annex 6: PICOS

Physical Activity Research Question and PICO

Research Question:

- What are the relationships between objectively measured total physical activity (light physical activity + moderate physical activity + vigorous physical activity) and health indicators in children and young people aged 5-17 years?
    - What is the intensity, duration and frequency of bouts of physical activity associated with improved health indicators?

Participants/population:
Apparently healthy school-aged children and youth aged 5-12 years (inclusive) and 13-17 years (inclusive).

Intervention(s), exposure(s):
Various volumes, durations, frequencies, and intensities of objectively measured total physical activity.
Studies will be included if they report:

- Objective total physical activity measures (e.g., actigraphy, accelerometers, heart rate monitors, pedometers, arm bands);
- Human participants;
- English language or can be translated with google translate;
- Apparently healthy (including overweight/obese) general populations;
- Mean age of 5-17 years (inclusive) for at least 1 exposure measurement point;
- Any design - for cohort studies, any follow-up length is allowed. Observational studies, cohort, panel, and retrospective studies) are required to have a minimum sample size of 300 participants;
- RCTs and intervention studies are required to have at least 30 participants. For adiposity markers, observational studies are required to have a minimum sample size of 1000 participants.

Studies will be excluded if they report:

- Clinical populations (those that only include children with a diagnosed conditions);
- Self/proxy-report measures of physical activity;
- Only report total energy expenditure as measured by doubly-labelled water.
- Grey literature (e.g., book chapter, reports, dissertations), except registered clinical trials and government reports/guidelines.

Comparator(s)/control
Various volumes, durations, frequencies and intensities of objectively measured total physical activity. In addition to structuring qualitative synthesis around the outcome, we will also structure it around the intensity of physical activity (i.e., light, moderate, moderate-to-vigorous, vigorous, or total physical activity).

Outcome(s)
Critical

1. Adiposity markers [(overweight/obesity measured by body mass index (BMI), waist circumference, skinfolds, bio-impedance analysis (BIA), dual-energy x-ray absorptiometry (DXA or DEXA), computed tomography (CT), magnetic resonance imaging (MRI)];

2. Cardiometabolic biomarkers (i.e. metabolic syndrome and cardiovascular disease risk factors: unfavourable lipid levels, blood pressure, markers for insulin resistance of type 2 diabetes such as HbA1c, impaired glucose tolerance and impaired fasting glucose);
3. Fitness (physical fitness, physical conditioning, musculoskeletal fitness, cardiovascular fitness);
4. Behavioural conduct/pro-social behaviour (aggression, child behavioural disorder, child development disorder, prosocial behaviour, behavioural conduct);
5. Cognition (concentration and memory)/academic achievement (school performance, grade-point average);
6. Quality of life/well-being;
7. Harms: Injuries.

Important

1. Bone density;
2. Motor skill development;
3. Psychological distress (stress, anxiety symptoms, depressive symptoms, mental health);
4. Self-esteem.

Other considerations

1. Consider and discuss *cost-effectiveness* and *resource use* as per the GRADE-ADOLOPMENT approach and in the context of the proposed Guideline recommendation.
2. Any key Australian studies under the sample size limit will be considered to inform the second part of GRADE (ie evidence-to-decision) to demonstrate that Australian studies are consistent (or not) with the body of evidence, and to address any context-specific issues.
3. As per NHMRC Guidelines, the evidence will seek to address the applicability of the recommendations to Aboriginal and Torres Strait Islander people and communities

Sedentary Behaviour Research Question and PICO

Research Question:

- What are the relationships between objectively and subjectively measured sedentary behaviours and health indicators in children and youth aged 5-17 years?

    - Which types of sedentary behaviours are associated with health indicators?
    - What dose of sedentary behaviour (i.e., total amount, interruptions, bout durations) is associated with improved health indicators?

Participants/population:
Apparently healthy school-aged children and youth aged 5-11 years (inclusive) and 12-17 years (inclusive).

Intervention(s), exposure(s):
Duration, patterns, and types of sedentary behaviour. For the purpose of this review, sedentary behaviour is defined as "any waking behaviour characterized by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture" (Tremblay et al., 2017).

Studies will be included if they report:

- Objective (e.g., actigraphy, accelerometer, inclinometer) or subjective (self-report, proxy-report) measures to assess sedentary time (e.g., screen time or non-screen time)
- Human participants
- English language or can be translated with Google translate
- Apparently healthy (including overweight/obese) general populations
- Mean age of 5-17 years (inclusive) for at least 1 exposure measurement point
- Any study design, excluding cross-sectional studies. For cohort studies, any follow-up length is allowed. Longitudinal observational studies (cohort, panel and retrospective studies) are required to have a minimum sample size of 300 participants; RCTs and intervention studies are required to have at least 30 participants. For body composition outcomes, observational studies using subjective measures of sedentary behaviour are required to have a minimum sample size of 1000 participants.
- Associations for outcomes that are considered critical (See below).

- Note: Studies on psychological distress will have no date limit as this outcome was not included in reviews on the health consequences of sedentary behaviour used to develop Canadian guidelines for children and adolescents.(31, 32) Studies for all other outcomes will be included if they were published after 1st January 2015, to update the most recent review conducted to inform guideline development in Canada.(32)

Studies will be excluded if they report:

- Clinical populations (those that only include children with a diagnosed conditions);
- Sedentary behaviour defined as 'failing to meet physical activity guidelines' (because this definition does not differentiate between sedentary behaviour and light physical activity)
- Exclusively "Active gaming" (e.g., Nintendo Wii™, Microsoft Kinect™, Sony's Playstation Move™, video arcades, etc.)
- Background television or screen access (e.g., television is turned on, but not necessarily being watched by the child);
- Cross-sectional observational studies will be excluded;
- For experimental studies, interventions must target sedentary behaviour exclusively and not multiple health behaviours (e.g., both sedentary behaviour and diet).
- Grey literature (e.g., book chapters, dissertations), except registered clinical trials and government reports/guidelines;
- Associations for outcomes that are considered important (See below).

Comparator(s)/control:
Various levels, patterns, or types of sedentary behaviour. In addition to structuring qualitative synthesis around the outcome, we will also structure it around the type of sedentary behaviour (e.g. screen time, reading).

Outcome(s):
Critical

1. Body composition [overweight/obesity measured by body mass index (BMI), waist circumference, skin folds, bio-impedance analysis (BIA), dual-energy x-ray absorptiometry (DXA or DEXA), computed tomography (CT), magnetic resonance imaging (MRI)]
2. Metabolic syndrome (26) and cardiovascular disease (CVD) risk factors (unfavourable lipid levels, blood pressure, markers for insulin resistance or type 2 diabetes such as HbA1c, impaired glucose tolerance and impaired fasting glucose)
3. Behavioural conduct/pro-social behaviour (child behaviour disorders, child development disorder, pro-social behaviour, behavioural conduct, aggression)
4. Cognition (concentration and memory/executive functions)/academic achievement (school performance, grade-point average);
5. Psychological distress (stress, anxiety symptoms, depressive symptoms, mental health);
6. Self-esteem (self-concept, self-esteem, self-efficacy)

Important

1. Fitness (physical fitness, physical conditioning, musculoskeletal fitness, cardiovascular fitness)

Other considerations

1. Consider and discuss *cost-effectiveness* and *resource use* as per the GRADE-ADOLOPMENT approach and in the context of the proposed Guideline recommendation.

2. Any key Australian studies under the sample size limit will be considered to inform the second part of GRADE (ie evidence-to-decision) to demonstrate that Australian studies are consistent (or not) with the body of evidence, and to address any context-specific issues.
3. As per NHMRC Guidelines, the evidence will seek to address the applicability of the recommendations to Aboriginal and Torres Strait Islander people and communities

Sleep Research Question and PICO

Review question:

- What are the objectively and subjectively measured sleep durations associated with health indicators in children and youth aged 5-17 years?

Participants/population:

Apparently healthy school-aged children and youth aged 5-12 years (inclusive) and 13-17 years (inclusive).

Intervention(s), exposure(s):

Various sleep durations. Studies will be included if they use objective (Polysomnography, accelerometry, actigraphy) or subjective (self-report, proxy-report) measures. For experimental studies, interventions must target sleep exclusively and not multiple health behaviors (e.g., both sleep and diet).

Studies will be included if they report:

- Human participants;
- English language or can be translated with google translate;
- Apparently healthy (including overweight/obese) general populations;
- Mean age 5-17 years (inclusive) for at least 1 exposure measurement point;
- Any design: for cohort studies, any follow-up length is allowed. Observational studies (cohort, panel, and retrospective studies) are required to have a minimum sample size of 300 participants;
- RCTs and intervention studies are required to have at least 30 participants. For adiposity markers, observational studies are required to have a minimum sample size of 1000 participants.

Studies will be excluded if they report:

- Clinical populations (those that only include children with a diagnosed condition)
- Grey literature (e.g., book chapters, dissertations), except registered clinical trials and government reports/guidelines;

Comparator(s)/control:
Various sleep durations

Outcome(s) (Health Indicators):
Critical

1. Adiposity markers [(overweight/obesity measured by body mass index (BMI), waist circumference, skinfolds, bio-impedance analysis (BIA), dual-energy x-ray absorptiometry (DXA or DEXA), computed tomography (CT), magnetic resonance imaging (MRI)];
2. Emotional regulation (stress, anxiety symptoms, depressive symptoms, mental health);
3. Cognition (concentration and memory)/academic achievement (school performance, grade-point average);
4. Quality of life/well-being;
5. Harms: injuries.

Important

6. Cardiometabolic biomarkers (i.e. metabolic syndrome and cardiovascular disease risk factors: unfavourable lipid levels, blood pressure, markers for insulin resistance of type 2 diabetes such as HbA1c, impaired glucose tolerance and impaired fasting glucose).

Other considerations

1. Consider and discuss *cost-effectiveness* and *resource use* as per the GRADE-ADOLOPMENT approach and in the context of the proposed Guideline recommendation
2. Any key Australian studies under the sample size limit will be considered to inform the second part of GRADE (ie evidence-to-decision) to demonstrate that Australian studies are consistent (or not) with the body of evidence, and to address any context-specific issues.
3. As per NHMRC Guidelines, the evidence will seek to address the applicability of the recommendations to Aboriginal and Torres Strait Islander people and communities

Integrated Research Question and PICO

Review question:

- How are each of the following combinations of movement/non-movement behaviours associated with health indicators in children and youth aged 5-17 years?

1) Physical Activity + Sedentary Behaviour,
2) Physical Activity + Sleep,
3) Sedentary Behaviour + Sleep,
4) Physical Activity + Sedentary Behaviour + Sleep.

Participants/population:
Apparently healthy school-aged children and youth aged 5-12 years (inclusive) and 13-17 years (inclusive)

Intervention(s), exposure(s):
Studies will be included if they report any of the following combinations of behaviours:

1) Physical Activity + Sedentary Behaviour,
2) Physical Activity + Sleep,
3) Sedentary Behaviour + Sleep,
4) Physical Activity + Sedentary Behaviour + Sleep.

Studies will be included if they report:

- Human participants
- English or other languages if able to be translated (google translate)
- For PHYSICAL ACTIVITY: Objective total physical activity measures (actigraphy, accelerometers, heart rate monitors, pedometers, arm bands)
- For SEDENTARY BEHAVIOUR: objective (actigraphy, accelerometer, inclinometer) or subjective (self/proxy-report) measures to assess sedentary time (e.g., screen time or non-screen time)
- For SLEEP: objective (polysomnography, accelerometry, actigraphy) or subjective (self/proxy-report) measures of sleep duration.
- cross-sectional studies and modelling (e.g., isotemporal substitution, compositional analyses) in the update.

Studies will be excluded if they report:

- For PHYSICAL ACTIVITY: Self-report or proxy-report measures of physical activity, or only total energy expenditure as measured by doubly labelled water.
- Grey literature (e.g., book chapters, dissertations), except registered clinical trials and government reports/guidelines;

- For experimental studies, interventions must target movement behaviours exclusively and not multiple health behaviours (e.g., movement behaviours and diet).

Comparator(s)/control

Various levels and combinations of physical activity, sedentary behaviour, and sleep

Outcome(s)

Critical

1) Adiposity markers [measured by (overweight/obesity measured by body mass index (BMI), waist circumference, skinfolds, bio-impedance analysis (BIA), dual-energy x-ray absorptiometry (DXA or DEXA), computed tomography (CT), magnetic resonance imaging (MRI) etc.];
2) Cardiometabolic biomarkers (i.e., metabolic syndrome and cardiovascular disease risk factors, e.g.: unfavourable lipid levels, blood pressure, markers for insulin resistance of type 2 diabetes such as HbA1c, impaired glucose tolerance and impaired fasting glucose)
3) Fitness (physical fitness, physical conditioning, musculoskeletal fitness, cardiovascular fitness)
4) Emotional regulation/psychological distress (e.g., stress, anxiety symptoms, depressive symptoms, mental health)
5) Behavioural conduct/pro-social behaviour (aggression, child behavioural disorder, child development disorder, prosocial behaviour, behavioural conduct)
6) Cognition (concentration and memory)/academic achievement (school performance, grade-point average)
7) Quality of life/well-being
8) Harms: injuries

Important

1. Bone density
2. Motor skill development
3. Self-esteem

Other considerations

1. Consider and discuss *cost-effectiveness* and *resource use* as per the GRADE-ADOLOPMENT approach and in the context of the proposed Guideline recommendation
2. As per NHMRC Guidelines, the evidence will seek to address the applicability of the recommendations to Aboriginal and Torres Strait Islander people and communities