The effects of a single bout of aerobic or resistance exercise on food reward

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Abstract:

It is unknown whether an acute bout of calorie-matched aerobic and resistance exercise alters food reward in a similar manner. Thus, we examined the effects of isocaloric resistance and aerobic exercise sessions on acute food reward. Sixteen men and women (age: 21.9 ± 2.6 years; BMI: 22.8 ± 1.8 kg/m^2) participated in three randomized crossover sessions: aerobic exercise, resistance exercise, and sedentary control. The target exercise energy expenditure was matched at 4 kcal/kg of body weight, and performed at 70% of VO_{2peak} or 12 repetition-maximum (equivalent to 70% of 1 repetition-maximum). A validated computer task assessed the wanting and liking for visual food cues following exercise, and following an *ad libitum* lunch. Decreases in the relative preference for high *vs.* low fat foods were noted following exercise compared to the control session, and this was independent of modality (aerobic: $P = 0.04$; resistance: $P = 0.03$). Furthermore, the explicit liking for high *vs.* low fat foods was lower following resistance exercise compared to the control session ($P = 0.04$). However, these changes in food reward were not correlated with changes in energy intake (EI) between sessions. Exercise, independent of modality, led to decreases in the relative preference for high fat relative to low fat foods. Additionally, decreases in the hedonic "liking" of high fat foods following resistance, but not aerobic, exercise may imply that modality does influence acute food hedonic responses. However, these decreases in food hedonics were not related to lower EI, thus suggesting that a dissociation may exist between food hedonics and actual EI.

Keywords: Resistance exercise | Aerobic exercise | Food reward

Article:

Introduction

Food "liking" (*i.e.* the acute hedonic or aversive reaction to a food item) and food "wanting" (*i.e.* the objective, and sometimes implicit, drive to seek and consume a targeted food item) have been previously identified as major forces in directing human eating behaviour (Berridge, 1996). With the use of functional MRI analyses, an acute bout of aerobic exercise has been shown to decrease neuronal activation in brain regions associated with hedonic "liking" (*i.e.* insula, orbitofrontal cortex) and motivational "wanting" (*i.e.* putamen) in response to visual food cues, compared to a sedentary control session (Evero, Hackett, Clark, Phelan, & Hagobian, 2012). Furthermore, Finlayson, Bryant, Blundell, and King (2009) observed greater relative preferences for high-fat sweet foods and a greater implicit wanting for high-fat foods in compensators (*i.e.* individuals with a greater energy intake (EI) compared to exercise energy expenditure (ExEE)) *vs.* non-compensators (*i.e.* individuals with a similar or lower EI compared to ExEE), after 50 minutes of stationary biking *vs.* 50 minutes of sedentary control. However, this does not seem to be explained by differences in fitness and/or fat mass, as a recent study observed no significant differences in the degree of compensation, or the prevalence of "compensators and non-compensators" in participants divided according to fitness and fat mass (Charlot & Chapelot, 2013). Lastly, a study by Farah, Brunstrom, and Gill (2012) observed no significant differences in food "liking" ratings and food utility responses (*i.e.* how much participants were willing to pay for certain food items) following 60 minutes of aerobic exercise compared to 60 minutes of restful sitting, despite noting smaller portion selections of high fat and/or savoury foods (*e.g.* pasta, crackers, KitKat® chocolate bar, cheese baguette) post-exercise. Collectively, the limited data on the acute effects of exercise on food "wanting" and "liking" are relatively equivocal, as food reward does not always seem to be altered by exercise, and may be potentially influenced by certain inter-individual characteristics (*e.g.* degree of post-exercise compensation).

Resistance training may have beneficial effects on weight maintenance, or may even improve body composition by increasing fat-free mass (Donnelly et al., 2004). Studies by Laan, Leidy, Lim, and Campbell (2010) and Balaguera-Cortes, Wallman, Fairchild, and Guelfi (2011) assessed the effects of acute bouts of aerobic and resistance exercises performed at 70% of maximal capacity for 35 and 45 minutes, respectively, on subsequent EI within the same study design and observed no significant differences in post-exercise EI between sessions. Similarly, Cadieux, McNeil, Lapierre, Riou, and Doucet (2014) recently reported no significant differences in EI between calorie-matched aerobic and resistance exercise in the same cohort of participants as the present study. Further analyses are needed to assess whether food reward may be altered by calorie-matched aerobic and resistance exercises, and whether this factor may be associated with EI under these conditions.

The objective of the current study was to examine the acute effects of an isocaloric resistance- and aerobic-based exercise session on the wanting and liking for foods varying in fat content and taste, and whether it may be associated with subsequent energy and macronutrient intakes during an *ad libitum* lunch. Based on current literature and the lack of difference in EI previously noted by Cadieux et al. (2014) in this cohort of participants, we hypothesized that no differences in food "wanting" and "liking" will be observed between exercise conditions.

Material and methods

Participants

Sixteen participants were recruited for the study (eight men and eight women; age: 21.9 ± 2.6 years; BMI: 22.8 ± 1.8 kg/m^2; body fat percentage: 20.6 ± 7.9%; VO_{2peak}: 53.0 ± 8.6 ml/kg/min). Study methodologies are described in more details elsewhere (Cadieux et al., 2014). Briefly, participants were between the ages of 18 and 45 years, non-smokers, weight stable (±4 kg) within the last 6 months, did not have heart problems or diabetes, and reported participating in less than 150 minutes of physical activity per week, which is below the Canadian Society of Exercise Physiology (CSEP) recommended exercise guidelines for adults. Participants received $25 at the end of each session (including preliminary and experimental sessions), for a total of $100 at the end of the study. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and the University of Ottawa ethics committee (File number: H 09-11-05) approved all procedures involving human participants. Written informed consent was obtained from all participants. The main objective of this study, which was to assess the effects of exercise modality on EI and energy expenditure following the exercise intervention, was mentioned in the consent form.

Design and procedure

During the preliminary session, anthropometric data were collected, and participants took part in a progressive exercise stress test to determine 70% of maximal VO_{2peak} and a 12-repetition maximum strength test (12-RM), which is equivalent to 70% of 1 repetition maximum (1-RM) (Balaguera-Cortes et al., 2011), for 12 different resistance exercises. Participants were asked to refrain from the practice of any vigorous exercise and alcohol consumption for at least 24 hours, and were also asked not to consume any food or coffee for at least 2 hours before these tests. Following this session, three randomized crossover sessions were performed: aerobic exercise, resistance exercise, and sedentary control. Six, six and four participants started with the sedentary control, aerobic exercise and resistance exercise sessions, respectively. The target ExEE was matched at 4 kcal/kg of body weight. Based on pilot data collection and ExEE estimations, this target ExEE was deemed sufficient to induce marked increases in perceived exertion during both exercise sessions, without having them being too long and cumbersome, and this especially for the resistance exercise session which would most likely be more than double the duration of the aerobic exercise session. A washout period of at least 7 days separated each session for men and at least 1 month for women because they were always tested between days 1 and 8 of the menstrual cycle. For each session, participants arrived at the laboratory at 8:00 AM following a 12-hour overnight fast. They were instructed not to consume alcohol or engage in structured physical activity (*e.g.* playing sports or training) for at least 24 hours prior to the start of each session, and during the data collection period. We did not control food or caffeine intake during the day prior to the exercise intervention, other than providing instructions not to consume caffeine during the data collection period. Figure 1 outlines the duration and start times for each measurement performed during the three experimental sessions. During the resistance exercise trial, participants completed the same 12 exercises as performed during the preliminary session at an intensity of 12-RM, which is equivalent to 70% of 1-RM (Balaguera-Cortes et al., 2011). The exercise “supersets” (*i.e.* similar to a circuit training, where a break is given after completing two different exercises at one set of 10 repetitions a piece) performed during this session included: incline bench and lateral pull down, leg press and leg curl, chest press and seated row, leg extension and calf raises, lateral raises and pectoral fly, and finally overhead press and calf press. Each “superset” was separated by a 120-s break, and was repeated four times.

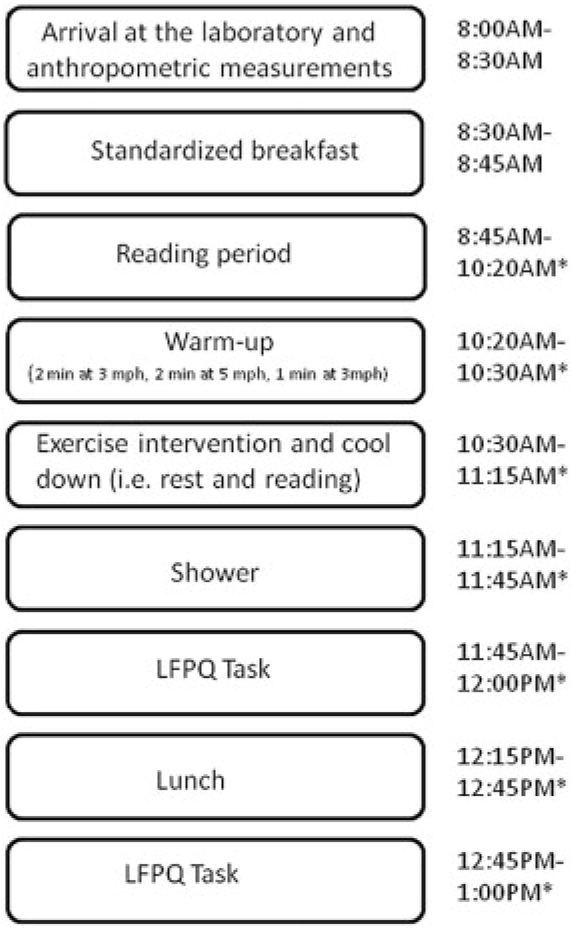

Fig. 1. Experimental protocol for each of the three experimental sessions. *During the resistance exercise session, the intervention started 30 minutes earlier (reading period: 8:45 AM–9:50 AM; warm-up: 9:50 AM–10:00 AM; exercise intervention and cool-down: 10:00 AM–12:00 PM). Since the duration of this session was longer (aerobic: 24.0 ± 4.3, resistance: 85.5 ± 13.7 minutes), the timing of the shower, LFPQ task and lunch were also delayed during this session (shower: 12:00 PM–12:30 PM; LFPQ task: 12:30 PM–12:45 PM; Lunch: 12:45 PM–1:15 PM; LFPQ task: 1:15 PM–1:30 PM). *Note:* LFPQ, Leeds Food Preference Questionnaire.

Supersets, rather than traditional resistance training (*i.e.* a break is given between different sets of the same exercise), were chosen because of the increased ExEE per unit of time associated with these types of exercises (Kelleher, Hackney, Fairchild, Keslacy, & Ploutz-Snyder, 2010). These supersets were repeated until target ExEE was reached. During the aerobic exercise trial, participants ran on a treadmill at an intensity of 70% of their VO_{2peak} until target ExEE was reached. During the control session, participants remained seated and were only allowed to do recreational reading.

Anthropometric measurements

Participants were weighed to the nearest 0.1 kg with a BWB-800AS digital scale upon arrival. Standing height was measured to the nearest centimeter using a wall stadiometer, Tanita HR-100 height rod, without shoes (Tanita Corporation of America, Inc.). Body composition was assessed with DXA (Lunar Prodigy, General Electric, Madison, WI, USA) at baseline only.

Maximal aerobic capacity measurement

The progressive exercise stress test to exhaustion was performed on a treadmill to assess each participant's peak maximal oxygen consumption (VO_{2peak}). The CSEP guidelines were followed (The Canadian Society for Exercise Physiology, 1996), for which each stage of the test lasted 2 minutes, and was maintained at a constant speed with an increasing grade to the point of exhaustion. Heart rate and perceived exertion measured with the Borg scale (Borg, 1982) were assessed at rest and at the end of each stage. Breath-by-breath samples of expired air were collected with a mouthpiece, and measurements of VO_2 and respiratory exchange ratio were automatically determined with a Vmax 229 series metabolic cart (SensorMedics Corporation, Yorba Linda, CA, USA). The VO_{2peak} was considered as the highest VO_2 value during the test.

12-repetition maximum strength test

A 12-RM strength test for 12 different exercises was also completed. This test was based on the procedures employed in a study by Balaguera-Cortes et al. (2011). Briefly, the weight of each exercise was adjusted until participants were not able to complete more than 12 (±1) repetitions. Participants alternated between performing upper and lower body exercises to allow enough rest between sets.

Exercise energy expenditure

ExEE during each intervention was assessed using a portable indirect calorimetry unit (model K4b^2, COSMED, Chicago, IL). This unit has been previously validated at different exercise intensities, including maximal, and showed no significant differences in VO_2 values at each exercise intensity, compared to an indirect calorimetry metabolic cart (Hausswirth, Bigard, & Le Chevalier, 1997). The EE values were displayed in real time on a laptop (Pavilion dv6, Hewlett-Packard) with the K4b^2 data management software (Version 9.1 b, COSMED). Participants were equipped with a facemask that covered the mouth and the nose, and were instructed to breathe normally throughout each trial. Two water breaks of 5 minutes each, after the 8th and 16th supersets, were added to the resistance exercise trials due to the length of this trial being much longer than the aerobic exercise trial. Participants were able to remove the facemask during these water breaks. Metabolic measurements were collected continuously for the duration of each trial, with the exception of the two water breaks during the resistance session.

Standardized breakfast and appetite measurements

Participants consumed a standardized breakfast, which included 78 g of thick sliced whole wheat bread (D'Italiano®, 200 kcal), 18 g of peanut butter (Kraft Smooth Peanut Butter®, 108 kcal), 16.3 g of raspberry jam (Kraft Pure®, 52 kcal), 21 g of ultra mild cheddar cheese (P'tit Québec®, 80 kcal) and 225 g of orange juice (Tropicana Pure Premium®, 94 kcal). This meal had a food quotient of 0.85 and a total caloric content of 534 kcal. Participants had 15 min to consume this entire meal. Feelings of appetite (*i.e.* desire to eat, hunger, fullness and prospective food consumption) were measured with visual analogue scales (VAS) (Hill & Blundell, 1986) prior to and immediately following breakfast consumption, 30 and 60 minutes post-breakfast consumption, 45 and 65 minutes following the exercise intervention, and immediately following lunch consumption.

Food reward and *ad libitum* food intake

Participants completed a validated computer-based behavioural procedure called the Leeds Food Preference Questionnaire (LFPQ) (Finlayson, King, & Blundell, 2008) prior to and immediately following an *ad libitum* lunch. Briefly, the LFPQ provides measures of the wanting and liking for an array of food images, varying in both fat content and taste. A total of 16 different foods, divided into four categories (high-fat savoury, low-fat savoury, high-fat sweet and low-fat sweet) formed the array for this study, and are presented in Table 1. During the forced choice part of the test, each food image was presented with every other image in turn. The participants were instructed to select the food they "most want to eat now" during each trial. A standardized implicit wanting score for each food category was calculated as a function of the reaction time in selecting a certain food adjusted for the frequency of choice for each category (French, Mitchell, Finlayson, Blundell, & Jeffery, 2013). To measure the explicit liking and explicit wanting, participants were asked to rate the extent to which they "liked" or "wanted" each randomly presented food item with a 100-mm visual analogue scale. The questions and scoring methods used to assess the implicit wanting, explicit wanting and explicit liking during this task are described elsewhere (Finlayson et al, 2008, French et al, 2013). For all food reward measurements, bias scores for fat content and taste were computed by subtracting the mean low fat scores from the mean high fat scores, and the mean savoury scores from the mean sweet scores, respectively. Positive values indicate a preference for high fat and/or sweet foods, negative values indicate a preference for low fat and/or savoury foods, and a score of 0 indicates an equal preference between fat content and taste categories. *Ad libitum* energy and macronutrient intakes were measured with a test meal selected by the participants from a validated food menu, as previously described (McNeil, Riou, Razmjou, Cadieux, & Doucet, 2012). This food menu is a list of 62 different items (*e.g.* lasagna, chicken stir-fry, juice, fruits, vegetables, milk, chips, chocolate). The participants had 15 minutes to choose which foods they may want to consume from this list of items. The chosen items were then prepared and served to the participants in *ad libitum* quantities. This meal was served 75 minutes following the completion of each intervention, which was held around 12:15 PM for the aerobic and control sessions, and 12:45–13:00 PM for the resistance session. The participants had 30 minutes to consume "as much or as little as they wanted" from this test meal.

Table 1. The food items presented to the participants during the forced choice computer task.

High fat sweet foods	Low fat sweet foods	High fat savoury foods	Low fat savoury foods
Blueberry muffin	Jelly candies	Salted peanuts	Bread roll
Milk chocolate	Candied popcorn	French fries	Spaghetti in tomato sauce
Shortbread	Marshmallows	Salted chips	Pilau rice
Jam doughnut	Fruit salad	Swiss cheese	Boiled potatoes

Statistical analysis

Statistical analyses were performed using SPSS (version 17.0; SPSS Inc, Chicago, IL). Two-way repeated measures ANOVA tests were used to determine the main effects of exercise intervention (control, aerobic and resistance) and time (before and after lunch) on food reward measurements. A one-way repeated measures ANOVA test was also used to assess the effects of exercise intervention (control, aerobic and resistance) on energy and macronutrient intakes. *Post-hoc* tests with LSD adjustments were used to determine where significant differences existed. Sex was added as a between-factor variable in secondary analyses to assess whether differences in the main outcomes existed between men and women. Bivariate Spearman correlations were used to assess the strength of the relationships between food reward measurements assessed prior to lunch with energy and macronutrient intakes at lunch, as well as the changes in food reward measurements with the changes in energy and macronutrient intakes between sessions (delta control-aerobic, control-resistance and aerobic-resistance). Values are presented as means ± standard deviations. Differences with P-values < 0.05 were considered statistically significant.

Results

As previously reported (Cadieux et al., 2014), no difference in body weight, a crude indication of energy balance maintenance, was noted between sessions (aerobic: 69.2 ± 12.5, resistance: 68.6 ± 12.3, control: 68.9 ± 12.4 kg; $P = 0.40$). As designed, there was no difference in ExEE between the two exercise trials (aerobic: 278.3 ± 51.3, resistance: 274.2 ± 56.4 kcal; $P = 0.14$). However, the resistance trial was significantly longer in duration (aerobic: 24.0 ± 4.3, resistance: 85.5 ± 13.7 minutes; $P = 0.0001$) and was reported as being more physically exerting on a Borg scale of 1–10 by participants (aerobic: 5.5 ± 1.8, resistance: 7.1 ± 1.8; $P = 0.02$), compared to the aerobic trial (Cadieux et al., 2014).

The fat and taste bias scores for the relative preference, implicit wanting, explicit wanting and explicit liking for foods assessed prior to and following lunch during each session are presented in Table 2. Despite overall decreases in absolute explicit wanting and liking post- *vs.* pre-lunch (results not shown), greater relative preference and explicit liking for high fat *vs.* low fat foods, as well as greater relative preference, implicit wanting, explicit liking and wanting for sweet *vs.* savoury foods were noted following lunch compared to before lunch. A greater preference for high fat relative to low fat foods was noted during the control session, compared to both exercise sessions (Fig. 2). Additionally, a greater explicit liking for high fat relative to low fat foods was noted during the control session, compared to the resistance exercise session (Fig. 3). No significant differences between conditions, or significant exercise × time interactions were noted for all food reward variables when assessing the relative bias for sweet comparatively to savoury foods. Lastly, no significant differences in these outcomes were noted between men and women (results not shown).

Table 2. The relative preference, implicit wanting, explicit wanting and explicit liking for high fat *vs.* low fat foods, and sweet *vs.* savoury foods between exercise conditions, across time (pre- and post-lunch), and exercise × time interactions.

	Sedentary control		Aerobic exercise		Resistance exercise		Exercise effect	Time effect	Exercise × Time interaction
	Mean	SD	Mean	SD	Mean	SD			
Relative preference									
High fat bias							$P = 0.03$	$P = 0.04$	$P = 0.31$
Before lunch	1.3	7.9	−0.1	8.0	−1.0	6.0			
After lunch	5.3	8.0	1.5	8.8	2.2	8.7			

	Sedentary control		Aerobic exercise		Resistance exercise		Exercise effect	Time effect	Exercise × Time interaction
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**			
Sweet taste bias							$P = 0.62$	$P = 0.0001$	$P = 0.27$
Before lunch	−8.1	10.6	−6.9	11.2	−7.9	9.7			
After lunch	11.3	11.8	7.9	10.5	7.8	11.7			
Implicit wanting									
Fat bias							$P = 0.16$	$P = 0.08$	$P = 0.29$
Before lunch	2.7	24.3	−1.4	22.5	−4.7	21.7			
After lunch	13.7	22.9	1.4	24.3	3.1	33.4			
Taste bias							$P = 0.90$	$P = 0.001$	$P = 0.40$
Before lunch	−20.9	36.7	−18.5	37.8	−17.5	37.2			
After lunch	32.6	34.9	25.8	37.7	23.5	33.6			
Explicit wanting									
Fat bias							$P = 0.43$	$P = 0.05$	$P = 0.16$
Before lunch	0.6	11.6	−2.5	13.4	−3.3	13.9			
After lunch	2.4	9.4	3.5	7.5	2.3	7.1			
Taste bias							$P = 0.20$	$P = 0.004$	$P = 0.61$
Before lunch	−6.6	12.0	−6.3	16.1	−9.8	16.8			
After lunch	6.0	9.0	3.0	9.0	1.7	7.2			
Explicit liking									
Fat bias							$P = 0.04$	$P = 0.01$	$P = 0.25$
Before lunch	1.4	12.8	−0.7	14.0	−4.9	13.3			
After lunch	5.2	12.3	3.1	10.5	2.7	7.9			
Taste bias							$P = 0.69$	$P = 0.001$	$P = 0.66$
Before lunch	−5.8	11.8	−8.5	18.0	−7.1	15.6			
After lunch	6.7	8.0	6.1	10.5	4.4	7.6			

Note: A positive score is indicative of a relative preference for high vs. low fat, or sweet vs. savoury, foods. A negative score is indicative of a relative preference for low vs. high, or savoury vs. sweet, foods. A score of 0 indicates an equal preference between fat and taste categories. SD, standard deviation.

As previously described (Cadieux et al., 2014), no significant differences in energy (resistance: 1068 ± 628, aerobic: 952 ± 459, control: 1032 ± 689 kcal; $P = 0.37$), carbohydrate (resistance: 543 ± 302, aerobic: 482 ± 226, control: 518 ± 278 kcal; $P = 0.28$), lipid (resistance: 376 ± 295, aerobic: 313 ± 207, control: 369 ± 379 kcal; $P = 0.56$) and protein (resistance: 169 ± 91, aerobic: 167 ± 96, control: 160 ± 98 kcal; $P = 0.82$) intakes were noted between conditions. However, a significant sex × exercise modality interaction for lunch EI was noted, where EI was higher in men following the resistance *vs.* aerobic exercise sessions (resistance: 1567 ± 469 *vs.* aerobic: 1255 ± 409 kcal; $P = 0.03$), but no differences between both exercise sessions were observed in women (resistance: 568 ± 237 *vs.* aerobic: 648 ± 270 kcal; $P = 0.36$). No differences between exercise sessions or exercise × sex interactions were noted for macronutrient intake (results not shown) (Cadieux et al., 2014). None of the food reward measurements assessed prior to lunch were correlated with energy and macronutrient intakes at lunch, nor were the changes in food reward measurements between exercise sessions correlated with delta energy, carbohydrate and fat intakes (results not shown). Lastly, no differences in all appetite measures were noted between exercise sessions (results not shown) (Cadieux et al., 2014).

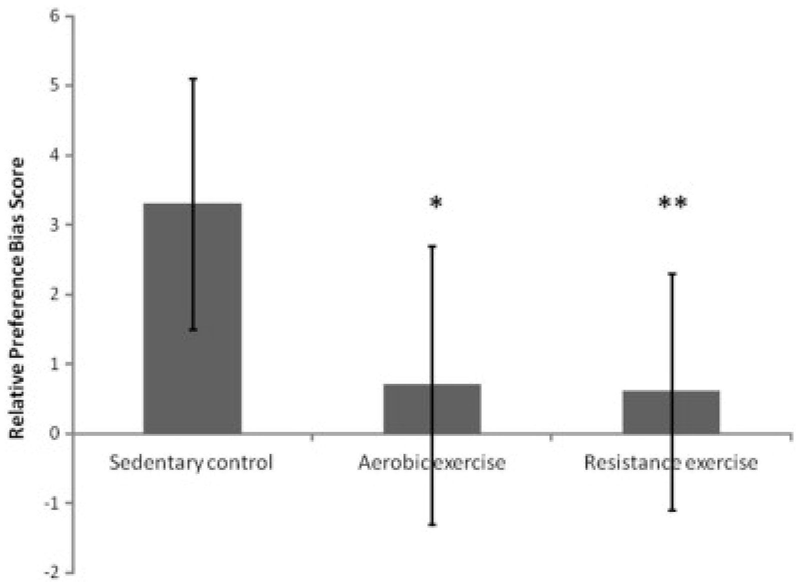

Fig. 2. Relative preference for high fat *vs.* low fat foods between exercise conditions. Values are presented as means for 16 participants with standard errors of the mean represented by vertical bars. *$P = 0.04$ and **$P = 0.03$ compared to sedentary control. *Notes:* A positive score is indicative of greater relative preference for high vs. low fat foods. A negative score is indicative of greater relative preference for low vs. high-fat foods. A score of 0 indicates an equal relative preference between fat categories.

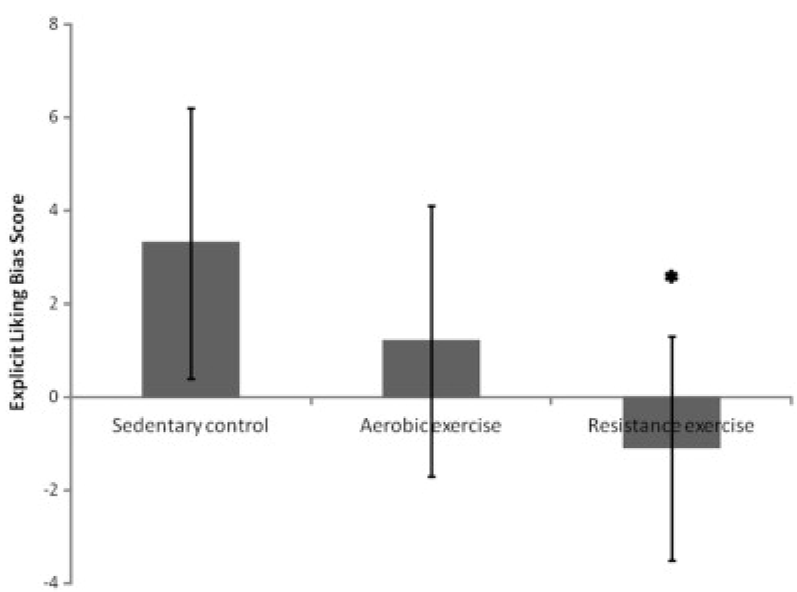

Fig. 3. Explicit liking for high fat *vs.* low fat foods between exercise conditions. Values are presented as means for 16 participants with standard errors of the mean represented by vertical bars. *$P = 0.03$ compared to sedentary control. *Notes:* A positive score is indicative of relatively greater explicit liking for high vs. low fat foods. A negative score is indicative of a relatively greater explicit liking for low vs. high-fat foods. A score of 0 indicates an equal explicit liking score between fat categories.

Discussion

This is the first study to examine the acute effects of isocaloric resistance and aerobic exercise sessions on pre- and post-lunch food reward. Collectively, our findings suggest that the relative preference for high fat *vs.* low fat foods is decreased following exercise, independent of modality. Furthermore, the explicit liking for high fat relative to low fat foods is lower following resistance, but not aerobic, exercise compared to sitting and reading (sedentary control). However, these changes in food reward were not associated with changes in energy and macronutrient intakes between sessions.

As expected, decreases in the absolute measurements of the explicit wanting and liking for foods were noted following the *ad libitum* lunch, comparatively to pre-lunch consumption, which are in line with other studies that have administered this tool prior to and following a test meal (Cameron et al, 2014, Finlayson et al, 2008, Finlayson et al, 2009, Finlayson et al, 2007). Despite these decreases, participants in the present study had overall greater relative preferences and explicit liking for high fat *vs.* low fat foods, as well as greater relative preference, implicit wanting, explicit wanting and explicit liking for sweet *vs.* savoury foods following lunch, comparatively to before lunch. These results contrast those previously noted by Finlayson et al, 2007, Finlayson et al, 2008, who saw little to no change in the explicit wanting and liking for sweet foods in response to a test meal. It is possible that the greater bias for high fat, sweet foods following lunch may be influenced by sensory specific satiety, where the consumption of a specific food to satiety may decrease the pleasantness ratings, or “liking”, and subsequent intake of this food (Rolls et al, 1981, Rolls, 2005). However, the pleasantness ratings, neuronal responses and/or subsequent intake of foods tasted, but not eaten to satiety, will not be altered and may persist after a meal (Rolls, 2005). Although a mere hypothesis in the context of the present study since *ad libitum* access to a large number of food items varying in both fat content and taste may have been selected by the participants, it is possible that the foods chosen at lunch were more likely low in fat content and/or savoury, meaning that the preference for high fat, sweet foods will remain elevated post-lunch consumption. Additionally, certain foods presented during the LFPQ task were not offered on the food menu, meaning that the rewarding value of a certain food will not necessarily change with the consumption of a lunch, if satiety effects are specific to the consumption of individual food items.

A lower relative preference for high fat *vs.* low fat foods was noted following both exercise sessions when compared to the sedentary control session. Furthermore, a lower explicit liking for high fat relative to low fat foods was observed following resistance exercise, compared to sedentary control. These novel results add to those previously observed by Evero et al. (2012), who noted a decreased responsiveness in regions of the brain related to food reward activity immediately following 60 minutes of high-intensity aerobic exercise *vs.* 60 minutes of sedentary control. Although untested in the present study, it is possible that resistance exercise may favour a hormonal milieu, which may lead to immediate suppressions of food reward. Balaguera-Cortes et al. (2011) previously reported reductions in active ghrelin (*i.e.* favours decreases in hunger) coupled with increased peripheral insulin levels following resistance exercise compared to sedentary control. Hence, it is possible that these acute changes in hormone levels may modulate neural pathways and neuropeptides, which may then modify the liking for food (de Graaf, Blom, Smeets, Stafleu, & Hendriks, 2004). This should however be interpreted with caution, as resistance exercise conducted by Balaguera-Cortes et al. (2011) and Cadieux et al. (2014) did not lead to lower EI at lunch. Future studies are needed to assess whether variations in gut hormones in and around exercise may differ according to calorie-matched exercise modality.

The observed lower relative preference and explicit liking for high fat *vs.* low fat foods following exercise was not associated to decreases in absolute EI in this cohort of participants. These results are further supported by a lack of significant correlations between pre-lunch food reward measurements with lunch energy and macronutrient intakes, as well as between the changes in food reward measurements and lunch energy and macronutrient intakes between conditions. These results add to those previously noted by Laan et al. (2010) and Balaguera-Cortes et al. (2011), who also noted no significant differences in EI between time-matched exercise modalities. Furthermore, a recent meta-analysis by Schubert, Desbrow, Sabapathy, and Leveritt (2013) reported only trivial effects of exercise on absolute EI, but large effects on relative EI, meaning that individuals tend to not compensate for the energy expended during exercise, despite little to no change in absolute EI following exercise *vs.* sedentary control. Interestingly, Cadieux et al. (2014) previously reported a significant positive association between the degree of post-exercise energy compensation following aerobic and resistance exercises, despite no differences in this outcome between the three experimental sessions in this cohort of participants. These results suggest that post-exercise energy compensation within an individual remains relatively stable, and may be more so influenced by inter-individual characteristics rather than exercise modality *per se* (Cadieux et al., 2014). As for the lack of association between food reward and subsequent EI, Farah et al. (2012) noted similar dissociations between feelings of wanting and liking for food with actual EI. More specifically, no significant differences in food reward measurements were noted following 60 minutes of aerobic exercise *vs.* 60 minutes of restful sitting, despite the selection of smaller portion sizes of high fat and/or savoury foods (*e.g.* pasta, crackers, KitKat® chocolate bar, cheese baguette) post-exercise (Farah et al., 2012). This dissociation may be in part explained by the ability to modulate food intake via higher cognitive processes, even in the presence of a physiological "need" or increased "wanting" for food (Berridge, 1996). This notion is also supported by a study (Hetherington, Pirie, & Nabb, 2002) that noted a decrease in the reported "liking" for chocolate, whereas *ad libitum* chocolate intake significantly increased over time, thus suggesting that pleasantness ratings (liking) and intake are at times distinct entities. It is also possible that the measurement of food reward and EI in regular exercisers, who tend to closely match ExEE with increased EI (Martins et al, 2007, Melzer et al, 2005), or the repetition of the intervention over many days (*e.g.* an acute bout of aerobic exercise everyday for 4–5 days *vs.* an acute bout of resistance exercise everyday for 4–5 days) may lead to measures of food reward and EI that are more closely matched, or associated, as a conditioning process would occur with an increased number of exercise sessions.

The present findings are limited by a small sample size of normal-weight, and relatively fit men and women, which may limit the generalization of these results to other populations. Furthermore, only 1-day assessments of food reward and EI were performed, which may not account for normal day-to-day variability in these variables. Similarly, this normal day-to-day variability in EI may impact the amount and types of foods consumed on the day preceding each exercise intervention, although we did ask participants to maintain habitual eating and activity patterns on the day preceding testing. Participants were aware of the main objective of this study (*i.e.* assess the effects of exercise modality on EI and energy expenditure following the exercise intervention), which could have potentially increased their vigilance for eating certain foods throughout the day. Lastly, the food images presented during the LFPQ were not the same as those offered to participants on the validated menu, and may in part explain the dissociation between these variables in the present study. Future studies would be needed to assess the associations between the “wanting” and “liking” of certain foods with the subsequent intake of these specific foods, and how these associations may be altered with different interventions (*e.g.* exercise modality).

These novel findings suggest that exercise decreases the relative preference for high fat *vs.* low fat foods acutely, and this was independent of exercise modality. Exercise modality did have an effect on the explicit liking for high fat foods, where lower hedonic “liking” ratings were noted following resistance, but not aerobic, exercise compared to the sedentary control session. However, this decrease in food reward was not related to a reduction in EI, thus suggesting that a dissociation may exist between food hedonics and actual EI. Future studies are required to not only confirm the results of the present study, but also to assess the medium- (2–5 days) and long-term (≥1 week) effects of exercise modality on food reward to assess whether these effects are sustained over many eating opportunities, or even days.

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