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Energy replacement diminishes the effect of exercise on postprandial lipemia in boys

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ABSTRACT

Purpose. Acute bouts of exercise reduce postprandial triacylglycerol concentrations ([TAG]) in healthy boys and girls; however, it is not known whether this effect is mediated by the energy deficit. This study examined whether the exercise-induced reduction in postprandial [TAG] persists after immediate dietary replacement of the exercise energy expenditure (EE).

Methods. Eighteen healthy 11- to 13-year-old boys (mean (SD): body mass 41.3 (8.4) kg; peak oxygen uptake ($\dot{V}O_2$) 55 (5) $mL \cdot kg^{-1} \cdot min^{-1}$) completed three, 2-day conditions in a within-measures, crossover design separated by 14 days. On day 1, participants rested (CON), exercised at 60% peak $\dot{V}O_2$ inducing a net EE of 32 $kJ \cdot kg^{-1}$ body mass (EX-DEF) or completed the same exercise with the net EE replaced immediately (EX-REP). On day 2, capillary blood samples were taken in the fasted state and at pre-determined intervals throughout the 6.5 h postprandial period. A standardised breakfast and lunch meal were consumed immediately and 4 h, respectively, after the fasting sample.

Results. Based on ratios of the geometric means (95% confidence intervals (CI) for ratios), EX-DEF fasting [TAG] was 19% and 15% lower than CON (−32 to −4%, ES = 1.15, P = 0.02) and EX-REP (−29 to 0%, ES = 0.91, P = 0.05) respectively; CON and EX-REP were similar (−4%; P = 0.59). The EX-DEF total area under the [TAG] versus time curve was 15% and 16% lower than CON (−27 to 0%, ES = 0.55, P = 0.05) and EX-REP (−29 to −2%, ES = 0.62, P = 0.03) respectively; CON and EX-REP were not different (2%; −13 to 20%, P = 0.80).

Conclusion. Immediate replacement of the exercise-induced energy deficit negates the reduction in postprandial [TAG] in boys; this highlights the importance of maintaining a negative energy balance immediately post-exercise to maximise the metabolic health benefits of exercise.

Abbreviations: CI, Confidence interval; CON, Control condition; CPM, Counts per minute; EE, Energy expenditure; ES, Effect size; EXDEF, Exercise with energy deficit condition; EX-REP, Exercise with energy replacement condition; iAUC, Incremental area under the concentration versus time curve; RPE, Rating of perceived exertion; TAG, Triacylglycerol; TAUC, Total area under variable versus time curve; $\dot{V}O_2$, Oxygen uptake.

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1. Introduction

Elevated postprandial triacylglycerol concentrations ([TAG]) are predisposed to the development and progression of atherosclerosis [1], and independently predict future cardiovascular disease risk in adults [2]. Although the clinical manifestations of atherosclerotic disease emerge in adulthood typically, the paediatric origins of atherosclerosis are well established [3]. Furthermore, childhood fasting [TAG] predicts young adult cardiovascular disease risk [4]. Most people spend the majority of waking hours in a postprandial state, resulting in extended periods of elevated postprandial [TAG]. Considering cardiovascular disease remains the leading cause of mortality in the United Kingdom [5], prevention by targeting modifiable risk factors is a high priority on the public health agenda. Therefore, lifestyle modifications that reduce postprandial [TAG] from a young age may delay precursors of atherosclerotic disease leading to important long-term metabolic health benefits [3].

Previous research highlights the potency of acute moderate- to vigorous-intensity exercise interventions completed up to 18 h before a standardised meal to reduce postprandial [TAG] in adults [6] and young people [7]. Furthermore, acute exercise has been shown to increase resting fat oxidation in the postprandial period in adults [8,9]. Considering energy status can have profound effects on metabolism [10], the acute exercise-evoked changes in postprandial TAG metabolism may be mediated by the associated energy deficit. In this regard, an exercise-induced energy deficit appears more potent than an isoenergetic diet-induced deficit in reducing postprandial [TAG] in girls [11] and women [12,13]. Moreover, replacement of the exercise-induced energy deficit in adults diminishes or even eliminates the reduction in postprandial [TAG] [8,14–16], and concomitant increase in resting whole-body fat oxidation [8,16]. However, the effect of replacing the exercise-induced energy deficit on postprandial [TAG] and resting whole-body fat oxidation has not been investigated in young people. Metabolic and hormonal responses to exercise differ considerably between men and boys [17,18], and hormonal changes occurring during pubertal development may influence [TAG] [19]. Consequently, it is important to address whether the acute exercise-induced reduction in postprandial [TAG] and increase in resting whole-body fat oxidation persist after replacing the exercise energy expenditure (EE) in boys.

Therefore, the aim of the present study was to examine the effect of acute moderate-intensity exercise, with and without immediate dietary replacement of the exercise-induced energy deficit, on postprandial [TAG] and resting whole-body fat oxidation in healthy, recreationally active boys.

2. Methods

2.1. Participants

Eighteen boys aged 11.4 to 13.2 years volunteered to participate in this study. The study was approved by the University Ethical Advisory Committee. Written assent was obtained from each participant and written informed consent by a parent or guardian. Participants completed a health screen questionnaire which confirmed they were all in good general health, had no history of medical conditions that may compromise participation in the study and were not taking any medications or dietary supplements known to influence lipid or carbohydrate metabolism. Physical and physiological characteristics of participants are presented in Table 1.

2.2. Anthropometry and Physical Maturation

Stature was measured to the nearest 0.01 m using a fixed stadiometer (Holtain, Crosswell, UK), and body mass was quantified to the nearest 0.1 kg using a digital scale (Seca 770, Seca, Hamburg, Germany). Body mass index was calculated as body mass (kg) divided by stature (m) squared. Skinfold thickness was measured at two sites (triceps and subscapular) to the nearest 0.2 mm on the right-hand side of the body using Harpenden callipers (Baty International, West Sussex, UK). The median of three measurements at each site was used to estimate percent body fat [20].

Participants undertook a self-assessment of their level of physical maturity using drawings depicting the five stages of genital and pubic hair development [21]. The median (interquartile range) stage of genital development was 3 (1) (stage 1: $n = 3$; stage 2: $n = 5$; stage 3: $n = 10$) and pubic hair development was 2 (1) (stage 1: $n = 2$; stage 2: $n = 11$; stage 3: $n = 5$).

2.3. Preliminary Exercise Measurements

During the first visit to the laboratory, participants were familiarised with walking and running on the treadmill (h/p/cosmos mercury med, Nussdorf-Traunstein, Germany) before completing two preliminary exercise tests. First, a submaximal incremental treadmill protocol was completed to establish the individual steady-state relationship between treadmill speed, oxygen uptake ($\dot{V}O_2$) and heart rate. Participants completed 4 × 4 min stages at a starting speed of 5 km·h^{-1} and increasing 1 km·h^{-1} at the start of each subsequent stage, with the gradient set at 1% throughout. Heart rate was monitored continuously via short-range telemetry (Polar PE 4000, Kempele, Finland) and ratings of perceived exertion (RPE) were recorded in the last 10 s of each minute. Expired air samples were collected during the final minute of each 4 min stage into 100 L Douglas bags (Cranlea

Table 1 – Physical and physiological characteristics.

Age (years)	12.3 (0.5)
Body mass (kg)	41.3 (8.4)
Stature (m)	1.50 (0.07)
Body mass index (kg·m^{-2})	18.1 (2.4)
Percent body fat (%)	16.3 (5.5)
Lean body mass (kg)	34.1 (4.7)
Genital development *	3 (1)
Pubic hair development *	2 (1)
Peak oxygen uptake (mL·kg^{-1}·min^{-1})	55 (5)

Values are mean (SD) for $n = 18$.
* Self-assessment — median (interquartile range).