Physical activity, fitness and cardiometabolic risk in children and adolescents

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Outline

- Associations between physical activity and sedentary time with adiposity and cardio-metabolic risk markers in young people
  - Are these associations *causal*?
  - Which *intensity* of activity is more important?
  - *Independent* associations and *direction* of association?
- Does cardio-respiratory fitness modify the association between physical activity and metabolic riskmarkers?

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Is physical activity *causally* associated with adiposity in young people?

Causality in observational research – Bradford Hill Criteria (slightly modified)

- **Strength** (effect size, magnitude of association)
- **Consistency** (reproducibility)
- **Specificity** (Specific population, specific site, specific cause, specific effect)
- **Temporality** (cause before effect)
- **Gradient** (Dose – response)
- **Plausibility** (Plausible biological mechanism)
- **Experiment** (Experimental evidence)

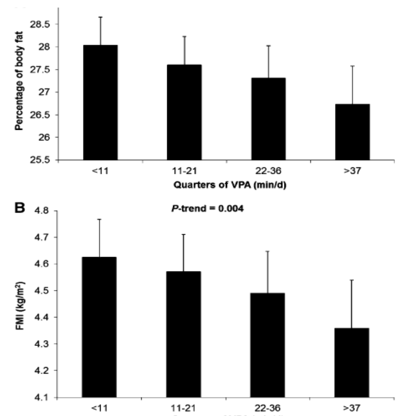
(Adapted from Bradford Hill, *Proc Royal Soc Med*, 1965)

Physical activity intensity, sedentary time, and body composition in preschoolers[1–3]

Paul J Collings, Soren Brage, Charlotte L Ridgway, Nicholas C Harvey, Keith M Godfrey, Hazel M Inskip, Cyrus Cooper, Nicholas J Wareham, and Ulf Ekelund

- 398 4-yr old boys and girls from the SWS study
- PA assessed by combined HR and movement sensing for 7 days

- Body composition assessed by DXA



- **Time spent in VPA strongly and independently associated with adiposity**
- **The cross-sectional evidence is clear and undisputable**

(Collings et al, *AJCN* 2013)

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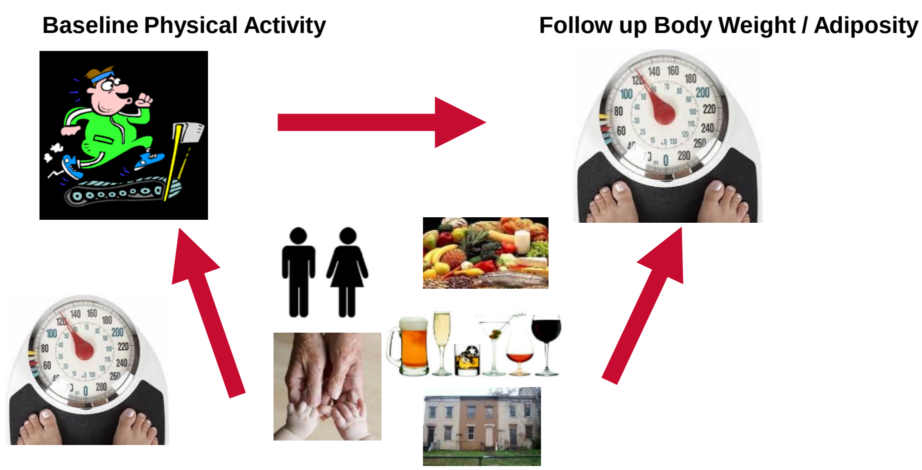
Causality in observational research – Bradford Hill Criteria (slightly modified)

- **Strength** (effect size, magnitude of association) √
- **Consistency** (reproducibility) √
- **Specificity** (Specific population, specific site, specific cause, specific effect) √
- **Temporality** (cause before effect) X
- **Gradient** (Dose – response) √
- **Plausibility** (Plausible biological mechanism) √
- **Experiment** (Experimental evidence) √

(Adapted from Bradford Hill, Proc Royal Soc Med, 1965)

Direction of association - Temporality



This model determines the direction of association

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Cross-sectional and prospective impact of reallocating sedentary time to physical activity on children's body composition

ORIGINALRESEARCH

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Summary

Background: The amount of time children spend in sedentary behaviours may have adverse health effects.

Objective: To examine the substitution effects of displacing a fixed duration of sedentary time with physical activity (PA) on children's body composition.

Methods: We included 386 children (197 boys). Outcomes were body mass index, waist circumference, total body fat mass and trunk fat mass assessed by dual-energy X-ray absorptiometry. Sedentary time and PA were measured with accelerometers. Data were analysed by isotemporal analyses estimating the effect of reallocating 15 and 30 min d^{-1} of sedentary time into light (light physical activity), and moderate-to-vigorous (MVPA) PA on body composition.

Results: Reallocating 15 and 30 min d^{-1} of sedentary time into MVPA was negatively associated with body fatness in cross-sectional analyses. Prospectively, reallocating 30 min of sedentary time into 30 min of MVPA was negatively associated with waist circumference ($\beta = -1.11$, $p < 0.05$), trunk fat mass ($\beta = -0.21$, $p < 0.05$), and total body fat mass ($\beta = -0.48$, $p < 0.05$) at follow-up (20 months). The magnitude of associations was half in magnitude and remained significant ($p < 0.05$) when reallocating 15 min of sedentary time into MVPA. Reallocating sedentary time into light physical activity was not related ($p > 0.05$) with body fatness outcomes.

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Substituting sedentary time with LIPA and MVPA

Table 3 Cross-sectional and prospective association of substituting 15 min of sedentary time for different physical activity intensity levels with body composition (N=387)

Replace 15 min of sedentary time with 15 min of	Body mass index (kg m^{-2}) z-score β (95% CI)	Waist circumference (cm) β (95% CI)	Trunk fat mass (kg) β (95% CI)	Total body fat mass (kg) β (95% CI)
Cross-sectional analysis				
Light PA	0.02 (−0.05, 0.06)	0.11 (−0.41, 0.62)	−0.05 (−0.18, 0.08)	−0.14 (−0.39, 0.14)
MVPA	−0.11 (−0.20, −0.02)*	−0.66 (−1.53, 0.21)	−0.41 (−6.30, −0.18)***	−0.81 (−1.26, −0.35)**
Prospective analyses				
Light PA	0.02 (−0.03, 0.05)	−0.11 (−0.44, 0.23)	0.02 (−0.05, 0.08)	0.05 (−0.08, 0.17)
MVPA	−0.03 (−0.09, 0.03)	−0.56 (−1.08, −0.03)*	−0.11 (−0.20, 0.00)*	−0.24 (−0.44, −0.03)*

In cross-sectional analysis results were adjusted for age, sex, and accelerometer wear time (h d^{-1}). In prospective analysis results were further adjusted for baseline body composition outcomes variables.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$
CI, confidence interval; MVPA, moderate-to-vigorous physical activity; PA, physical activity.

(Sardinha et al, *Pediatr Obes* 2017)

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PHYSICAL ACTIVITY, HEALTH AND EXERCISE

Check for updates

Bi-directional prospective associations between sedentary time, physical activity and adiposity in 10-year old Norwegian children

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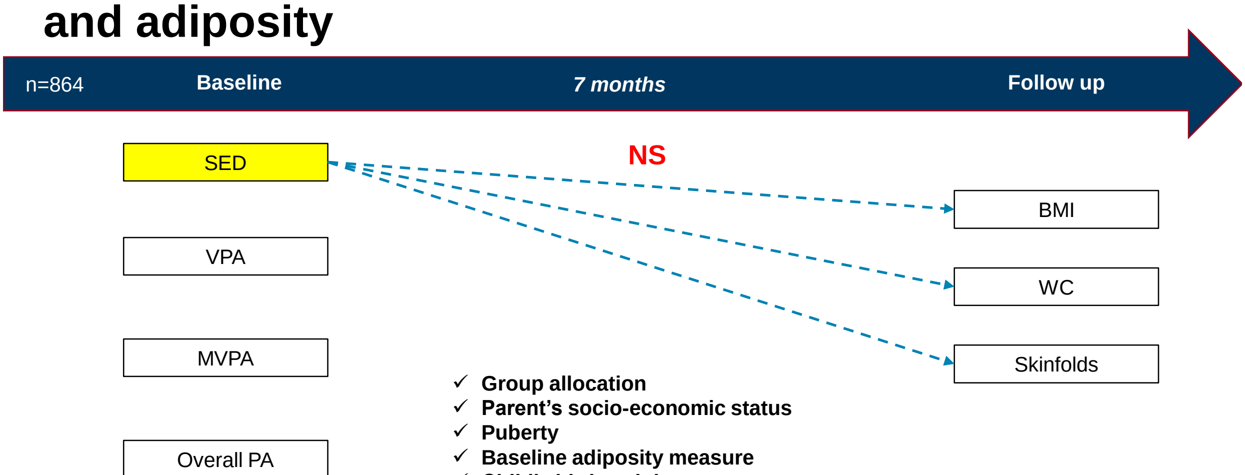
ABSTRACT
There is an adverse cross-sectional association between sedentary time, physical activity (PA) and adiposity, but weak and inconsistent estimates raise question to the direction of associations. The present study aims to examine whether the prospective association between sedentary time, different PA intensities and indicators of adiposity is bi-directional. The Active Smarter Kids Study obtained data from 869 ten-year-old children with valid measurements for sedentary time, PA, and adiposity at baseline and follow-up. Time spent sedentary and PA was measured by accelerometry, adiposity was assessed by three different measures: body mass index (BMI), waist circumference (WC) and sum of four skinfolds (S4SF). Neither overall PA nor time spent sedentary predicted lower BMI or WC at follow-up, but the time spent in moderate-and-vigorous PA (MVPA) and vigorous PA (VPA) predicted lower S4SF at follow-up among boys (MVPA β – 0.066 [95% CI −0.105, −0.027] $p = 0.001$). Baseline BMI and WC predicted less overall PA, MVPA and VPA in boys. All adiposity measures predicted more time spent sedentary at follow-up in boys. The results suggest that overall PA and sedentary time do not predict future adiposity. Baseline adiposity may rather predict more sedentary time and less higher intensity activity.

ARTICLE HISTORY
Accepted 26 February 2021

KEYWORDS
Accelerometer; MVPA; intensity; longitudinal; overweight

(Skrede et al, *J Sports Sci* 2021)

Bi-directional prospective associations between PA and adiposity



- ✓ **Group allocation**
- ✓ **Parent's socio-economic status**
- ✓ **Puberty**
- ✓ **Baseline adiposity measure**
- ✓ **Child's birth weight**
- ✓ **Parental weight**

(Skrede et al, *J Sports Sci* 2021)

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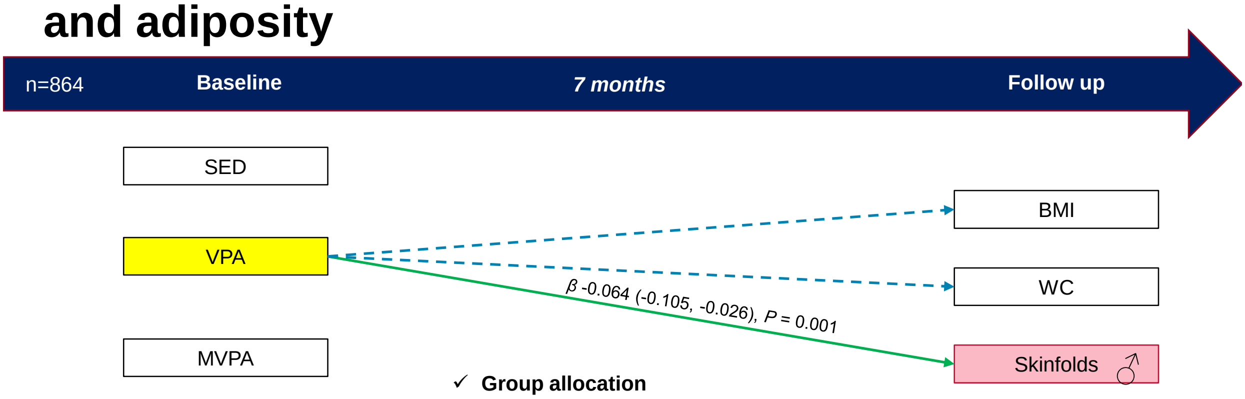
Bi-directional prospective associations between PA and adiposity



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(Skrede et al, *J Sports Sci* 2021)

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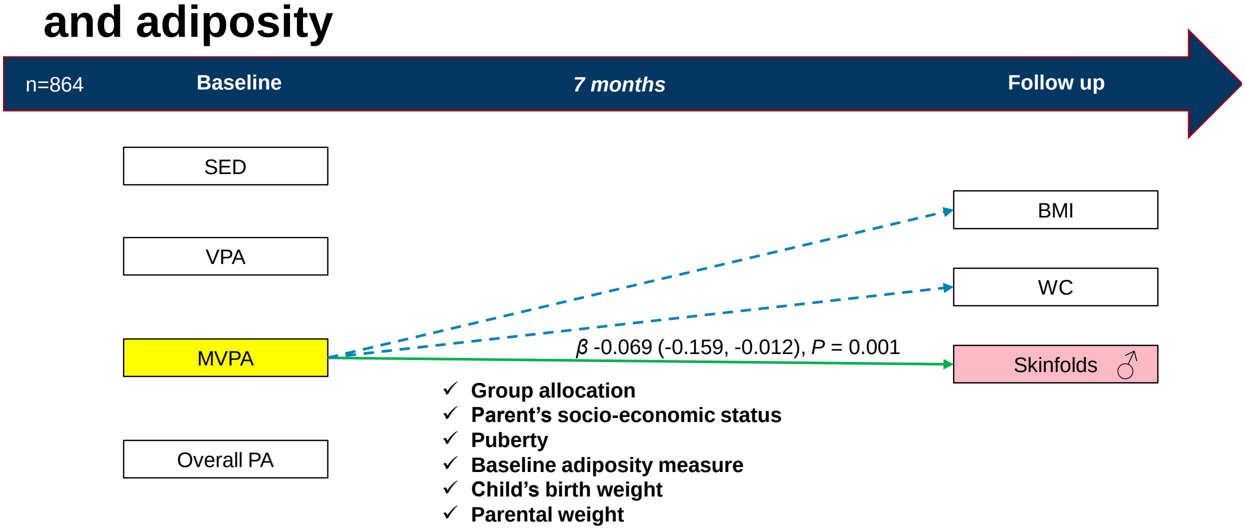
Bi-directional prospective associations between PA and adiposity



(Skrede et al, *J Sports Sci* 2021)

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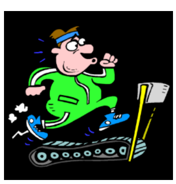
Direction of association?

Baseline Body Weight / Adiposity

Follow up Activity

Baseline Activity



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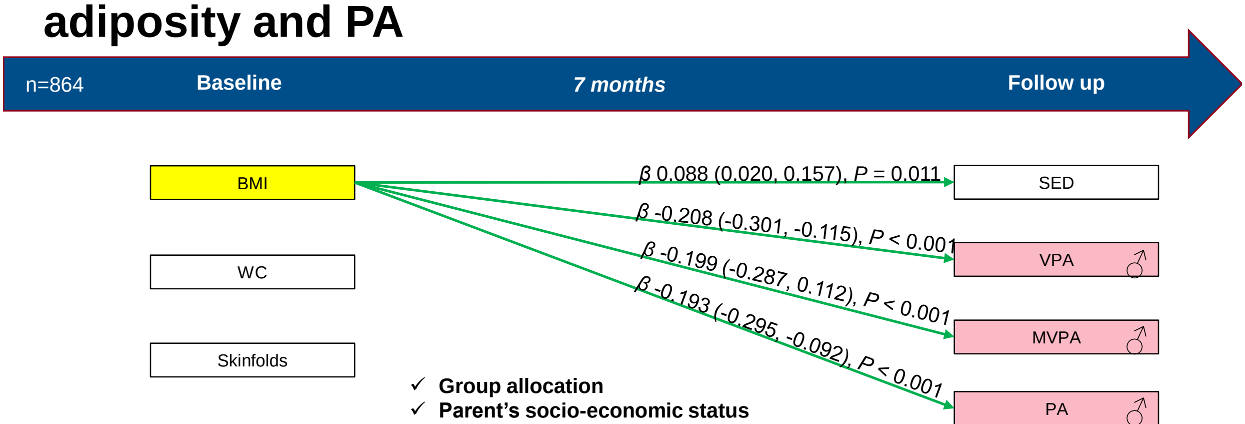
Bi-directional prospective associations between adiposity and PA



- ✓ **Group allocation**
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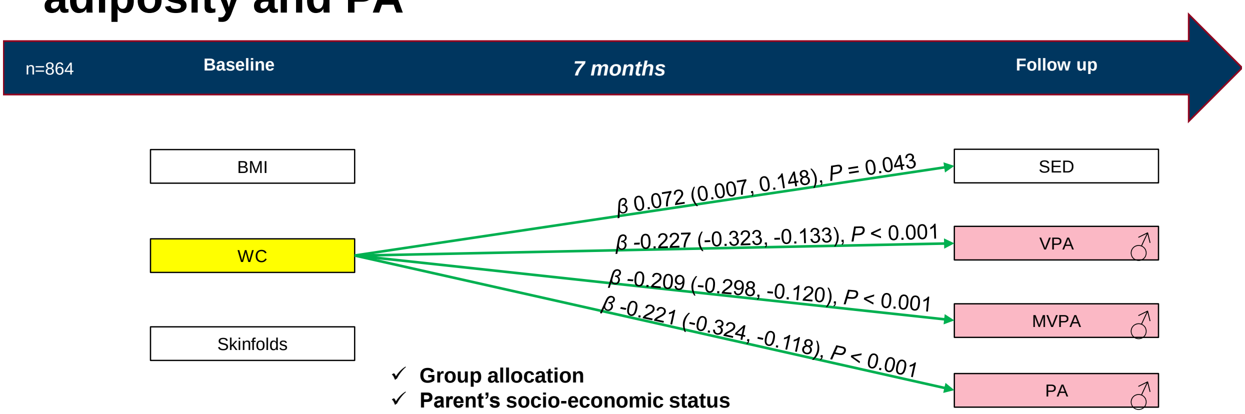
(Skrede et al, *J Sports Sci* 2021)

Bi-directional prospective associations between adiposity and PA



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(Skrede et al, *J Sports Sci* 2021)

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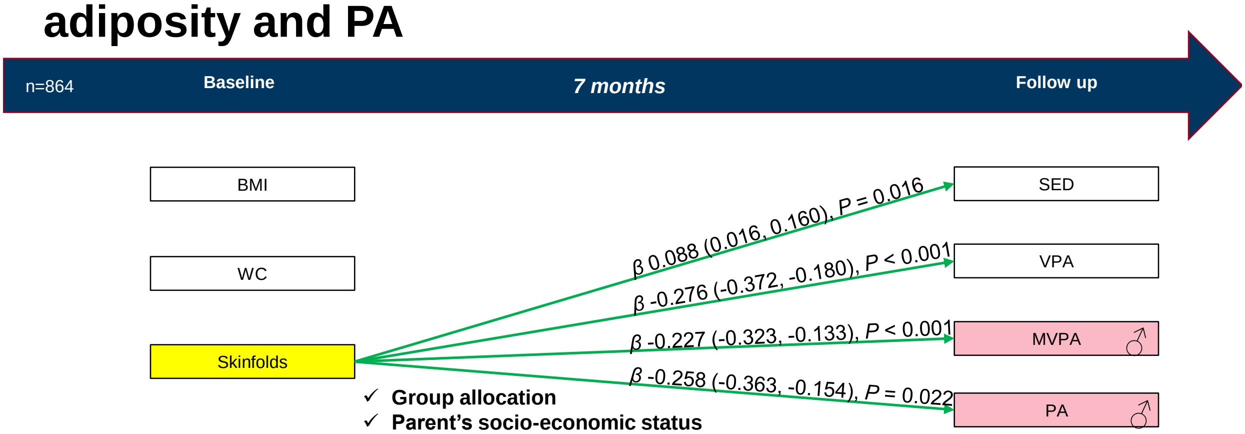
Bi-directional prospective associations between adiposity and PA



- ✓ **Group allocation**
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(Skrede et al, *J Sports Sci* 2021)

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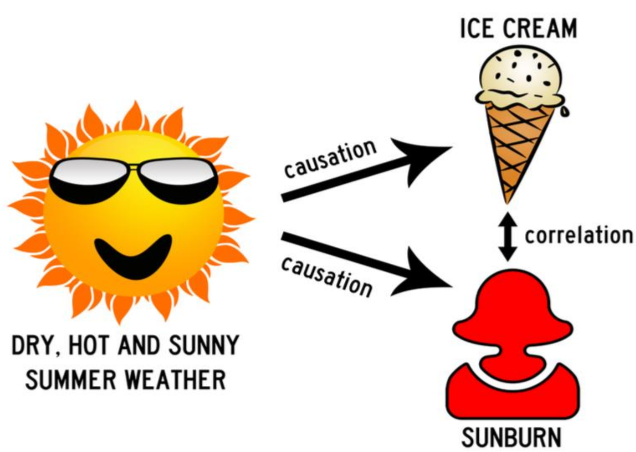
Interpretation of the Direction of Association

- The use of an imprecise measure of an exposure variable (PA) will tend to *underestimate* its relationship with an outcome variable (**regression dilution**)

- The use of an imprecise outcome variable (PA) *increase the uncertainty* in the estimate of the effect size (wider confidence intervals) and does not result in systematic underestimation of the association

- **Be cautious when interpreting associations when exposures and outcomes are measured with different degree of precision**

Is it possible to infer causality from observational research



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Mendelian Randomization – Inference about Causality

MR design control for confounding and reverse causation

Obesity → **Physical Activity / Sedentary time**

SNPs associated with obesity
(FTO, ...) ”Genetic risk score”

<u>**Key Assumptions - MR**</u>
- **Genotypes randomised**
- **Instrumental variable affecting the outcome only by modifying the ”biomarker” (pleitrophy)**
- **Genotype independent of confounders**

(Lawlor et al, *Stats Med* 2008)

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Assessing Causality in the Association between Child Adiposity and Physical Activity Levels: A Mendelian Randomization Analysis

Methods and Findings: The Avon Longitudinal Study of Parents and Children collected data on objectively assessed activity levels of 4,296 children at age 11 y with recorded BMI and genotypic data. We used 32 established genetic correlates of BMI combined in a weighted allelic score as an instrumental variable for adiposity to estimate the causal effect of adiposity on activity. In observational analysis, a 3.3 kg/m^2 (one standard deviation) higher BMI was associated with 22.3 (95% CI, 17.0, 27.6) movement counts/min less total physical activity ($p = 1.6\times10^{-16}$), 2.6 (2.1, 3.1) min/d less moderate-to-vigorous-intensity activity ($p = 3.7\times10^{-29}$), and 3.5 (1.5, 5.5) min/d more sedentary time ($p = 5.0\times10^{-4}$). In Mendelian randomization analyses, the same difference in BMI was associated with 32.4 (0.9, 63.9) movement counts/min less total physical activity ($p = 0.04$) (~5.3% of the mean counts/minute), 2.8 (0.1, 5.5) min/d less moderate-to-vigorous-intensity activity ($p = 0.04$), and 13.2 (1.3, 25.2) min/d more sedentary time ($p = 0.03$). There was no strong evidence for a difference between variable estimates from observational estimates. Similar results were obtained using fat mass index. Low power and poor instrumentation of activity limited causal analysis of the influence of physical activity on BMI.

Conclusions: Our results suggest that increased adiposity causes a reduction in physical activity in children and support research into the targeting of BMI in efforts to increase childhood activity levels. Importantly, this does not exclude lower physical activity also leading to increased adiposity, i.e., bidirectional causation.

- **1 SD higher BMI associated with 2.6 min lower MVPA and 3.5 more min spent sedentary**
- **In MR analyses the associations were almost unchanged**
- **Poor instrumentation of activity limited causal analyses of the PA and BMI relationship**

(Richmond et al, *PLOS Med* 2014)

Physical Activity or Sedentary time? Causal associations with cardio-metabolic health markers?

Moderate to Vigorous Physical Activity and Sedentary Time and Cardiometabolic Risk Factors in Children and Adolescents

Ulf Ekelund, PhD
Jian'an Luan, PhD
Lauren B. Sherar, PhD
Dale W. Esliger, PhD
Pippa Griew, MSc
Ashley Cooper, PhD
for the International Children's Accelerometry Database (ICAD) Collaborators

Context Sparse data exist on the combined associations between physical activity and sedentary time with cardiometabolic risk factors in healthy children.

Objective To examine the independent and combined associations between objectively measured time in moderate- to vigorous-intensity physical activity (MVPA) and sedentary time with cardiometabolic risk factors.

Design, Setting, and Participants Pooled data from 14 studies between 1998 and 2009 comprising 20 871 children (aged 4-18 years) from the International Children's Accelerometry Database. Time spent in MVPA and sedentary time were measured using accelerometry after reanalyzing raw data. The independent associations between time in MVPA and sedentary time, with outcomes, were examined using meta-analysis. Participants were stratified by tertiles of MVPA and sedentary time.

Main Outcome Measures Waist circumference, systolic blood pressure, fasting triglycerides, high-density lipoprotein cholesterol, and insulin.

Results Times (mean [SD] min/d) accumulated by children in MVPA and being sedentary were 30 (21) and 354 (96), respectively. Time in MVPA was significantly associated with all cardiometabolic outcomes independent of sex, age, monitor wear time, time spent sedentary, and waist circumference (when not the outcome). Sedentary time was not associated with any outcome independent of time in MVPA. In the combined analyses, higher levels of MVPA were associated with better cardiometabolic risk factors across tertiles of sedentary time. The differences in outcomes between higher and lower MVPA were greater with lower sedentary time. Mean differences in waist circumference between the bottom and top tertiles of MVPA were 5.6 cm (95% CI, 4.8-6.4 cm) for high sedentary time and 3.6 cm (95% CI, 2.8-4.3 cm) for low sedentary time. Mean differences in systolic blood pressure for high and low sedentary time were 0.7 mm Hg (95% CI, –0.07 to 1.6) and 2.5 mm Hg (95% CI, 1.7-3.3), and for high-density lipoprotein cholesterol, differences were –2.6 mg/dL (95% CI, –1.4 to –3.9) and –4.5 mg/dL (95% CI, –3.3 to –5.6), respectively. Geometric mean differences for insulin and triglycerides showed similar variation. Those in the top tertile of MVPA accumulated more than 35 minutes per day in this intensity level compared with fewer than 18 minutes per day for those in the bottom tertile. In prospec-

NATIONAL AND INTERNATIONAL public health authorities agree that children and adolescents should accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity (MVPA) daily.[1-6] Although the exact amount of physical activity needed for optimal health is unknown, recent research has established inverse cross-sectional associations between objectively measured physical activity with adiposity and cardiometabolic risk factors in youth.[7-10]

Many health authorities and organizations have also recognized the potentially detrimental effects of prolonged

ICAD
International Children's Accelerometry Database

To examine the joint associations between SED and MVPA with CVD risk factors

N=20,871 (4 to 18 yrs)

Pooled analysis 14 studies

(Ekelund et al, *JAMA* 2012)

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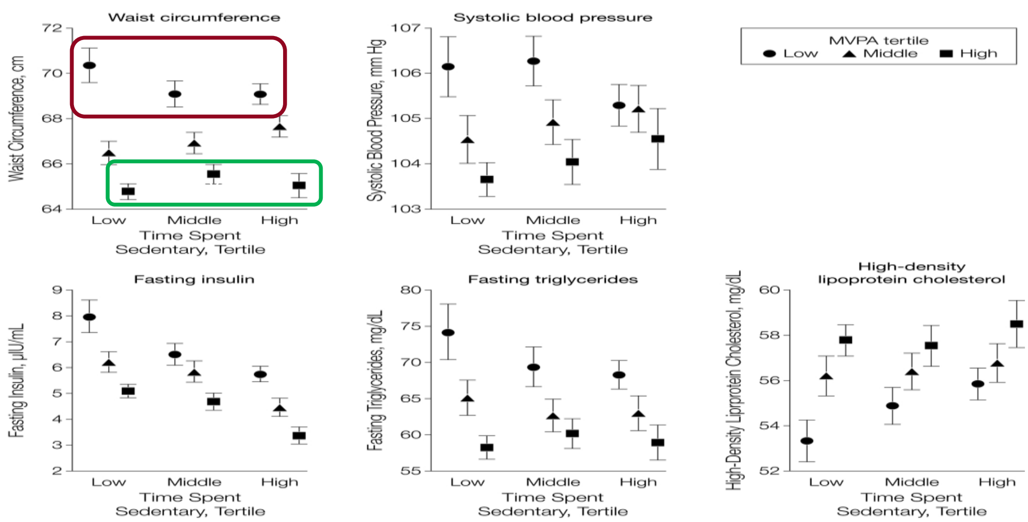
Combined Associations of Time Spent Sedentary and in MVPA With Metabolic Risk Factors



(Ekelund et al. *JAMA* 2012)

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Causality in observational research – Bradford Hill Criteria (slightly modified)

- **Strength** (effect size, magnitude of association) √
- **Consistency** (reproducibility) √
- **Specificity** (Specific population, specific site, specific cause, specific effect) √
- **Temporality** (cause before effect) *X*
- **Gradient** (Dose – response) √
- **Plausibility** (Plausible biological mechanism) √
- **Experiment** (Experimental evidence) √

(Adapted from Bradford Hill, Proc Royal Soc Med, 1965)

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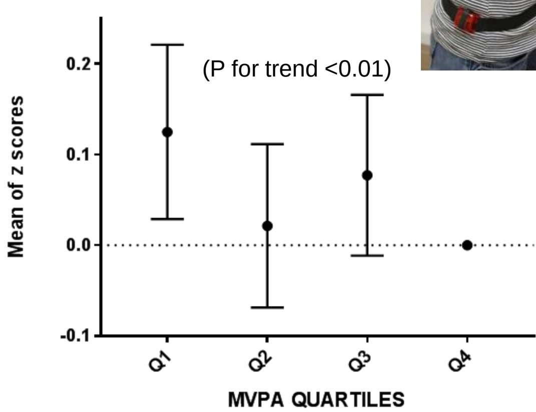
Moderate-to-vigorous physical activity, but not sedentary time, predicts changes in cardiometabolic risk factors in 10-y-old children: the Active Smarter Kids Study[1,2]



- N=700
- Clustered metabolic risk (HOMA, WC, SBP, TG, TC:HDL-C)
- MVPA and SED measured with accelerometry
- Data adjusted for sex, socio-economic status, Tanner stage, monitor wear time, and baseline cardio-metabolic risk
- **MVPA and VPA, but *not sedentary* time, is prospectively associated with cardio-metabolic risk in healthy children.**

(Skrede et al, *Am J Clin Nutr*, 2017)

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Pediatric Obesity/Obesity Comorbidity

The prospective association between objectively measured sedentary time, moderate-to-vigorous physical activity and cardiometabolic risk factors in youth: a systematic review and meta-analysis

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Summary

Sedentary time and moderate-to-vigorous physical activity (MVPA) may be uniquely related to cardiometabolic health. Excessive sedentary time is suggested as an independent cardiometabolic risk factor, while MVPA is favourably associated with cardiometabolic health. This systematic review and meta-analysis summarizes the evidence on a prospective relationship between objectively measured sedentary time, MVPA and cardiometabolic health indicators in youth.

PubMed, Embase, CINAHL, PhyscINFO and SPORTDiscus were systematically searched from January 2000 until April 2018. Studies were included if sedentary time and physical activity were measured objectively and examined associations with body mass index, waist circumference, triglycerides, high-density lipoprotein, insulin, blood pressure or the clustering of these cardiometabolic risk factors.

We identified 30 studies, of which 21 were of high quality. No evidence was found for an association between sedentary time and cardiometabolic outcomes. The association between MVPA and individual cardiometabolic risk factors was inconsistent. The meta-analysis for prospective studies found a small but significant effect size between MVPA at baseline and clustered cardiometabolic risk at follow-up (ES –0.014 [95% CI, −0.024 to −0.004]). We conclude that there is no prospective association between sedentary time and cardiometabolic health, while MVPA is beneficially associated with cardiometabolic health in youth.

(Skrede et al, *Obes Rev* 2019)

The prospective association between objectively measured sedentary time, moderate-to-vigorous physical activity and cardiometabolic risk factors in youth: a systematic review and meta-analysis

Outcome	Beneficially associated with SED	**Not** associated with SED	n/N for outcome (%)	Level of evidence
BMI	*Obs.:* Stamatakis[a]	*Obs.:* Treuth, Fisher[a], Griffiths[a], Basterfield[b]	1/5 (20 %)	No evidence
WC	*Obs.:* Chinapaw[b]	*Obs.:* Skrede[a], Stamatakis[a], Ekelund[a], van Slujis[a], Fisher[a]	1/6 (16 %)	No evidence
Insulin/HOMA-IR		*Obs.:* Skrede[a], Stamatakis[b], Chinapaw[b]	0/3 (0 %)	No evidence
TG	*n/a*	*Obs.:* Skrede[a], Stamatakis[b], Chinapaw[b]	0/3 (0 %)	No evidence
HDL/TC:HDL	*n/a*	*Obs.:* Skrede[a], Stamatakis[b], Chinapaw[b]	0/3 (0 %)	No evidence
Blood Pressure	*n/a*	*Obs.:* Skrede[a], Stamatakis[b], Chinapaw[b]	0/3 (0 %)	No evidence
CM Risk	*Obs.: Chinapaw[b]*	*Obs.:* Skrede[a], Stamatakis[b]	1/3 (33 %)	No evidence

(Skrede et al, *Obes Review*, 2019)

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Outcome	Beneficially associated with MVPA	Not associated with MVPA	n/N for outcome (%)	Level of evidence
BMI	*Obs.:* Stamatakis[a] , Carson[a], Griffiths[a] (♂), Fisher[a], Basterfield [b](♂) *Int..:* Kriemler[c], Gorely[d] (2009)	*Obs.:* Metcalf[a] *Int.:* Meyer[e], Bugge[d], Gorely[e], Lubans[c], Stevens[b], Seabra[d], Andrade[d]	7/15 (43 %)	Inconsistent
WC	*Obs.:* Stamatakis[a], Stevens[b], Chinapaw[b] *Int.:* Bugge[d], Gorely[d] (2009), Seabra[d]	*Obs.:* Fisher[a], Skrede[a], Metcalf[a] *Int.:* Meyer[e], Bugge[d], Gorely[e]	6/12 (50 %)	Inconsistent
Insulin/ HOMA	*Obs.:* Skrede [a], Stamatakis[b], Chinapaw[b] *Int.:* Bugge[d] (♂)	*Obs.:* Metcalf[a] (2008), Metcalf [b] (2015), *Int.:* Seabra[d]	4/7 (57 %)	Inconsistent
TG	*Obs.:* Skrede[a], Metcalf[b] (♂) (2015), Metcalf [a] (♀) (2008) *Int.:* Kriemler[c]	*Int.:* Meyer[e], Bugge[d], Seabra[d]	4/7 (57 %)	Inconsistent
HDL/TC:HDL	*Obs.:* Stamatakis[b] *Int.:* Kriemler[c]	*Obs.:* Skrede[a], Metcalf[b] (2015), Metcalf[a] (2008) *Int.:* Meyer[e], Seabra[d]	2/7 (29 %)	Inconsistent
Blood Pressure (MAP, SBP, DBP)	*Obs.:* Stamatakis[a], Metcalf[a] (♂) (2008), Carson[a] (♂),Chinapaw[b], Metcalf [b] (♂) (2015) *Int.:* Bugge[d] (♂)	*Obs.:* Knowles[a], Skrede[a] *Int.:* Kriemler[c], Meyer[e], Seabra[d]	6/11 (54 %)	Inconsistent
CMRisk	*Obs.:* Skrede[a], Stamatakis[b], Chinapaw[b], Metcalf [a] (2008)	*Int.:* Bugge[d], Meyer[e]	5/7 (71 %)	Inverse

(Skrede et al, *Obes Review*, 2019)

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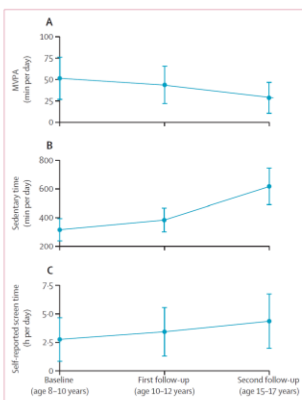
Estimating causal effects of physical activity and sedentary behaviours on the development of type 2 diabetes in at-risk children from childhood to late adolescence: an analysis of the QUALITY cohort

Soren Harnois-Leblanc, Marie-Pierre Sylvestre, An… Angelo Tremblay, Vicky Drapeau, Gilles Paradis, M…



	Insulin sensitivity	
	Complete case	Multiply imputed
MVPA, 10 min daily increment		
Point-in-time	4·4% (1·5 to 7·4)*	3·9% (1·6 to 6·2)*
Cumulative	5·1% (2·7 to 7·5)*	5·6% (2·8 to 8·5)*
Sedentary time, 1 h daily increment		
Point-in-time	–3·4% (–8·0 to 1·3)	–4·2% (–6·9 to –1·3)*
Cumulative	–8·5% (–13·2 to –3·5)*	–8·2% (–12·3 to –3·9)*
Screen time, 1 h daily increment		
Point-in-time	–2·1% (–4·8 to 0·7)	–3·4% (–5·6 to –1·0)*
Cumulative	–2·6% (–5·6 to 0·5)	–6·4% (–10·1 to –2·5)*

Interpretation Using modern causal inference approaches strengthened the evidence of MVPA and sedentary behaviours as key drivers of development of type 2 diabetes in at-risk children and adolescents, and should be considered as key targets for prevention.

(Harnois-Leblanc et al, *Lancet Child Adolesc Health* 2022)

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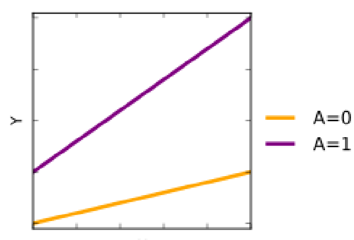
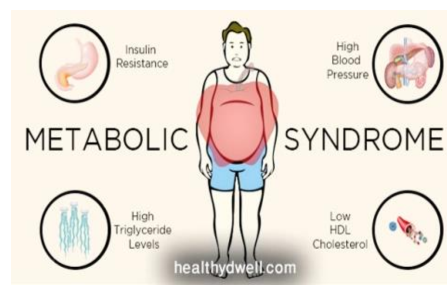
Is CRF a modifier between MVPA and clustered CM risk?





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JAMA Pediatrics | Original Investigation

Association of Cardiorespiratory Fitness Levels During Youth With Health Risk Later in Life

A Systematic Review and Meta-analysis

Antonio García-Hermoso, PhD; Robinson Ramírez-Vélez, PhD; Yesenia García-Alonso, MSc; Alicia M. Alonso-Martínez, PhD; Mikel Izquierdo, PhD

IMPORTANCE Although the associations between cardiorespiratory fitness (CRF) and health in adults are well understood, to date, no systematic review has quantitatively examined the association between CRF during youth and health parameters later in life.

OBJECTIVES To examine the prospective association between CRF in childhood and adolescence and future health status and to assess whether changes in CRF are associated with future health status at least 1 year later.

DATA SOURCES For this systematic review and meta-analysis, MEDLINE, Embase, and SPORTDiscus electronic databases were searched for relevant articles published from database inception to January 30, 2020.

STUDY SELECTION The following inclusion criteria were used: CRF measured using a validated test and assessed at baseline and/or its change from baseline to the end of follow-up, healthy population with a mean age of 3 to 18 years at baseline, and prospective cohort design with a follow-up period of at least 1 year.

DATA EXTRACTION AND SYNTHESIS Data were processed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Random-effects models were used to estimate the pooled effect size.

MAIN OUTCOMES AND MEASURES Anthropometric and adiposity measurements and cardiometabolic health parameters.

Key Points

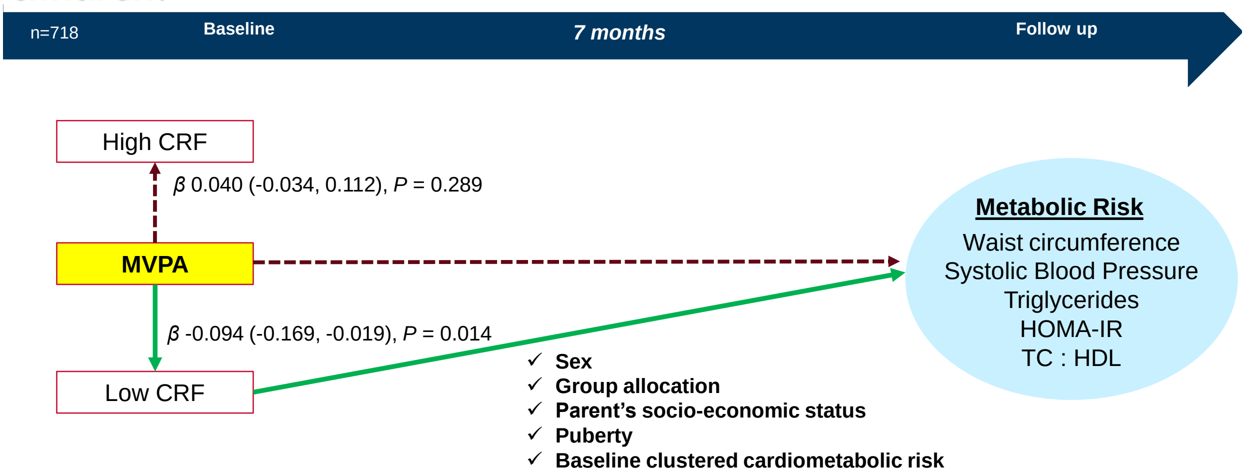
Question Is cardiorespiratory fitness associated with future health benefits in children and adolescents?

Findings This systematic review and meta-analysis of 55 studies that included 37 563 youths revealed that cardiorespiratory fitness levels and change over approximately 1 year during youth were associated with lower risk of developing obesity and cardiometabolic disease later in life. These early associations detected from baseline to follow-up dissipated over time.

Meaning The study suggests that prevention strategies that target youth cardiorespiratory fitness may be associated with improved health parameters in later life.

(Garcia-Hermoso et al, *JAMA Pediatr* 2020)

Does cardiorespiratory fitness moderate the prospective association between physical activity and cardiometabolic risk factors in children?



(Skrede et al, *Int J Obes* 2018)

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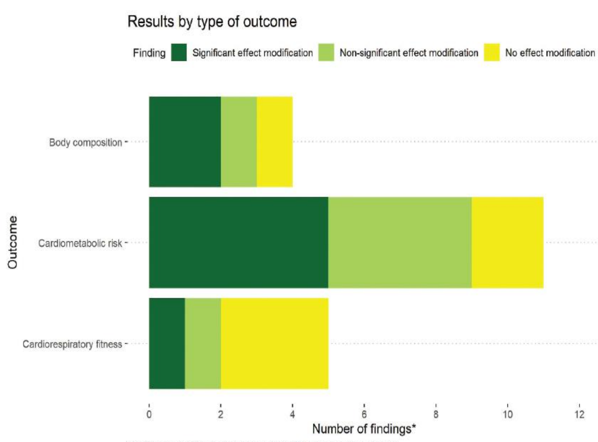
Effect modification by cardiorespiratory fitness on the association between physical activity and cardiometabolic health in youth: A systematic review



- Data from 15 unique study samples
- 70% of observations supported grester benefits from physical activity in less fit children
- The clinical importance is unclear
- Weak quality evidence
- High quality prospective studies and well-designed randomised trials are needed

(Husøy et al, *J Sports Sci* 2020)

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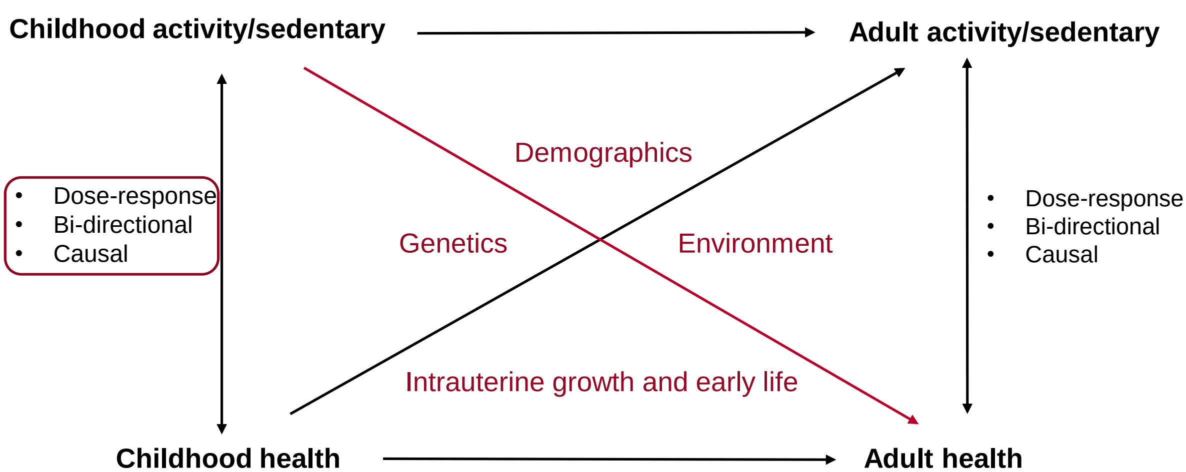
Summary

- Higher intensity PA is associated with lower adiposity levels – ***Causality not determined***
- Mendellian randomisation - adiposity is a ***causal factor*** for lower levels of PA
- ***Emerging evidence for a bi-directional association*** between PA and adiposity
- Sedentary time appears **unrelated**
- Higher amounts of MVPA and VPA ***causally and independently associated with clustered cardio-metabolic risk?***
- ***Sedentary time may be causally associated with cardio-metabolic risk?***
- Cardio-respiratory fitness ***liekly modifies the association*** between PA and cardio-metabolic risk factors
- **The optimal amount and intensity of physical acitivity for cardio-vascular health in young people is not firmly established**

Future perspectives



(Adapted from Blair)

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World Health Organization 2020 guidelines on physical activity and sedentary behaviour

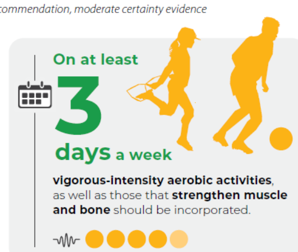
It is recommended that:

- Children and adolescents should do at least an average of 60 minutes per day of moderate- to vigorous-intensity, mostly aerobic, physical activity, across the week.

Strong recommendation, moderate certainty evidence

- Vigorous-intensity aerobic activities, as well as those that strengthen muscle and bone, should be incorporated at least 3 days a week.

Strong recommendation, moderate certainty evidence



It is recommended that:

- Children and adolescents should limit the amount of time spent being sedentary, particularly the amount of recreational screen time.

Strong recommendation, low certainty evidence

(Bull et al, *Br J Sports Med*, 2020)
(Chaput et al, IJBNPA 2020)
(https://www.who.int/publications/i/item/9789240015128)

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Thank You for the attention