Physical activity, inactivity and health during youth

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Physical activity, sedentary time and obesity in an international sample of children.

Katzymarzyk PT, Barreira t, Broyles ST, Champagne C, Chaput J-P, Fogelholm M, Hu G, Johnson WD, Kuriyan R, Kurpad A, Lambert EV, Maher C, Maia J, Matsudo V, Olds, T, Onywera V, Sarimento OL, Standage M, Tremblay M, Tudor-Locke C, Zhao P, Church T.

Abstract:

Purpose: To determine the relationships between moderate-to-vigorous physical activity (MVPA), vigorous physical activity (VPA), sedentary time, and obesity in children from 12 countries representing a wide range of human development. **Methods:** The sample included 6539 children age 9–11 yr. Times in MVPA, VPA, and sedentary behaviors were assessed by accelerometry. The body mass index (BMI; $kg.m^{-2}$) was used to classify children as obese based on z-scores (> +2 SD) from World Health Organization reference data. **Results:** The mean (SD) times spent in MVPA, VPA, and sedentary behavior were 60 (25) $min.d^{-1}$, 18 (11) $min.d^{-1}$, and 513 (69) $min.d^{-1}$, respectively. The overall proportion of the sample that was obese ranged from 5.2% to 24.6% across sites. The odds ratios for obesity were significant for MVPA (0.49; 95% CI, 0.44–0.55), VPA (0.41; 0.37–0.46), and

sedentary time (1.19; 1.08–1.30) in the overall sample. The associations of MVPA and VPA with obesity were significant in all 12 sites, whereas the association between sedentary time and obesity was significant in five of the 12 sites. There was a significant difference in BMI z-scores across tertiles of MVPA ($P < 0.001$) but not across tertiles of sedentary time in a mutually adjusted model. The results of receiver operating characteristic curve analyses for obesity indicated that the optimal thresholds for MVPA (area under the curve [AUC], 0.64), VPA (AUC, 0.67) and sedentary behavior (AUC, 0.57) were 55 (95% CI, 50–64) $min.d^{-1}$, 14 (11–16) $min.d^{-1}$, and 482 (455–535) $min.d^{-1}$, respectively. **Conclusions:** Greater MVPA and VPA were both associated with lower odds of obesity independent of sedentary behavior. Sedentary time was positively associated with obesity, but not independent of MVPA. Attaining at least 55 $min.d^{-1}$ of MVPA is associated with lower obesity in this multinational sample of children, which supports current guidelines.

Citation: Katzymarzyk PT, Barreira t, Broyles ST et al. Physical activity, sedentary time and obesity in an international sample of children. Med Sci Sports Exerc 2015; 47(10):2062-2069.

Commentary:

2015 saw the release of a number of papers reporting findings from the International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE). This ambitious multi-national cross-sectional study recruited over 6000 children, aged about ten, from 12 countries spread across five major regions of the world (Europe, Africa, the Americas, South-East Asia and the Western Pacific). The study purposely included low, medium and high income countries and also spanned a range of the Human Development Index – a measure which takes into account life expectancy, gross national income and school participation – from Australia with the highest score (0.929) through to Kenya

with the lowest (0.509). So, by design, exposures to the types of things that may be expected to impact on lifestyle behaviours and obesity varied massively across the whole sample.

Crucially a standardised study protocol and rigorous training of personnel across all countries was implemented. Physical activity was measured objectively, using waist-worn ActiGraph accelerometers worn 24 h a day with the same procedures, processing and analytics for all study sites. Anyone who has used accelerometers or tried to compare accelerometer data between even two studies knows how important (and challenging) this achievement is. The lack of standardised protocols for assessing physical activity with accelerometry has hindered comparisons in activity levels between studies, let alone between countries.

This enabled not only a robust comparison between obesity and lifestyle behaviours between countries, but also examination of the extent to which the influence of these lifestyle behaviours differs in places that are environmentally, culturally and socioeconomically very diverse. Despite this variability, the key findings were robust across countries. Namely moderate-to-vigorous physical activity (MVPA) and vigorous physical activity (VPA) were consistently negatively associated with obesity, independently of sedentary time, across the whole multinational sample and at each site individually. The quantity of MVPA that best discriminated obese and normal weight children was 55 minutes adding further support to the existing guidelines that recommend children accumulate 60 minutes of MVPA per day.

The relationship between obesity and sedentary time was less robust; while significant for the whole sample it was not independent of MVPA and was less consistent, being significant in only 5 of the 12 sites (Australia, Canada, Columbia, South Africa and the US). TV viewing tends to have stronger associations with obesity than total sedentary time, leading the authors to suggest that TV viewing may be more prominent in these five countries contributing to the stronger associations found. In a subsequent paper (3), the authors did find that self-reported TV viewing was positively related to obesity in the whole sample, with similar effects across countries. A quick ‘back of the envelope’

calculation shows that the proportion of sedentary time that was made up of screen time was positively related to the odds ratio for the relationship between sedentary time and obesity ($r = 0.65$, $p < 0.05$); without Brazil which had the highest time spent viewing TV (soccer viewing figures unfortunately not available), but more or less average sedentary time, the correlation jumps to 0.87 ($p < 0.001$). Disclaimer: this is my very rough and ready guestimate based on sedentary time and screen time by country taken from a further paper from the ISCOLE group (4) and odds ratios estimated from Figure 2 (yes – with a ruler!) in Katzymarzyk et al. (2).

The well-established higher level of MVPA of boys relative to girls was present in all countries. Further, another 'back of the envelope' calculation reveals the ratio of these differences appears reasonably consistent across countries at 1.3 (SD = 0.1). The consistency of the sex differences in activity across countries was also highlighted by Cooper et al. (1), reporting on results from the International Children's Accelerometry Database (ICAD). ICAD covered children aged between 2 and 18 y, so was also able to identify the consistency of the age-related decline in MVPA as well as sex effects across countries, leading the authors to suggest that differences across age and sex may be, at least partially, biological.

The authors further analyse these data in a subsequent paper (3) and report that, even in the face of the large range of cultures and environments that were home to the children participating in ISCOLE, just under 90% of the variation in obesity levels was attributable to individual-level factors. Low MVPA, high TV viewing and short time spent sleeping were consistently found to be important behavioural correlates of obesity. As the authors point out (3), the consistency of these findings across countries that span a range of health, social and economic indicators highlights just how robust these relationships are.

References

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Combined effects of time spent in physical activity, sedentary behaviours and sleep on obesity and cardio-metabolic health markers: A novel compositional data analysis approach.

Chastin S, Palarea-Albaladejo J, Dontje ML, Skelton DA.

Abstract:

The associations between time spent in sleep, sedentary behaviors (SB) and physical activity with health are usually studied without taking into account that time is finite during the day, so time spent in each of these behaviors are codependent. Therefore, little is known about the combined effect of time spent in sleep, SB and physical activity, that together constitute a composite whole, on obesity and cardio-metabolic health markers. Cross-sectional analysis of NHANES

2005–6 cycle on N = 1937 adults, was undertaken using a compositional analysis paradigm, which accounts for this intrinsic codependence. Time spent in SB, light intensity (LIPA) and moderate to vigorous activity (MVPA) was determined from accelerometry and combined with self-reported sleep time to obtain the 24 hour time budget composition. The distribution of time spent in sleep, SB, LIPA and MVPA is significantly associated with BMI, waist circumference, triglycerides, plasma glucose, plasma insulin (all $p<0.001$), and systolic ($p<0.001$) and diastolic blood pressure ($p<0.003$), but not HDL or LDL. Within the composition, the strongest positive effect is found for the proportion of time spent in MVPA. Strikingly, the effects of MVPA replacing another behavior and of MVPA being displaced by another behavior are asymmetric. For example, re-allocating 10 minutes of SB to MVPA was associated with a lower waist circumference by 0.001% but if 10 minutes of MVPA is displaced by SB this was associated with a 0.84% higher waist circumference. The proportion of time spent in LIPA and SB were detrimentally associated with obesity and cardiovascular disease markers, but the association with SB was stronger. For diabetes risk markers, replacing SB with LIPA was associated with more favorable outcomes. Time spent in MVPA is an important target for intervention and preventing transfer of time from LIPA to SB might lessen the negative effects of physical inactivity.

Citation: Chastin S, Palarea-Albaladejo J, Dontje ML, Skelton DA. Combined effects of time spent in physical activity, sedentary behaviours and sleep on obesity and cardio-metabolic health markers: A novel compositional data analysis approach. PLoS One 2015; 10(10):e0139984. doi: 10.1371/joutnal.pone.0139984.

Commentary:

Although it sometimes may not feel like it, there are always 24 h in a day. Okay, for the pedants amongst us, that is except for when we switch to or from daylight savings… This means that the amount of time spent on one behaviour has to, by definition, impact on other behaviours. Likewise, adding or removing a behavior, e.g. MVPA, means something else in this finite 24 h period will have to move to accommodate the change, perhaps sleep or sedentary behaviour. For example, Gomersall et al. (5) recently showed that to accommodate the time required for an exercise intervention, adults reduced time spent on TV viewing and sleep. Six months following the removal of the six-month intervention, these time distributions returned to baseline with pretty amazing precision - physical activity within two minutes, sleep within six minutes and TV within 18 minutes (4). As Chastin and colleagues clearly show in this innovative paper how, or which, other behaviours change appear to affect the health impact of the targeted behavior.

When investigating the relationships between physical activity or sedentary behavior and health, researchers commonly investigate whether any effects of physical activity and sedentary behavior are independent of each other. However, as outlined by Chastin and colleagues, the co-dependence of the time spent on different behaviours in any finite period means that the behaviours cannot be truly independent. The authors' stress that a compositional data framework is necessary to take into account the intrinsically compositional distribution of time spent in physical behaviours across the day.

Using adult data from the National Health and Nutrition Examination Survey (NHANES), Chastin and colleagues showed that the distribution of time across physical behaviours was associated with several health outcomes including BMI, plasma insulin and blood pressure with the prime importance of MVPA for health supported. Notably, although light intensity physical activity and sedentary behavior were both detrimental to health markers, light intensity physical activity was less so. This meant that replacing MVPA with sedentary behaviour was more detrimental than replacing it with light activity. A striking finding was that replacing 10 min of time spent in MVPA with

sedentary time was associated with a 1.2% higher BMI, yet replacing 10-minute of sedentary time with MVPA was only associated with a 0.001% lower BMI. That is a 1000 fold lower benefit for replacing sedentary time with MVPA than the penalty for replacing MVPA with sedentary time! Something to think about if your activity level is slipping as the nights draw in. Or your children's activity level - the effects of decreasing MVPA may be particularly pertinent in children in light of the well-documented age-related decline in MVPA (3).

This study is the first to apply a compositional approach to examine the association of the relative distribution of physical behaviours across the day and with health. To exemplify the approach, the authors focused on sedentary behavior, light physical activity, MVPA and sleep from adult NHANES data. However, as outlined by the authors, this approach could equally be applied to sub-classes of sedentary behaviour, e.g. screen time. Given the evidence for associations between TV viewing, MVPA, sleep and obesity in children in the ISCOLE study a compositional analysis including TV viewing, as a sub-class of sedentary behaviour would be valuable.

There is a growing recognition in the children's physical activity literature that, in order to maximize health benefits, there is a need to address all components of the movement continuum and guidelines should follow an integrated approach including all components of the 24 h day (2). The analysis framework presented in this paper provides a vehicle for furthering the evidence base to inform 24 h movement behavior guidelines, such as the world's first Integrated 24 Hour Movement Behaviour Guidelines for Children and Youth (aged 5-17 years) currently being developed in Canada by experts from across the world (2). There are existing children's datasets with objective assessments of sleep, sedentary behavior and physical activity using accelerometers worn 24/7 (e.g. ISCOLE, NHANES). Application of this novel compositional analysis approach to these data has the potential to make a significant contribution to our understanding of the associations between the combined effects of physical behaviours and health in children.

With serendipitous timing, I was lucky enough to bump into Dr Valerie Carson from the University of Alberta (Canada), while at Loughborough University (UK) today. She is leading a team of researchers (Mark Tremblay, Jean-Phillipe Chaput and Sebastien Chastin) who have done just that with children's data from NHANES and the Canada Health Measures Survey (CHMS). The paper with the CHMS findings is being worked on 'even as we speak' and Valerie presented the pediatric NHANES findings at the International Conference of Diet and Activity Methods (ICDAM, Brisbane, September, August 2015, (1)), with the paper to be prepared next year. These results are already informing the development of the 24 Hour Movement Behaviour Guidelines (2). I believe this approach marks a turning point in research into physical behaviours and health which has the potential to transform our field – exciting times.

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