BACKGROUND

Exercising is a common strategy used by individuals to get health benefits and to control weight. However, compensatory adaptations in components of energy balance (i.e., energy intake and energy expenditure) are generally observed with exercise (1-3). The degree to which individuals compensate by increasing their food intake and/or decreasing their physical activity level subsequent to the exercise intervention is variable between individuals and may depend on many factors (4, 5). External stimuli such as screen time or music have been reported to increase food intake compared to a control condition with no distraction (6-8). However, previous studies have not looked at the influence of these stimuli on energy balance while exercising, thereby limiting inferences on whether exercising with or without a screen/music leads to different post-exercise energy compensation that may ultimately impact body weight control.

Electronic screen devices and/or music while exercising can serve as motivating factors, making it more pleasant and even easier for some people to exercise (9, 10). This finding may have positive implications for fitness professionals encouraging new exercisers and it is certainly something to keep in mind when one prescribes exercise. However, whether watching a screen or listening to music while exercising impacts components of energy balance is unknown. Gaining information on this issue will help to determine if people should care about the use of personal music players and/or screen devices while exercising with regard to body weight control.

OBJECTIVE AND HYPOTHESIS

The objective of this study will be to examine the effects of watching a screen or listening to music while exercising on acute energy intake and expenditure. We hypothesize that the post-exercise energy compensation will be greater in both conditions with stimuli (i.e., screen and music) compared with the control condition (i.e., exercise alone).

STUDY DESIGN AND RESEARCH METHODS

Study Design

Randomized, 3-condition crossover study (within-subjects experimental design).

Participants

The present study will recruit 25 male adolescents between the ages of 13 and 17 years. Participants will be recruited via advertisements in the community (e.g., grocery stores, fitness centers, restaurants), at CHEO, and through word of mouth. Volunteers will be excluded for any of the following reasons: smoking, unstable body weight (±4 kg) during the 3 months preceding testing, excessive alcohol intake (>15 drinks/week), celiac disease, metabolic disease (e.g., thyroid disease, heart disease, diabetes), medication use that could interfere with the outcome variables, highly restrained eating behavior (score of ≥12 for cognitive dietary restraint on the Three-Factor Eating Questionnaire), irregular sleeping pattern (e.g., shift work or working overnight shifts), and inability to comply with the protocol. Following a phone call with the potential participant to confirm eligibility and explain the study, consent forms will be mailed and

will need to be returned to us in the pre-paid envelope provided before any testing can begin. Participants who are capable of consenting will be asked to do so on their own behalf; otherwise, written informed parental consent and child assent will be obtained. Ethical approval will be obtained from the Children's Hospital of Eastern Ontario Research Ethics Boards. Participants will receive $30 per condition for their participation in the study ($120 total).

Overview of the Study Protocol

Preliminary Visit

The participants will attend one baseline session and three experimental sessions, each separated by at least one week. All sessions will begin at 07:30, and the participants will be instructed to fast and abstain from structured exercise for 12 hours before each visit. The preliminary visit will include measurements related to anthropometry (body weight, height, waist circumference), resting metabolic rate and cardiorespiratory fitness (VO_2 peak). Participants will also complete questionnaires in order to better characterize them. During this initial visit, participants will be asked to identify any food allergies or intolerances that might impact the standardized breakfast and buffet meals provided during the experimental sessions.

Experimental Sessions

Each participant will be engaged in each of the following three 30-min experimental conditions followed by an *ad libitum* lunch: ***(1) walking/jogging on a treadmill at 60% of VO_2 peak while watching a screen (exercise + screen); (2) walking/jogging on a treadmill at 60% of VO_2 peak while listening to music (exercise + music); and (3) walking/jogging on a treadmill at 60% of VO_2 peak with no other stimulus (control condition).*** These 3 conditions will be randomly assigned by using a computerized randomization scheme. Participants will be free to watch whatever they want on the screen and listen the music of their choice using a personal music player.

One at a time, on 3 separate occasions, the participant arrives at the laboratory (Children's Hospital of Eastern Ontario Research Institute, Ottawa) at 07:30 after fasting for 12 hours. An accelerometer will be attached immediately on arrival and will be worn until bedtime. Visual analogue scales (VAS) will be used to record subjective measures of appetite at 07:45 (and at other time points during the day), and the participant will be provided a standardized breakfast at 08:00. The participant will then refrain from eating until the *ad libitum* lunch. The 30-min experimental intervention consists of 1 of the 3 conditions, starting at 10:30. Participants will be asked to relax on a comfortable chair between the end of the breakfast and the beginning of the testing condition. After the experimental condition, an *ad libitum* test lunch will be given to the participant to evaluate spontaneous food intake. A dietary record will be used to assess food intake for the remainder of the day. A schematic overview of the study protocol is presented in the Appendix.

Measurements

Anthropometric Measurements

Body weight will be measured without shoes in light clothing, after voiding, to the nearest 0.1 kg on a calibrated electronic scale. Height will be measured to the nearest 0.1 cm with the participant standing against a wall-mounted stadiometer, feet together, without shoes and with the head in the Frankfort plane, after a deep inspiration. Body mass index (BMI) will be determined and interpreted with the WHO BMI-for-age growth charts (11). Waist circumference will be measured to the nearest 0.1 cm using a non-extendable linen tape and measured midway between the lower border of the last rib and the upper border of the iliac crest at the end of a normal expiration.

Breakfast

A standardized breakfast will be given to the participants at 08:00, consisting of 2 pieces of whole-wheat bread (78 g, 837 kJ; D'Italiano), peanut butter (18 g, 452 kJ; Kraft Smooth Peanut Butter), raspberry jam (16 mL, 218 kJ; Kraft Pure Raspberry), cheddar cheese (21 g, 335 kJ; Kraft Cracker Barrel Marble), and orange juice (200 mL, 418 kJ; Minute Maid 100% Orange Juice). Participants will eat alone in a room with no distractions, and will need to consume the entire breakfast within 15 min. Participants with food intolerances will have individual food items replaced; however, they will receive an identical breakfast at each of the three visits.

Ad libitum lunch

Spontaneous food intake, including liquids, will be assessed by using an *ad libitum* food menu immediately after each experimental condition, which will allow us to assess both total energy intake and macronutrient preference (12). The food menu contains a variety of meal-type foods (both hot and cold), beverages, and snacks differing in macronutrient composition (74 items in total). The foods will be offered in large amounts, and the participants will be instructed to eat *ad libitum*, alone, in a room without distractions, with no restrictions on the amount to be consumed. The participants will be given 30 min for this meal, and all foods will be measured to the nearest 0.1 g before and after ingestion. *Ad libitum* energy intake will be measured by a food technician using calculations performed on the amount of the meal consumed. This type of food menu, which has a high appreciation of food items on the menu, has been shown to produce a reliable measure of energy intake inside the laboratory in both adults and adolescents (12, 13).

Appetite Sensations

For each condition, the participants will be instructed to complete 9 VAS for their sensations of hunger, satiety, prospective food consumption, fullness, and desire to eat something sweet, salty, or rich in fat. They will also rate their opinion on the general appreciation of the meal and on the overall satisfaction/enjoyment of the experimental conditions, from "extremely boring" to "extremely pleasant". The VAS is a line (100 mm in length) with statements anchored at each end expressing the most positive and most negative rating of the participants' appetite sensations. The VAS have been shown to be both reproducible and valid for measurement of appetite sensations in a laboratory setting (14). The VAS will be completed during each experimental condition: at fasting (07:45), before the experimental condition (10:25), immediately after the experimental condition (11:05), and immediately after the *ad libitum* lunch.

Dietary Record

All participants will be instructed to complete a dietary record (15), with help from the parents, after each experimental condition to evaluate the degree of potential compensation in food intake for the remainder of the day. Participants will be instructed on how to complete the dietary record and on how to measure quantities of ingested foods. The food records will be reviewed with each participant upon their return to improve the validity of the information provided. Mean energy and macronutrient intakes will be calculated by using the Food Processor SQL software (version 9.6.2; ESHA Research).

Resting Metabolic Rate and Cardiorespiratory Fitness Measurements

Resting metabolic rate (RMR) will be measured during the preliminary visit by indirect calorimetry (Vmax 229 series metabolic cart; SensorMedics). RMR will be measured for 30 min after a 30-min rest period and a 12-h overnight fast. The first and last 5 min will be excluded from the calculations; thus, minutes 6-25 will be used in the calculation. Mean RMR will be calculated by using the Weir equation (16). VO_2 peak will be measured using the same metabolic cart and using the Dubowy graded treadmill protocol (17). Exercise sessions on the treadmill will be set at 60% of VO_2 peak (moderate-intensity physical activity).

Perceived Exertion

Ratings of perceived exertion (RPE) will be used to quantify participants' perceived exertion during the experimental conditions by using the OMNI scale of perceived exertion. The scale ranges from 0 (extremely easy) to 10 (extremely hard) and has been previously validated in the pediatric population (18). Participants may find the exercise session easier to perform with the use of a stimulus (e.g., music or TV program). It is also possible that the RPE may influence post-exercise energy compensation. Participants will rate their RPE at every 5 min during the conditions and the area under the curve (AUC) will be calculated using the trapezoid method.

Physical Activity Energy Expenditure Compensation

Changes in physical activity after each condition will be assessed by using an Actical accelerometer (Philips Respironics). The accelerometer, on an elastic belt, will be positioned on the right iliac crest in midaxillary position immediately on arrival at the laboratory (07:30) and worn until bedtime. The Actical measures and records time-stamped acceleration in all directions (omni-directional), and the digitized values are summed over a user-specified interval of 1 minute. The Actical has been validated to measure physical activity in children and adolescents (19) and has better instrument reliability than other accelerometer models (20). Accelerometry data will undergo standardized quality control and data reduction procedures, as previously reported (21). Physical activity energy expenditure (PAEE) will be determined from the Actical by using validated equations (19).

Questionnaires

To better characterize the adolescents, some questionnaires will be administered during the preliminary visit. The 51-item Three-Factor Eating Questionnaire (22) will be used to

verify that the participants are not restrained eaters (those with a score ≥12 for cognitive dietary restraint will not be eligible). The purpose of this questionnaire is to assess 3 factors related to cognition and eating behaviours: cognitive dietary restraint (intent to control food intake), disinhibition (overconsumption of food in response to cognitive or emotional cues), and susceptibility to hunger (food intake in response to feelings and perceptions of hunger). This questionnaire has been validated, and its 3 scales have been reported to show good test–retest reliability (23). In addition, participants will complete the Pittsburgh Sleep Quality Index (24), a self-rated questionnaire that assesses sleep quality and disturbances over the preceding month. Sleep hygiene will be assessed in this study because sleep has been shown to influence appetite sensations (25). A total score >5 is associated with poor sleep. The physical activity pattern of participants will be assessed by using the Physical Activity Questionnaire for Adolescents, a self-report measure of physical activity that has been validated in white Canadian samples (26). A score of 1 and a score of 5 indicate low and high physical activity participation, respectively. Finally, the pubertal status of adolescents will be evaluated with a self-assessment questionnaire that aims to measure pubertal status by using gender-specific line drawings of the Tanner puberty stages (27).

POTENTIAL RISKS

The procedures of the proposed study have been chosen to minimize the burden and risk posed to the personal safety of study participants. Participants with food allergies will be excluded from the study because many food items we serve have been associated with allergic reactions (e.g. peanuts, wheat, etc.). The foods are prepared by our research coordinators in our experimental kitchen and we adhere to the Canadian food safety guidelines for families. The aerobic fitness test will be performed under the supervision of a certified exercise physiologist, with CPR and first aid certifications, and who is specifically trained to screen-out participants prior to the test, terminate the test in the face of specific contraindications, and manage any adverse events should they occur. A proper warm-up and cool-down will also be conducted to prevent injuries. In the unlikely event that participants experience an injury, medical or other crisis (e.g. chest pain, heart attack, psychotic episode, panic attack, etc) during the fitness test, a safety protocol is in place in the HALO laboratory and the hospital emergency response team will be contacted immediately. Staff will immediately accompany unstable participants to the emergency room at CHEO, and stay with them until they are assessed. Parents will be contacted and informed of this emergency for participants. Finally, if participants feel uncomfortable with some of the questions being asked in the questionnaires, they may choose not to answer a question.

CONFIDENTIALITY AND PRIVACY

Personal information will be kept strictly confidential except as required or permitted by law. The data produced from this study will be stored in a locked filing cabinet. Only members of the research team will have access to the data. Following completion of the research study the data will be kept for 7 years after the last publication of this study. They will then be destroyed. Participants will not be identified in any publication or presentation of this study.

STATISTICAL CONSIDERATIONS

Outcome Measures

The primary outcome measure will be post-exercise energy compensation. The food intake outcome will be assessed by using an *ad libitum* test meal immediately after the conditions and a dietary record for the remainder of the day. The energy expenditure outcome will be assessed by using an Actical accelerometer until bedtime. Total energy expenditure (TEE) will be calculated by using the following formula: TEE = (PAEE from the Actical + RMR) x 1.11 (28) where the thermic effect of food is fixed at 10% of TEE. The secondary outcome measures will include appetite sensations (VAS) and the RPE (OMNI scale).

Sample Size Calculation

It is estimated that a sample size of 25 participants will provide 90% power at 5% level of significance (two-sided) to detect a minimal group difference of 100 kcal in energy intake and expenditure, assuming a standard deviation of 200 kcal. This is based on previous studies by our group, using a similar crossover design, that compared active video game play with passive video game play in adolescents (29, 30). We used a conservative SD estimate because large variability is generally observed for energy intake (especially with the use of dietary records) and to increase the likelihood of detecting a significant difference between conditions.

Statistical Analysis

Before statistical analysis, all data will be tested for normality by using the Shapiro-Wilk W test and variance homogeneity and will be log-transformed if necessary. Repeated measures analysis using the mixed model will be used to assess the effect of the 3 interventions on outcome measures, with effects for age, condition, pubertal status and BMI. The models will be adjusted for covariates if they are found to significantly interact with the outcome variables. To account for the fact that repeated measures are taken across conditions, the models will include a participant-specific random effect. Effect sizes will be examined by using the Cohen's *d* method, reflecting the magnitude of the difference between groups in SD units. Cohen's *d* is computed by subtracting the average score of the control group from the average score of the intervention group and then dividing the difference by the pooled SD. Effect sizes are considered negligible if <0.2, small if between 0.2 and 0.5, moderate if between 0.5 and 0.8, and important if >0.8. Correlations will be used to examine if the RPE are associated with post-exercise energy compensation. Differences will be considered significant at $P<0.05$ and data will be presented as mean values and SDs. All statistical analyses will be performed by using SPSS Statistics 23.0 (SPSS Inc, Chicago, IL, USA).

FACILITIES AND EQUIPMENT

The present project will be carried out in our facilities at the Children's Hospital of Eastern Ontario Research Institute in Ottawa. As a national centre of excellence for research, leadership, training and advocacy, our research group strives to provide international leadership and research excellence as it relates to healthy active living and obesity in children and youth (www.haloresearch.ca). All of the proposed methods are routinely performed in our laboratories and the research staff is highly qualified for the

purpose of the study. The personnel needed for this study and the infrastructure and equipment required to conduct the research is available and accessible. The main investigators involved in the proposed research project are also very experienced in designing and conducting studies in this field of research.

KNOWLEDGE TRANSLATION APPROACH

The dissemination of study findings will occur after results are obtained. We intend to publish the findings in a good peer-reviewed journal (e.g., American Journal of Clinical Nutrition or Medicine & Science in Sports & Exercise). Other methods that will be used for disseminating and communicating findings include scientific meetings, blogs, and local and national media. It is worth noting that our Research Institute has a communication department who will assist with knowledge translation activities. The target audience includes the scientific community, health professionals and the general population (including teenagers and their parents).

BUDGET

Breakfast: $6/meal x 25 participants x 4 sessions = $600
Ad libitum lunch: $25/meal x 25 participants x 3 sessions = $1875
Indirect calorimetry: in-kind
Cardiorespiratory fitness: in-kind
Actical accelerometers: in-kind
Parking fees: $14/visit x 25 participants x 4 visits = $1,400
Participant compensation: $30/visit x 25 participants x 4 visits = $3,000

Total = $6,875

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Appendix. Overview of the study protocol. Black dots = visual analogue scales; gray rectangle = dietary record and accelerometry.