

## Metabolism and Exercise During Youth – The Year that was 2017

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### Abstract

Two publications were selected because they are excellent representations of studies examining different ends of the exercise-sedentary behaviour continuum in young people. The first is an acute response study with 13 mixed-sex, mid to late adolescents presenting complete data from four different randomised experimental, cross-over conditions for analyses. Continuous glucose monitoring showed that interrupting prolonged continuous sitting with body-weight resistance exercises reduced the postprandial glucose concentration compared with a time matched uninterrupted period of sitting. Furthermore, the effects of the breaks in sitting time were independent of the energy content of the standardised meals, but variations in the area under the glucose time curves expression were important. The second study adopted a chronic 12-week exercise training intervention design with a large sample of obese children and adolescents who were allocated randomly to high-intensity interval training (HIIT), moderate-intensity continuous training (MICT) or nutritional advice groups. HIIT was the most efficacious for improving cardiorespiratory fitness compared with the other interventions; however, cardiometabolic biomarkers and visceral/subcutaneous adipose tissue did not change meaningfully in any group over the 12 weeks. Attrition rates from both HIIT and MICT groups reduce the validity of the exercise training comparison, yet this still provides a solid platform for future research comparisons using HIIT in young people.

### Citation

Fletcher EA, Salmon J, McNaughton SA, Orellana L, Wadley GD, Bruce C, Dempsey PC, Lacy KE, Dunstan DW. Effects of breaking up sitting on adolescents' postprandial glucose after consuming meals varying in energy: a cross-over randomised trial. *J Sci Med Sport*. 2017 Jun 9. pii: S1440-2440(17)30449-8. <http://dx.doi.org/10.1016/j.jsams.2017.06.002>

### Abstract

**Objectives:** To explore the impact of uninterrupted sitting versus sitting with resistance-type activity breaks on adolescents' postprandial glucose responses while consuming a diet varying in energy. Design: Cross-over randomised trial. **Methods:** Thirteen healthy participants (16.4 ± 1.3 years) completed a four-treatment cross-over trial: (1) uninterrupted sitting + high-energy diet; (2) sitting with breaks + high-energy diet; (3) uninterrupted sitting + standard-energy diet; and (4) sitting with breaks + standard-energy diet. For all four conditions, two identical meals were consumed; at 0 h and 3 h. A continuous glucose monitoring system (CGM) recorded interstitial glucose concentrations every five minutes. Linear mixed models examined differences in glucose positive incremental area under the curve (iAUC) and total AUC between the sitting and diet conditions for the first meal, second meal and entire trial period. **Results:** Compared to the uninterrupted sitting conditions, the breaks condition elicited a 36.0 mmol/L/h (95%CI 6.6–65.5) and 35.9 mmol/L/h (95%CI 6.6–65.5) lower iAUC response after the first and second meal, respectively, but not for the entire trial period or for total AUC. Compared to the standard-energy diet, the high-energy diet elicited a 55.0 mmol/L/h (95%CI 25.8–84.2) and 75.7 mmol/L/h (95%CI 8.6–142.7)

higher iAUC response after the first meal and entire trial, respectively. Similar responses to the high-energy diet were observed for total AUC. **Conclusions:** According to iAUC, interrupting sitting had a significant effect on lowering postprandial glucose for both dietary conditions, however, it was not significant when examining total AUC. Larger studies are needed to confirm these findings. Clinical Trial Registration ACTRN12615001145594.

## Commentary

Decades of research shows that moderate-to-vigorous physical activity (PA) is associated with favourable cardiometabolic health in children and adolescents (10,12). In this regard, the World Health Organization (18) and international guidelines (6,17) recommend that young people should spend a minimum of 60 minutes each day engaged in moderate-to-vigorous PA. At the other end of the energy expenditure continuum, sedentary behaviour can be defined as any waking behaviour with an energy expenditure  $\leq 1.5$  metabolic equivalents while in a sitting or reclining posture (15). In recent years, evidence has accumulated showing that sedentary behaviour (4) and infrequent breaks in sedentary time (14) are associated with poor cardiometabolic health in young people. However, a meta-analysis of more than one million adults reported that high levels of moderate intensity PA (about 60-75 minutes per day) eliminates the increased mortality risk associated with high sitting time (8). Furthermore, the cross-sectional (7) and prospective (16) association between sedentary time and poor cardiometabolic health may not be independent of moderate-to-vigorous PA in young people. So, is sedentary behaviour an important determinant of cardiometabolic health? Using an acute randomised cross-over trial, the paper highlighted in this commentary by Fletcher et al. (9) aimed to provide some evidence to help address this question in young people.

A growing body of evidence from small-scale, acute experimental trials shows that breaking up sedentary time and replacing it with light-intensity PA breaks induces favourable changes in postprandial cardiometabolic markers in physically inactive and type 2 diabetic adults, whereas a higher intensity or volume appears to be required in adults who are habitually physically active (3). Relatively little is known comparatively regarding the acute responses to PA breaks in young people. Specifically, Belcher et al. (2) reported that 3-minute light-intensity walking breaks every 30 minutes reduced postprandial glucose and insulin concentrations in children aged 7 to 11 years, whereas Saunders et al. (13) showed no effect of 2-minute light- or moderate-intensity walking breaks every 20 minutes on postprandial

glucose or insulin concentrations. The study by Fletcher et al. (9) critically examined here addressed a number of limitations of this past laboratory work. First, the acute response to PA breaks was assessed in the context of both a standard- and high-energy diet, whereas the possible interaction with diet has been neglected previously. This is particularly relevant in terms of practical application because combined dietary and PA programmes are commonly recommended for reducing future disease risk (1). Second, the use of continuous glucose monitoring enabled a detailed examination of glycaemia, which is not often used within paediatric research and should be commended. Third, the use of 2-minute resistance-type PA breaks every 18 minutes progresses previous research where walking was the PA mode. Specifically, the body-weight resistance exercises using large muscle groups (i.e., 30-s half squats, 30-s calf raises, 30-s knee lifts and 30-s step-ups) would be expected to promote increased energy expenditure and glucose uptake compared with PA utilising a smaller muscle mass, but could still be performed with minimal equipment.

From a small, mixed-sex sample of 13 healthy adolescents aged 14 to 17 years, Fletcher et al. (9) reported that the resistance PA breaks attenuated the glycaemic incremental area under the curve response for both the high- and standard-energy diets. This may challenge the logic that there would be greater 'room for improvement' and, thus, more pronounced effects when consuming a high-energy diet. However, the PA breaks did not significantly attenuate incremental area under the curve for the entire trial period, or the total area under the curve. Thus, the authors highlighted that the incremental area under the curve, where the data that drop below baseline are disregarded, was more sensitive for detecting between-condition effects. Moreover, focusing on segments of time immediately after individual meals might also be prudent when considering lowering postprandial glycaemia through PA. In addition, the comparison between the standard- and high-energy diets yielded some interesting findings. As expected, the high-energy diet elicited a higher glycaemic response after the first meal and entire trial when compared with the standard-energy diet. However, the glycaemic response to the second meal did not differ between the two diets. The authors proposed that this suggested an improvement in glucose tolerance for the meal consumed after breakfast. Hence, PA breaks may be best completed in the morning for the greatest benefits. It is also possible that consuming the high-energy meal at breakfast lowered the glycaemic response to the next high-energy meal. Indeed,

breakfast consumption reduces the glycaemic response to a standard lunch when compared with breakfast omission in adults, possibly due to enhanced muscle glycogen storage (5,11). Again, this raises important questions that require clarification in paediatric populations.

Moving forward, the reported findings provide a number of novel avenues to advance current understanding of the complex interplay between PA and diet in young people. Ultimately, a complete understanding of the intensity, duration and frequency of PA breaks that may improve cardiometabolic health would be a significant step in providing enhanced PA guidelines for children and adolescents. Indeed, the recommendation to minimise the amount of prolonged sedentary time in some guidelines is vague (6) and may depend on PA status (8). Unfortunately, the inclusion of both male and female adolescents that varied in pubertal stage in the Fletcher et al. (9) study highlighted here is likely to have exaggerated the variability in the glycaemic responses of the sample. Thus, accounting for biological maturation and sex will be important in future research. The measurement of a range of cardiometabolic markers, including, but not limited to glycaemia would also be prudent. In terms of the interaction with diet, an additional 'next step' for this research would be to ascertain the glycaemic responses to meals consumed at different times of the day and varying in composition in children and adolescents. This would help to inform combined PA and dietary approaches to prevent the development of chronic disease in young people.

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#### Citation

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biomarkers in children with obesity: a randomised controlled trial. *Sports Med.* 2017; Epub ahead of print. doi: [10.1007/s40279-017-0777-0](https://doi.org/10.1007/s40279-017-0777-0)

### Abstract

**Background:** Paediatric obesity significantly increases the risk of developing cardiometabolic diseases across the lifespan. Increasing cardiorespiratory fitness (CRF) could mitigate this risk. High-intensity interval training (HIIT) improves CRF in clinical adult populations, but the evidence in paediatric obesity is inconsistent. **Objectives:** The objectives of this study were to determine the efficacy of a 12-week, HIIT intervention for increasing CRF and reducing adiposity in children with obesity. **Methods:** Children with obesity ( $n = 99$ , 7-16 years old) were randomised into a 12-week intervention as follows: (1) HIIT [ $n = 33$ , 4 × 4-min bouts at 85-95% maximum heart rate ( $HR_{max}$ ), interspersed with 3 min of active recovery at 50-70%  $HR_{max}$ , 3 times/week] and nutrition advice; (2) moderate-intensity continuous training (MICT) [ $n = 32$ , 44 min at 60-70%  $HR_{max}$ , 3 times/week] and nutrition advice; and (3) nutrition advice only (nutrition) [ $n = 34$ ]. CRF was quantified through a maximal exercise test ( $\dot{V}O_{2peak}$ ) while adiposity was assessed using magnetic resonance imaging (MRI), dual-energy X-ray absorptiometry (DXA) and air-displacement plethysmography. **Results:** HIIT stimulated significant increases in relative  $\dot{V}O_{2peak}$  compared with MICT (+3.6 mL/kg/min, 95% CI 1.1-6.0,  $P = 0.004$ ) and the nutrition intervention (+5.4 mL/kg/min, 95% CI 2.9-7.9,  $P = 0.001$ ). However, the intervention had no significant effect on visceral and subcutaneous adipose tissue, whole body composition or cardiometabolic biomarkers ( $P > 0.05$ ). **Conclusion:** A 12-week, HIIT intervention was highly effective in increasing cardiorespiratory fitness when compared with MICT and nutrition interventions. While there were no concomitant reductions in adiposity or blood biomarkers, the cardiometabolic health benefit conferred through increased CRF should be noted. Clinical Trial Registration NCT01991106.

### Commentary

Over the last four decades, the prevalence of obesity in young people has reached alarming proportions and represents a significant global public health challenge in contemporary society (8). Preventing and reversing excess adipose tissue in young people is imperative considering pediatric obesity represents a precursor to deleterious health outcomes throughout the life-course (11). Lifestyle interventions manipulating exercise energy expenditure and dietary energy intake represent an integral component of obesity management in children and adolescents. Although a plethora of lifestyle-based strategies targeting obesity treatment in youth have been instigated with varying degrees of success (1,7), additional carefully designed experimental studies are required to identify efficacious exercise regimes for the management of paediatric obesity. The dual-centre randomised controlled trial by Dias and colleagues (5) involving a large sample of obese youth, two comparative exercise prescriptions and important methodological rigor provided a timely contribution to extend the evidence base. Although the advantages of adopting a multi-

centre approach are recognised, a notable challenge, and possible limitation, to highlight concerns the subtle variations in experimental protocols between the two study locations (Brisbane, Australia and Trondheim, Norway); however, these differences were controlled statistically in this clinical trial.

The rationale for the study focused on examining the efficacy of 12 weeks high-intensity interval training (HIIT) for increasing cardiorespiratory fitness and reducing adiposity in young people with obesity. A total of 99 obese youth aged 7 to 16 years (mean (SD) BMI z-score 2.14 (0.29); body fat percentage 44.1 (6.2)%) were randomly allocated to one of three groups: (1) HIIT with nutrition advice; (2) moderate-intensity continuous training (MICT) with nutrition advice; or (3) nutrition advice only (control). Baseline comparisons of study outcomes with an age-matched healthy weight control group revealed lower peak oxygen uptake (normalised to body mass and fat free mass), higher visceral adipose tissue and total body fat, and an adverse fasted cardiovascular risk factor profile (including lipids, glucose, C-reactive protein and estimated insulin resistance) in the obese participants. The HIIT stimulus consisted of 4 × 4 min bouts of walking, running or cycling at 85 to 95% maximum heart rate performed three times per week, which has been well-tolerated previously in obese adolescents (12). Several important features of the study design are worthy of note before appraising the main research findings; the inclusion of a work-matched MICT protocol (60 to 70% maximum heart rate) allowed a direct comparison to HIIT, at least two of the weekly exercise sessions were supervised, and the combination of exercise training with nutrition advice supports a more holistic approach to body size management. Another key strength of the study was the impressive array of physiological and behavioural outcomes assessed using rigorous and objective techniques, which will be highlighted further in the proceeding commentary. A further important aspect integrated into the study design was the absence of exercise in the 48 h before the pre- and post-intervention assessments. Whilst an essential control to isolate the chronic adaptation to the training stimulus, it is likely that this design feature precluded the identification of any transient health benefits in response to the last exercise training bout (2).

The primary finding was that HIIT provoked a greater increase in peak oxygen uptake (assessed using a maximal exercise test to exhaustion) compared with MICT (+3.6

mL/kg/min) and nutrition control (+5.4 mL/kg/min), which did not coincide with any meaningful changes in visceral and subcutaneous adipose tissue, whole body composition, or fasting cardiometabolic biomarkers. Scientific interest regarding the health benefits of HIIT has increased dramatically in recent years and the upsurge in popularity has principally centred on the asserted time efficiency and higher enjoyment associated with this exercise modality. The findings from the highlighted study contribute to the discussion surrounding the importance of exercise intensity for stimulating physiological adaptations to training, and suggests that HIIT may be a more potent stimulus than MICT for enhancing peak oxygen uptake in obese youth. The implications of this finding are clear considering cardiorespiratory fitness is a strong predictor of cardiometabolic health in young people (10). Although HIIT did not alter the elevated fasted cardiovascular risk factor profile, the authors highlight that the increase in peak oxygen uptake with HIIT may help to mitigate the adverse risk factor profile in the obese participants (5) and we speculate further that this could also help to facilitate future long-term engagement in exercise. In contrast, MICT only resulted in small, non-significant changes in peak oxygen uptake; however, this exercise protocol did elicit a small reduction in glycosylated haemoglobin compared with the nutrition control group, which may be indicative of enhanced blood glucose control. From a practical standpoint, this study contributes to providing obese young people with different exercise tools for health promotion that may have important long-term implications if the exercise stimulus can be applied repeatedly.

The assessment of visceral and subcutaneous adipose tissue using magnetic resonance imaging and total body fat using dual-energy x-ray absorptiometry and air-displacement plethysmography should be commended and represents an important advance from the crude adiposity parameters such as body mass index that have dominated the paediatric literature. Although no effect of the exercise training interventions on abdominal adiposity (or whole body composition) were noted, it is possible that a greater exercise volume or continued exposure to the exercise stimulus beyond the relatively short 12 week intervention may be required to provoke changes in body fat distribution. Considering young people with obesity exhibit a diminished growth hormone and catecholamine response to acute high-intensity exercise (6), the authors also speculated that lower adipose tissue lipolysis and free fatty acid release due to impaired hormone release may have



restricted any potential HIIT-induced reduction in visceral adipose tissue in the obese participants (5). Clearly, this avenue of enquiry requires future investigation considering the accumulation of fat in visceral and ectopic depots is more closely associated with obesity-related comorbidities in youth than global indicators of adiposity (3), and the importance of fitness versus fatness in the context of metabolic disease risk continues to generate scientific debate (9).

A universal concern of longitudinal studies is attrition. The highlighted study is no exception with reported attrition rates of 30% HIIT, 25% MICT and 21% nutrition control group, which rose to 48%, 25%, and 38%, respectively, when excluding participants who completed less than or equal to 80% of the interventions. That intervention fidelity was not examined in the paper is a shortcoming, which weakens the direct comparison of the interventions; for example, the average attendance rates for HIIT and MICT were 68% and 56% over the 12 weeks, respectively. This represents an inherent challenge for paediatric exercise scientists interested in fostering lifelong adherence to regular physical activity. Furthermore, the higher attrition rate in HIIT suggests that future work is required to elucidate HIIT protocols that optimise motivation and enjoyment in order to facilitate longer-term adherence to this exercise modality. A novel extension to the highlighted clinical trial involves the continuation of the HIIT and MICT arms consisting of three predominantly unsupervised training sessions per week for an additional 9 months (4). Although no change in accelerometer-measured physical activity was observed after the initial 12 week exercise interventions, the planned follow-up assessment at 12 months will provide valuable information regarding the extent young people with obesity can maintain their motivation to adhere to exercise training beyond 12 weeks. Such insight is essential to advance our understanding of the potential longevity of training-induced physiological and metabolic adaptations before these types of exercise training can be recommended as realistic treatment options for paediatric obesity.

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