

Physical activity, inactivity and health during youth - 2017

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Abstract

It is well known that physical activity is important for children's current and future mental and physical health. Despite this, there appears to be a secular decline in children's physical activity (2, 3). Further, (frustratingly) interventions aiming to increase children's physical activity have limited success (8), demonstrating a need for more information on the amenability of activity levels to change.

How active someone is can appear to simply be a matter of personal choice, but reflects both external (e.g. is there a park nearby?) and biological (e.g. how old are they?) determinants. Exploring the extent to which external and biological factors determine physical activity, and how flexible an individual's activity level is given different external conditions, could inform the development of interventions that optimise physical activity levels.

I have selected two papers to highlight that, I believe, contribute significantly to this: the first demonstrates the impact of weather conditions on physical activity and whether this varies by country (5); the second introduces an alternative model of total daily energy expenditure that provides a means of investigating whether imposed activity/exercise leads to compensatory changes in energy expenditure (9).

Citation 1

Weather and children's physical activity; how and why do relationships vary between countries.

Harrison F, Goodman A, van Sluijs EMF, Anderson LB, Cardon G, Davey R, Janz KF, Kriemler S, Molloy L, Page AS, Pate R, Puder JJ, Sardinha LB, Timperio A, Wedderkopp N, Jones AP. Weather and children's physical activity; how and why do relationships vary between countries. *Int J Behav Nutr Phys Act.* 2017; 14: 74. DOI 10.1186/s12966-017-0526-7.

Abstract:

Background: Globally most children do not engage in enough physical activity. Day length and weather conditions have been identified as determinants of physical activity, although how they may be overcome as barriers is not clear. We aim to examine if and how relationships between children's physical activity and weather and day length vary between countries and identify settings in which children were better able to maintain activity levels given the weather conditions they experienced. **Methods:** In this repeated measures study, we used data from 23,451 participants in the International Children's Accelerometry Database (ICAD). Daily accelerometer-measured physical activity (counts per minute; cpm) was matched to local weather conditions and the relationships assessed using multilevel regression models. Multilevel models accounted for clustering of days within occasions within children within study-cities, and allowed us to explore if and how the relationships between weather variables and physical activity differ by setting. **Results:** Increased precipitation and wind speed were associated with decreased cpm while better visibility and more hours of daylight were associated with increased cpm. Models indicated that increases in these variables resulted in average changes in mean cpm of 7.6/h of day length, -13.2/cm precipitation, 10.3/10 km visibility and -10.3/10kph wind speed (all $p < 0.01$). Temperature showed a cubic relationship with cpm, although between 0 and 20 degrees C the relationship was broadly linear.

Age showed interactions with temperature and precipitation, with the associations larger among younger children. In terms of geographic trends, participants from Northern European countries and Melbourne, Australia were the most active, and also better maintained their activity levels given the weather conditions they experienced compared to those in the US and Western Europe.

Conclusions: We found variation in the relationship between weather conditions and physical activity between ICAD studies and settings. Children in Northern Europe and Melbourne, Australia were not only more active on average, but also more active given the weather conditions they experienced. Future work should consider strategies to mitigate the impacts of weather conditions, especially among young children, and interventions involving changes to the physical environment should consider how they will operate in different weather conditions.

Commentary:

Weather impacts on children's physical activity; not surprisingly increased rainfall has a detrimental impact (6, 8), while physical activity increases with temperature up to around 20° C, but then tends to decline with further increases in temperature (8) as highlighted in Ridgers and colleagues' (11) aptly named paper, 'Too hot to move?'.

But as Harrison et al. (5) show in this analysis of over 23,000 children across three continents (International Children's Accelerometry Database, ICAD), the effect of weather is not uniform across settings. As the authors state, this is significant as understanding why the physical activity level is higher in some settings than anticipated, given the weather conditions, could increase understanding of potentially modifiable factors that may optimise physical activity levels.

Studies investigating the effect of weather on children's physical activity are typically limited to a single, or small number of, sites and assessed over a relatively small timeframe. This limits the range of weather conditions and settings/environments that can be investigated. Comparisons across studies are complicated by the differing physical activity measurement protocols employed. Using

the ICAD, which houses consistently analysed objectively measured physical activity data from studies around the world, the authors were able to look at children's physical activity across a wide range of exposures across many settings that differed in typical climate, population, environment and/or culture.

While the nature of the associations between weather conditions and physical activity appeared to be broadly (although not entirely) similar across demographics and settings, the magnitude of these associations did differ. For example, activity increased between temperatures of 0 and 20 °C and declined at higher temperatures, with this effect most pronounced in the youngest (and most active) age group (age 3-5 y), suggesting that the weather presents more of a barrier to the youngest children. As the authors have previously suggested (7), weather likely impacts more strongly on discretionary/spontaneous activity, e.g. free-play, than on structured and/or obligatory activity, e.g. walking for transport. Weather presenting more of a barrier to younger children's physical activity therefore makes sense; free-play will make up a greater proportion of younger children's physical activity than that of older children. Similarly, seasonal variation in children's physical activity patterns is greater on weekends (i.e. free days) than weekdays (i.e. school days) (1), and rainfall impacts more on children's physical activity during lunchtimes and after school periods (free-time) than on their commute times (7). As the authors warn, the impact of weather on children's activity levels, particularly young children, means that weather and season should be considered when comparing, or collating, measures of children's physical activity across settings. This is particularly pertinent given the rapidly increasing number of studies globally collecting potentially comparable objective measures of children's physical activity data.

Across settings, studies from Northern Europe and Australia reported the highest level of activity. But, interestingly the weather conditions didn't explain this. On average, these children were also the most active given the weather conditions they were exposed to (after controlling for explanatory variables). What was it about these settings in Northern Europe and Australia that facilitated these

higher average activity levels? Further examination of regions where, on average, physical activity levels are higher and their environments/culture could give valuable insights into increasing physical activity levels in other regions.

For example, as well as the impact of weather conditions shown here by Harrison et al, we know that physical activity is affected by environmental factors. A systematic review published this year showed that neighbourhood walkability, quality of parks and playgrounds, and provision of adequate active transport infrastructure have positive effects on physical activity in children and adults (14). How does the effect of environmental interventions on physical activity interact with the weather conditions experienced? If so, to what extent (and why) do these effects vary across settings? With the increasing objective measurement of physical activity globally and the harmonisation of datasets into international databases, there will be more opportunities to address these questions across wide demographics.

Citation 2

The effect of exercise on non-exercise physical activity and sedentary behaviour in adults

Melanson EL. The effect of exercise on non-exercise physical activity and sedentary behaviour in adults. *Obes Rev.* 2017; 18(S1):40-49.

Abstract: It is widely assumed that structured exercise causes an additive increase in physical activity energy expenditure (PAEE) and total daily energy expenditure (TDEE). However, the common observation that exercise often leads to a less than expected decrease in body weight, without changes in energy intake, suggests that some compensatory behavioral adaptations occur. A small number of human studies have shown that adoption of structured exercise can lead to decreases in PAEE, which is often interpreted as a decrease in physical activity (PA) behavior. An even smaller

number of studies have objectively measured PA, and with inconsistent results. In animals, high levels of imposed PA induce compensatory changes in some components of TDEE. Recent human cohort studies also provide evidence that in those at the highest levels of PA, TDEE is similar when compared to less physically active groups. The objective of this review is to summarize the effects of structured exercise training on PA, sedentary behavior, PAEE and TDEE. Using models from ecological studies in animals and observational data in humans, an alternative model of TDEE in humans is proposed. This model may serve as a framework to investigate the complex and dynamic regulation of human energy budgets.

Commentary:

In addition to the impact of external factors, considerable evidence exists for some degree of biological control of physical activity. For example: the pattern of physical activity with age mirrors that of basal metabolic rate; is consistent across cultures and indeed other animals; boys are more active than girls, again across diverse cultures; and twin studies suggest an overall heritability estimate of around 50% for physical activity, analogous to the heritability estimates for resting metabolic rate (13, p63-65). Understanding the extent to which physical activity may be biologically regulated, and how flexible activity levels are to extrinsic factors, could be crucial in informing efforts to help people become more active. In this paper, Melanson explores whether imposed physical activity induces compensatory responses in non-exercise physical activity and sedentary behaviour in humans and animals. While the paper focuses on data from adult humans and animals, the proposed framework would be useful for exploring potential compensatory responses to imposed exercise, or lack of, in children.

When conducting an activity or exercise intervention, the assumption is that the additional activity will increase total physical activity and thus energy expenditure, but this is not always observed, suggesting that people may compensate in some way for the imposed activity by way of an

‘activitystat’ (4, 12; 13 p8) or ‘energystat’ (4). However, a systematic review investigating the activitystat hypothesis in studies in children and adults was inconclusive with approximately half of studies supporting compensation and half opposing (4). Melanson proposes an alternative model of total daily energy expenditure for exploring whether or when compensatory changes in activity and/or total daily energy expenditure occur following imposed activity/exercise. Instead of assuming that an activity intervention will have an additive effect on total daily energy expenditure, the alternative model is based on Pontzer’s (10) proposal of total daily energy expenditure as a constrained variable. As activity/exercise is added, total daily energy expenditure increases up to a point, a ‘ceiling’, and then plateaus. At this point further increases in physical activity will be compensated for by one or more of the ‘adaptable’ components of total daily energy expenditure: non-exercise physical activity, resting metabolic rate, thermic effect of food, other energy expenditure. It is important to note that, for children, the alternative model of total energy expenditure would also need to take into account the energy needed for growth.

In support of a constrained model of total daily energy expenditure, Melanson highlights evidence from adult studies indicating that increases in total daily energy expenditure are more likely to be attenuated at higher training volumes/intensities than at lower training volumes/intensity. If total daily energy expenditure is a constrained variable, this would mean that the closer someone is to their ‘ceiling’, the less likely it is that an intervention will impact on their overall total daily expenditure. It would seem logical to assume that any ‘ceiling’ would undergo the same age-related decline as activity (and basal metabolic rate). Correspondingly, as children are more active than adults, the ‘ceiling’ would presumably be higher. A priority for further research is empirically testing the constrained energy expenditure hypothesis (9). If empirical studies support the model, regarding the efficacy of attempts to increase activity level, a key question would be how to move someone closer to their ‘ceiling’. Other key questions would be (as proposed by Melanson): how fixed the ‘ceiling’ is; to what extent it differs between populations; whether it is amenable to change (e.g. following environmental interventions); and whether the nature of the imposed activity/exercise

affects this (e.g. intensity, dose, duration, timing). The models outlined in this paper provide a conceptual framework that will aid the investigation of whether (and/or when) imposed activity/exercise may lead to compensatory changes in children's total daily energy expenditure and, if so, what factors impact on this, e.g. are some patterns of accumulation of activity more likely to lead to compensation than others? Addressing these questions could inform the design of activity interventions that minimised any potential compensatory decreases in non-exercise physical activity (or other component of total daily energy expenditure).

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