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Title: When exercise does not pay: Counterproductive effects of impending exercise on energy intake among restrained eaters

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Running head: Effect of impending exercise on energy intake

Abstract

Evidence suggests people may overestimate the effectiveness of future positive behaviour, leading to counterproductive behaviours in the present. Applied to weight-management, we hypothesize that inaccurate expectations about impending exercise may impede weight management by promoting overconsumption prior to exercise. This study aimed to determine how expectations about impending exercise and its potential ability to expend energy may influence i) energy intake before exercise and ii) overall energy balance (energy intake minus energy expended via exercise). Using a randomised, counterbalanced design, 21 inactive, overweight males, following a baseline session, completed two experimental trials: i) *ad-libitum* snack meal (potato-crisps) followed by an exercise session (SE) and ii) *ad-libitum* snack meal only (SO). There was no main effect of condition (SE vs. SO) on *ad-libitum* snack intake ($p=0.917$). However, after accounting for dietary restraint (covariate), a difference in snack intake between SE and SO was revealed ($p=0.050$). Specifically, participants who scored higher in dietary restraint consumed more in the SE (vs. SO) session (162 ± 359 kcal more) compared with participants who scored lower in dietary restraint (89 ± 135 kcal less). Among restrained eaters, the relative (net) energy consumed after accounting for energy expended from exercise in SE was not different from the energy consumed in the SO condition, suggesting that energy expended via exercise in SE does not appear to negate extra energy consumed in this condition compared with SO. Of interest, desire to eat and prospective food consumption ratings at the start of the trial were greater ($p\leq0.029$) in SE compared with SO. Findings suggest that restrained-eaters are at risk of adopting compensatory eating behaviour that may impede negative energy balance typically resulting from exercise (i.e. expending insufficient energy to negate compensatory energy intake).

Keywords: dietary restraint, compensatory health beliefs, exercise, energy balance, meal-planning

Introduction

A decline in daily energy expenditure through physical activity, combined with an increased intake of energy dense food have largely been accepted to be the main causes of the rise in obesity levels (WHO, 2011). While there has been some evidence, encouragingly, pointing towards a stabilizing or a slight increase in leisure-time physical activity levels (Dwyer-Lindgren et al., 2013; Knuth & Hallal, 2009; Ministry of Health, 2010; Roehr, 2013), obesity levels have continued to increase (WHO, 2011), suggesting a trend of overconsumption. This decoupling between energy intake and expenditure may be explained, at least in part, by biases or inaccurate assumptions guiding the appraisal of appropriate energy intake and energy expenditure for weight loss and/or maintenance. While it is widely accepted that obesity is a complex and multifaceted issue, the compensatory health belief model (CHB) (Knäuper et al., 2004; Rabia et al., 2006), provides a potential psychological framework that may contribute to explaining why even with increased levels of physical activity, obesity rates have increased. Accordingly, the CHB model proposes that when faced with temptations, individuals tend to form convictions that the negative consequences of present indulgent behaviour (e.g. consuming calorie-dense foods) may be compensated for by engaging in future positive behaviour (e.g. exercising) (Knäuper et al., 2004; Rabia et al., 2006).

There has been evidence showing a trend towards individuals overestimating the amount of progress they would make towards a future goal compared with past or current goal progress, such that individuals generally appear to have an overoptimistic evaluation of the degree of success an impending effort may bring (Coelho et al., 2011; Fishbach & Dhar, 2005). These inaccurate expectations about future progress, in this case impending exercise, can be counterproductive for weight-loss or weight-maintenance goals if they lead individuals to display obesogenic eating behaviour. For example, a study by Fishbach and Dhar (2005) demonstrated that individuals on the way to exercise indicated a greater intent to consume a

heavy, high-caloric meal compared with individuals who have recently completed exercise. Similarly, Coelho and colleagues (2011) revealed that individuals who ate before exercising were observed to have higher expectations of the efficacy of the impending exercise session towards assisting them to reach their health goals compared with individuals who ate following exercise. This compensatory link between exercise and food intake appears to be evident regardless of whether exercise was expected to be performed or not. Participants that merely thought of their exercise habits and read a brief description of an exercise session were more likely to increase snack consumption compared with a control group (Werle et al., 2011).

While the studies mentioned above provide useful preliminary insight into the psychological processes potentially governing the relationship between energy intake and energy expenditure, a number of methodological limitations prevent definitive conclusions to be drawn. For instance, in the study of Fishbach and Dhar (2005), only the influence of impending exercise on intentions to consume calorie-dense meals was assessed and not actual food intake. Of relevance, it has been shown previously that significant differences in intentions did not necessary translate to similar differences in food intake (Webb & Sheeran, 2006). This limitation was addressed by Coelho et al (2011), who examined the influence of meal and exercise order on actual food intake. However, these authors' findings were contrary to their expectations. That is, they found no differences in energy intake in the test-meal between experimental conditions that involved exercising after eating, exercising before eating and control (no exercise). While this lack of difference in the findings may be due to the moderate sample size employed, a number of limitations of their study warrant a more thorough investigation of the topic. These include: i) employing a between-subject, rather than within-subject design which may have critically prevented the detection of intra-individual differences in eating behaviour ii) not standardizing pre-test meal dietary intake; an important feature in energy intake studies (Blundell et al., 2010; Gregersen et al., 2008) and iii) fixing exercise-

intensity and duration for exercise testing since measuring self-regulated exercise would allow for a more ecologically valid investigation.

Crucially, previous research have not accounted for individual differences in attitudes towards eating when assessing study outcomes. One especially relevant variable is dietary restraint (individual's conscious efforts to restrict food intake for weight control – i.e. prevent weight gain and/or weight loss), which has been shown to influence eating behaviour, especially when provided triggers to justify overconsumption (Eldredge et al., 1994; Urbszat et al., 2002). For instance, individuals with high dietary restraint have been shown to display counter-regulatory eating behaviour (increased consumption) when presented with opportunities to carry out goal-favourable behaviour (e.g. anticipating an upcoming diet or period of calorie restriction which may be favourable for weight-maintenance/loss goals). CHBs have been identified to function as strategies to reconcile conflicts emerging from desires for indulgence and pleasure (e.g., eating unhealthy yet palatable foods) and competing motivations to adhere to broader health goals (e.g., limiting excess caloric intake) (Rabia et al., 2006). As such, restrained-eaters, who maintain active goals to monitor and regulate their caloric intake; (despite underlying desire to eat) may be especially vulnerable to adopting counterproductive CHBs to justify or negate immediate indulgence when confronted with future opportunities for energy expenditure.

Therefore, the main aim of this study was to investigate the influence of impending exercise and the opportunity to expend energy on prior eating behaviour. It is hypothesized that there is a compensatory effect of impending exercise on energy intake, that is, participants will show an increase in appetite and energy intake in anticipation of impending exercise. It is also predicted that this compensatory effect will be especially prominent among those exhibiting dietary restraint, given that restrained eaters may experience especially strong goals to reconcile competing motivations for indulgence and restricting caloric intake. Lastly, it is

hypothesized that the predicted increase in appetite and energy intake (as hypothesised above) will result in participants being at a greater risk of being in a state of positive energy balance.

Methods

Participants

Twenty-one overweight and physically inactive men (age: 24 ± 2 y; BMI: 26.7 ± 1.8 kg/m²; body fat: $24.6 \pm 2.5\%$; $\dot{V}O_{2Peak}$: 29.3 ± 3.0 mL/kg/min) from the local community were recruited for the present study. Sample size was based on calculations from previous research (Gregersen et al., 2008) that state a repeated-measures study design requires 17 participants to detect differences in energy intake between ad-libitum meals. Overweight was defined as having a BMI of 23 kg/m² and above; evidence suggests an increased risk of weight-related comorbidities in the Singaporean population at this cut-off index (WHO, 2004). Participants' physical activity levels were assessed using the International Physical Activity Questionnaire (IPAQ – Short Form) (Craig et al., 2003). Physical inactivity was defined as not engaging in moderate intensity exercise for more than 75 min per week – i.e. the lower threshold of the recommended levels of physical activity for an adult (WHO, 2016). Ethical approval was granted by the Institutional Review Board at the National University of Singapore and written consent was obtained from all recruited participants. Participants were naïve to the actual objective of the study and were told instead the study was about examining the relationship between post-meal activities (exercise) and blood pressure. A debrief and an end of study interview (funnel-type) revealed participants did not suspect and were not aware of the true aim of the study. Participants were each compensated \$50 for completing the study.

Experimental design

Participants were required to attend an initial baseline and familiarisation session. Participants were then randomly (counter-balanced) (Urbaniak & Plous, 2011) assigned to either i) an *ad-libitum* snack meal (potato-crisps) followed by exercise (SE) or ii) an *ad-libitum* snack meal only (SO) experimental group.

Baseline testing and familiarisation

Aerobic fitness (estimated $\dot{V}O_{2Peak}$) (corrected for a Singaporean sedentary male population) (Ong et al., 2002) was measured via a continuous maximal graded exercise test (Storer et al., 1990) performed on a mechanically-braked cycle ergometer (Monark 839E, AB, Vansbro, Sweden). This involved an initial workload of 0 watts for 4 min, followed by a progressively incremental workload of 15 watts/min until volitional exhaustion was reached. The pedal rate was kept constant at 60 rpm, with the help on an on-board metronome. Anthropometrical measures along with surveys regarding participant's general health, demographics, physical activity levels and attitudes towards food and eating habits (DEBQ) (Van Strien et al., 1986) - dietary restraint (2.6 ± 0.6), emotional eating (2.4 ± 0.8), external eating (3.1 ± 0.5) were also assessed. A familiarisation test-meal was also presented to the participants to minimise any novelty consuming a meal in an unfamiliar environment. Any potential hedonic bias associated with the test-meal was accounted for via the use of a nine-point Likert hedonic scale (rating: 6.8 ± 1.1 ; descriptively equated to "like moderately" on the hedonic scale) (Peryam & Pilgrim, 1957). A standardized breakfast meal and physical activity monitor (accelerometer) were provided to take home at the end of the first (screening and baseline) and second (first experimental session) visit to the lab.

Experimental trial

To control for potential external influences on study outcomes, participants were required to wear a physical activity monitor (accelerometer) and asked not to partake in any vigorous physical activity on the day prior to an experimental trial. Participants were also required to document all food and drink intake in a food journal that was reviewed by investigators at the start of each experiment session. Participants were asked to replicate their dietary consumption prior to the subsequent experimental session. To increase the rate of compliance, a reminder (i.e. email, text) was provided to participants prior to each visit.

For each visit, participants were required to be at the research facility at about 1200h having consumed the standard breakfast (506 kcal) (i.e. commercially available cereal, long life milk, juice and oat cracker) provided earlier at about 0900h (offsite; i.e. home). Participants took pictures of the completed breakfast meals, which were verified by experimenters during their visit. At about noon, participants visited the lab where they were provided with a standardized lunch (510 kcal) (commercially available ready-to-eat meal; teriyaki chicken with rice, CP Foods, Singapore) to be consumed in its entirety. Following lunch, participants were allowed to continue with their day (i.e. attend class/work) until they returned for testing later in the day. Participants were also told not to consume any other food or perform any physically strenuous tasks during this period.

At approximately 1500h, participants returned to the laboratory and following some basic anthropometrical measurements were briefed on the experimental protocol of the upcoming session: either the SE or SO experimental condition.

SE involved an *ad-libitum* test-meal (potato-crisps) (see details below; *Energy intake assessments*) followed by an exercise session on a cycle ergometer. The initial 60 min of the protocol involved participants having *ad-libitum* access to the test-meal whilst watching a

video (comedy sitcom “Modern Family” – same two episodes randomly screened between the two conditions/experimental sessions). This genre was specifically selected to minimise any potential influence other genres like horror and action have been reported to influence eating behaviours (Mattar et al., 2015; Tal et al., 2014). Following this, participants performed an ‘*ad-libitum*’ exercise session, where the workload/intensity and duration (maximum of 60 min) of the exercise session was self-regulated. Participants were instructed to exercise until they considered they had completed a “sufficient workout”. They were also explicitly told they could exercise at any intensity and for any duration (minimum of 10 minutes) they wanted. Estimated energy expended during this exercise session was also assessed (see details below; *Energy expenditure assessments*). In addition, heartrate and participants’ rating of perceived exertion (RPE) (Borg, 1982) were periodically recorded. Participants perceived enjoyment of the exercise session was also measured using the Physical Activity Enjoyment Scale (PACES) (Kendzierski & DeCarlo, 1991).

SO involved an *ad-libitum* test-meal while watching a video (as per SE), but with the subsequent *ad-libitum* session of SE replaced with 60 minutes of continued video viewing without access to food (i.e. 120 min of video watching for SO). This control activity was chosen to allow for the direct comparison of a contrast and neutral activity, that is, a no exercise condition compared with exercise.

To maintain the covertness of the study objective, blood pressure readings were also measured at the start and end of both experimental trials. Following the last experimental session, participants were thoroughly debriefed about the experiment.

Energy intake assessments

To assess whether energy intake was influenced by the experimental protocols, measurements of the *ad-libitum* test-meal were made. The test-meal was made available for a fixed duration

of 60 min (for both SE and SO) and consisted of non-restricted access to the test-meal (potato-crisps; Original Flavoured Potato-Chips, First Choice, Cold Storage, Singapore) of known quantity and nutrition content (portion presented – equivalent to two full bags of crisps; 220g/1163 kcal). No participant finished consuming the two full bags of crisps. The test-meal was presented together with a bottle of plain drinking water (~1 litre). All test food items were weighed before and after consumption. Perceived appetite (ratings of hunger, fullness, satiety, desire to eat, and prospective food consumption (i.e. “How much do you think you could eat?”)) was periodically assessed at three different time points; i) at the start of the session, ii) 60 min after exposure to the test-meal and iii) at the end of the session.

To assess daily energy intake, participants were required to maintain a 24h food diary before and after (day before and day of) each experimental session for both experimental trials. Maintenance of the food diary required participants to record portion size (with the assistance of provided kitchen scales) and details of all food and drinks ingested. An estimate of total daily energy consumption, together with the quantity of macronutrients consumed were determined using a commercially available dietary assessment software (Foodworks; Xyris Software, Queensland, Australia).

Energy expenditure assessments

To accurately estimate the amount of energy expended during the exercise session, anthropometrical and sessional variables collected from each participant together with established metabolic equations were used. Specifically, energy expenditure was estimated using two widely used metabolic equations i) calculating estimate oxygen cost from stationary cycling (less oxygen cost at rest): $VO_2 = 10.8 * (\text{work-rate in watts}) / (\text{body mass in kg}) + \text{unloaded cycling (3.5 ml/kg/min)}$ and ii) calculating caloric expenditure: $\text{kcal} = (VO_2 \text{ in l/min}) * 5 * \text{number of min on bike}$ (ACSM, 2014).

To determine the effect of the experimental protocol on free-living physical activity levels, each participant wore a physical activity monitor (accelerometer) (GT3X+ Activity Monitor, ActiGraph, Florida, USA) for the remainder of the experimental day for both experimental trials. Average daily step count, estimated energy expenditure and time spent engaged in sedentary, light, moderate and heavy physical activity was computed as per previous studies in examining spontaneous free-living physical activity rates (Sim et al., 2014, 2015).

Statistical Analysis

A series of analysis-of-variance (ANOVA) and covariance (ANCOVA) were employed to assess i) the effect of the experimental conditions on *ad-libitum* energy intake from the test-meal and appetite ratings, ii) within the SE session - difference between energy intake and energy expenditure and iii) the effect of unrestrained- vs. restrained-eaters on the difference of *ad-libitum* energy intake between the two experimental sessions (energy consumed in SE minus energy consumed in SO). Dietary restraint classification was based on the following cutoff values of mean ratings for restrained eating items on the DEBQ - restrained eaters: ≥ 3 and unrestrained-eaters: < 3 . An average of 3 and above on the dietary restraint subscale reflects the average response of “often” and “very often” to questions associated with restrained-eating. For example, “Do you try to eat less at mealtimes that you would like to eat?”. All values are presented as mean $\pm$ SD (standard deviation) unless otherwise indicated. Statistical significance was accepted at $p \leq 0.050$ (SPSS ver. 23, IBM Corporation, Armonk, N.Y., USA).

Results

Trial Characteristics

All provided standardised meals (breakfast and lunch), across both conditions, were visually verified to be consumed in their entirety. Both energy expenditure from physical activity and energy intake of the day prior to each visit were well-matched (energy expenditure: SE 450 ± 256 kcal, SO 459 ± 268 kcal; $F(1,19)=0.145$, $p=0.707$; energy intake: SE 1889 ± 908 kcal, SO 1900 ± 959 kcal; $F(1,19)=0.003$, $p=0.957$).

Average RPE for the self-regulated exercise session was 15 ± 2 ; equivalent to the descriptive rating of “hard” on the RPE chart (Borg, 1982). Average exercise duration was 31 ± 13 min, within the 60 min period allocated for exercise. Of note, physical activity enjoyment ratings were positively correlated with the duration of exercise session ($r=0.44$, $p=0.044$) – that is, the longer participants exercised the more likely they were to report that they enjoyed the exercise.

Ad-Libitum Energy Intake and *Ad-Libitum* Energy Expenditure

There was no main effect of condition (SE vs. SO) ($F(1,20)=0.01$, $p = 0.917$) on *ad-libitum* energy intake. However, an ANCOVA, controlling for dietary restraint (as a continuous variable) revealed a difference in snack intake between SE and SO ($F(1,19)=4.38$, $p = 0.050$) (Figure 1).

Figure 1 - Mean ($\pm$ SE) energy intake at the test-meal (potato-crisps) during the snack followed by exercise (SE) and snack only (SO) experimental conditions. ($n = 21$).
[#]Significantly different from SO (controlling for dietary restraint). ($P \leq 0.050$).

Specifically, participants who were classified as high in dietary restraint (restrained eaters; RE) consumed more in the SE (vs. SO) session (energy consumed in SE minus energy consumed in SO) (162 ± 359 kcal) compared with participants who scored lower in dietary restraint (unrestrained eaters UE) (-89 ± 135 kcal) ($F(1,19)=5.320$, $p=0.033$) (Figure 2). Consistent with this finding, dietary restraint was positively correlated with the difference in snack intake between SE and SO, $r(19)=0.43$, $p=0.050$ (i.e. the greater the dietary restraint of participants, the greater the snack intake in SE compared with SO). There was no difference in *ad-libitum* water intake at the test-meal between SE and SO ($F(1,20)=0.104$, $p=0.750$).

295 Figure 2 - Mean ($\pm$ SE) difference in energy intake at the test-meal (potato-crisps) between the
 296 snack followed by exercise (SE) and snack only (SO) conditions – (SE minus SO) of
 297 unrestrained- ($n=13$) and restrained- ($n=8$) eaters. #Significantly different from unrestrained-
 298 eaters. ($P \leq 0.050$).

299

300 Analysis of relative energy intake (i.e. net energy consumed; accounting for the additional
 301 energy expended from self-regulated exercise) in the SE session show that in RE, relative
 302 energy intake during SE (411 ± 316 kcal) was not different compared with energy intake in SO
 303 (388 ± 261 kcal) ($F(1,7)=0.031$, $p=0.864$). Conversely, relative energy intake among UE was
 304 greater in SO (451 ± 271 kcal) compared with SE (211 ± 308 kcal) ($F(1,12)=23.66$, $p<0.001$)
 305 (Figure 3).

Figure 3 - Mean ($\pm$ SE) relative energy intake (energy intake from test-meal minus additional energy expended from self-regulated exercise) during the snack followed by exercise (SE) experimental condition and energy intake during the snack only (SO) experimental condition in restrained eaters (RE; $n=8$) and unrestrained eaters (UE; $n=13$). #Significantly different from UE (SO). ($P \leq 0.050$).

Post-Test Free-Living Energy Intake and Free-Living Energy Expenditure

There was no effect of condition (SE vs. SO) on free-living cumulative energy intake for the remainder of the test day ($F(1,17)=0.24$, $p=0.629$; Figure 4A). However, energy expenditure (via accelerometry) from physical activity for the remainder of the trial day was lower after the SE condition compared with SO ($F(1,19)=5.04$, $p=0.037$; Figure 4B). No difference in relative

energy intake after SE compared with SO was detected when accounting for energy intake/expenditure over the remainder of the day ($F(1,17)=3.884$, $p=0.065$; Figure 4C).

Perceptions of Appetite

There was a main effect of condition revealing an increase in desire to eat and prospective food consumption ratings in the SE condition compared with SO ($p\leq 0.018$) (Figure 5A and 5B). Post-hoc analysis revealed that at the start of the experimental trial (after the experimental protocol was revealed) participants in the SE condition had significantly greater desire to eat and prospective food consumption ratings compared with SO ($p\leq 0.029$).

Dietary restraint was also positively correlated with the difference in hunger ($r(21)=0.494$, $p=0.023$) and fullness ($r(21)=-0.461$, $p=0.027$) ratings between SE and SO at the start of the session. That is, the greater the dietary restraint of participants, the greater and lesser the feelings of hunger and fullness respectively were at the start of SE compared with SO.

Except for prospective food consumption, there was also a main effect of time within each test session for all other perceived appetite variables ($p<0.001$); with increased feelings of fullness and satiation, together with decreased hunger and desire to eat following the test-meal. There were no significant interactions of condition*time on perceived hunger, fullness, satiation, and desire to eat ($p\geq 0.445$), except for prospective food consumption ($F(2,40)=3.745$, $p=0.032$).

Figure 4 - Mean ($\pm$ SE) free-living estimated energy intake (A) ($n=18$), energy expenditure from physical activity (B) ($n=20$) and relative energy intake (energy intake minus energy expenditure) (C) ($n=18$) assessed after the snack followed by exercise (SE) and snack only (SO) experimental trial sessions. #Significantly different from SO. ($P \leq 0.050$).

Figure 5 - Mean ($\pm$ SE) perceived desire to eat (A) and prospective food consumption (B) ratings during the snack followed by exercise (SE) and snack only (SO) experimental conditions ($n = 21$). The left block on the horizontal axis (time) indicates when the test meal was consumed and the right block indicates when the exercise was performed (SE)/when participants continued with rest/video watching (SO). #Significantly different from SE. ($P \leq 0.050$).

Discussion

The main objective of the present study was to examine the influence of an anticipated bout of exercise on snacking behaviour among inactive overweight men. After factoring dietary restraint (which may promote CHB's) into the analysis, *ad-libitum* energy intake in SE was observed to be higher compared with SO. This difference in eating behaviour is even more pronounced between restrained- and unrestrained-eaters when examining the difference in snack intake between the two experimental conditions. Restrained-eaters (RE) on average consumed 162 kcal more in SE compared with SO, while unrestrained-eaters (UE) consumed 89 kcal less in SE compared with SO. These contrasting trends were also observed when accounting for the additional energy expended from the exercise in SE. Among RE, relative energy intake in the SE condition was not different to the energy consumed in the SO condition (i.e. energy expended via exercise does not appear to negate energy consumed). Whereas, among UE, relative energy intake was significantly lesser than the energy consumed in SO (Figure 3).

Previous research has examined the influence of impending exercise on intentions to eat and food intake (Coelho et al., 2011; Fishbach & Dhar, 2005). However, to our knowledge this is the first study that has investigated the effects of post-prandial exercise on appetite and energy intake in overweight and inactive individuals, a population whose eating behaviour arguably requires most attention. Another key feature of the present study is the consideration of individual differences (i.e. attitudes towards eating) when analysing study outcomes. Examination of these characteristics of the present study may explain the differing study outcomes compared with previous research. For instance, consistent with the findings of Coelho and colleagues (2011), initial analysis from the present study revealed no differences in energy intake between experimental conditions. However, after accounting for dietary restraint, a significant difference between conditions emerged, suggesting that the

compensatory effect of impending exercise on energy intake may be greatly influenced by an individual's degree of dietary restraint.

The finding that individuals with increased dietary restraint may be susceptible to flawed compensatory eating behaviour (overconsumption) is consistent with current literature on CHBs (Eldredge et al., 1994; Urbszat et al., 2002). Given that CHBs may function to alleviate conflicts between the simultaneous desire to indulge and adhere to health goals, individuals who are actively monitoring and regulating their food intake may be especially at risk of adopting such beliefs when encountering palatable foods. Accordingly, restrained-eaters have been shown to display disinhibited eating behaviour when placed in a situation that may lead to behaviour favourable to their goals; in this case, weight-management behaviour either through exercise (present study) or dietary restriction. For instance, Urbszat and colleagues (2002) reported that when led to believe that they would be going on a diet the following day, restrained-eaters consumed more food compared with unrestrained-eaters and restrained-eaters assigned to a no-diet condition. A similar finding was also observed amongst binge eaters (a function of restrained-eating), who displayed Eldredge and colleagues' "last supper" effect, where an anticipated period of food deprivation provided suitable justification to overeat (Eldredge et al., 1994). Besides exercise or dieting, reminders of potentially healthy eating habits, such as the availability of goal-promoting food options, may also promote increased consumption (Joerg, 2016) and selection of palatable and indulgent foods (Wilcox et al., 2009) among individuals who are actively regulating their eating. In the present study, impending opportunities to "burn off" excess calories may have served as valid justification or license to withhold restraint among restrained-eaters that may have contributed to overcompensation of impending exercise by indulging in the test-food.

Notably and also consistent with previous research, unrestrained-eaters in the present study did not display disinhibited eating behaviour when faced with an appropriate trigger (Urbszat et

al., 2002). In fact, unrestrained-eaters ate significantly more in the SO condition compared with SE. A number of factors may have contributed to this outcome. One possibility may be that the test-meal (potato-crisps) may not have had the same hedonic influence on unrestrained-eaters compared with restrained-eaters. Another possible reason may simply be that unrestrained-eaters may not be as “sensitive” or prone to the use of increased energy expenditure that exercise provides as license to indulge and engaged in unhealthy behaviour (increase snacking). Consequently, unrestrained-eaters may not have employed compensatory eating behaviour as heavily in the SE condition compared with restrained-eaters.

Supporting the notion that expectations of future health-relevant behaviours may be mediating the influence of impending exercise on immediate food intake, desire to eat and prospective food consumption ratings at the start of experimental trial (after the session protocol was made known to participants) was observed to be greater in SE compared with SO. Additionally, and further highlighting the role of dietary restraint in compensatory health behaviour, the difference in feelings of hunger and fullness, after being told which condition participants were going to be in (i.e. exercise vs. rest) were positively and negatively (respectively) associated with dietary restraint. Taken together, and in line with our hypotheses and the CHB framework, the findings presented above suggest that among restrained-eaters, merely anticipating a healthy behaviour (exercise and an opportunity to expend energy) is sufficient to trigger an increase in consumption, especially of indulgent, palatable food.

Another important observation from this study is behaviours among individuals high in dietary restraint, that potentially suggest inaccurate expectations and overestimation of the ability of anticipated exercise to expend prior energy intake. RE in the present study routinely fell short of expending sufficient energy via the exercise session to offset energy previously consumed through potato-crisps. This finding is notable considering that exercising before food intake has been identified to produce the opposite effect. While the effect of exercise performed before

food consumption was not directly examined in the present study, a meta-analysis (Schubert et al., 2012) investigating the effects of exercise on subsequent energy intake reported that energy balance (relative energy intake) in these studies was typically negative. In other words, energy consumed in the post-exercise meal is typically demonstrated to not fully compensate for energy expended from the exercise session performed prior.

In addition, strengthening the notion that compensatory/licensing behaviour favouring weight gain are employed in this situation, estimates of free-living physical activity levels following the experimental session were found to be significantly lower after SE compared with SO. Taken together, these findings fit the maladaptive outcomes proposed by the CHB model by suggesting that individuals typically fall short of their goals when “borrowing” health-promoting behaviour from future progress compared with healthy behaviour performed before indulgence. This has important implications regarding the impact of food intake and exercise performance order on exercise prescription guidelines for weight-management.

A number of limitations apply to the present study. While the total sample size met recommendations to detect energy intake differences of repeated ad-libitum meals (Gregersen et al., 2008), present study outcomes may be limited by the sample size when split to compare groups (i.e. restrained vs non-restrained eaters). Next, the targeted recruitment of only men with a BMI of above 23 kg/m² may not allow our findings to be representative for both genders and weight-range. Further, our findings on energy intake at the experimental session are also only limited to the type of test-meal used; palatable, snack food (potato-crisps). Therefore, whether these findings apply to women, men of different weight-range, and apply to other food types (i.e. non-snack/meal type) will require future research. Finally it should be noted that, in order to limit potential bias and demand characteristics from the suggestion of compensatory health behaviours, an explicit measure of participants’ tendency of employing compensatory health beliefs (CHB Scale; Knäuper et al. (2004)) was not administered for the present study –

465 dietary restraint was instead used as an indirect indicator of susceptibility to CHBs in the
466 domain of energy intake.

467 In summary, this study's main findings suggest i) that inactive overweight restrained-eaters
468 appear to employ compensatory health beliefs and adjust their eating behaviour depending on
469 perceived healthiness of upcoming events, such as anticipated exercise, and ii) that these
470 individuals may have inaccurate expectations of impending health-promoting behaviors (i.e.,
471 exercise), and potentially overestimate its effectiveness to expend energy from prior food
472 intake. Accordingly, given today's modern busy lifestyle, where we frequently find ourselves
473 having to schedule opportunities to exercise around other commitments (e.g. at the end of a
474 workday), findings from the present study may have significant implications for exercise
475 prescription guidelines for weight management. That is, the order of food intake and exercise
476 appear to play an important role, especially in restrained-eaters, in influencing subsequent
477 energy balance - favouring snack and food consumption to be scheduled after the exercise
478 rather than before. Importantly, these findings may provide some insight into why,
479 paradoxically, both exercise rates and weight gain could both be on the rise.

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486 **Conflict of interest**

487 The authors have no conflict of interest to declare.

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