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Research report

A brisk walk, compared with being sedentary, reduces attentional bias and chocolate cravings among regular chocolate eaters with different body mass ☆

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ABSTRACT

Poor self-regulation of high energy snacking has been linked to weight gain. Physical activity can acutely reduce chocolate consumption and cravings but the effects on attentional bias (AB) are unknown. The study aimed to test the effects of exercise among normal and overweight/obese individuals during temporary and longer abstinence. Participants were 20 normal and 21 overweight regular female chocolate eaters (after 24 h abstinence), and 17 females (after ⩾1 week abstinence during Lent). They were randomly assigned to engage in 15 min brisk walking or rest, on separate days. AB was assessed using an adapted dot probe task pre and post-treatment at each session, with chocolate/neutral paired images presented for 200 ms (initial AB; IAB) or 1000 ms (maintained AB; MAB). Chocolate craving was assessed pre, during, immediately after, and 5 min and 10 min after treatment, using a 0–100 visual analogue score. Three-way mixed ANOVAs revealed that there was no significant interaction effect between group (i.e., BMI status, or abstinence status) and condition × time for craving and AB to chocolate cues. Fully repeated 2-way ANOVAS revealed a significant condition × time interaction for IAB ($F(1,57) = 6.39$) and chocolate craving ($F(2.34,133.19) = 14.44$). After exercise IAB ($t(57) = 2.78$, $p < 0.01$) was significantly lower than after the rest condition. Craving was significantly lower than the rest condition at all assessments post-baseline. A short bout of physical activity reduces cravings and AB to chocolate cues, relative to control, irrespective of BMI or abstinence period.

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Introduction

Subtle accumulative weight gain over time can result from poor self-regulation of daily snacking on high energy food sources, such as chocolate (Berteus Forslund, Torgerson, Sjostrom, & Lindroos, 2005; Bes-Rastrollo et al., 2010). Chocolate is a commonly craved food (Bruinsma & Taren, 1999; Rodríguez et al., 2007; Rozin, Levine, & Stoess, 1991), particularly among women, since it is highly palatable and associated with positive affect (Hetherington, 2001; Weingarten & Elston, 1990), and may share some features of addiction (Avena, Rada, & Hoebel, 2008; Hetherington & MacDiarmid, 1993).

Recent interest has extended from simple self-reported measures of craving to cognitive mechanisms (e.g., attentional bias (AB); Tapper, Pothos, & Lawrence, 2010). The Incentive-Sensitization Theory (Robinson & Berridge, 1993) and Elaborated Intrusion (EI) Theory (Kavanagh, Andrade, & May, 2005) underpin the idea that cravings and attentional bias can contribute to behaviour (Field, Maunafo, & Franken, 2009). Substance-related conditioned stimuli acquire the ability to grab attention and elicit cravings prior to substance-seeking behaviour (Field & Cox, 2008; Mogg, Bradley, Field, & De Houwer, 2003; Mogg, Field, & Bradley, 2005). Indeed, AB has been associated with self-reported craving (Field et al., 2009; Werthmann, Roefs, Nederkoorn, & Jansen, 2013), the level of substance dependence, and repeated unsuccessful quit attempts (Bradley, Mogg, Wright, & Field, 2003). Two different attentional processes appear to occur: Initial attentional bias (IAB) indicates a rapid automatic shift in attention when stimuli appear (e.g., 100–500 ms) and maintained attentional bias (MAB) is the subsequent AB to cues with longer exposure (e.g., 500–1000 ms) (Brignell, Griffiths, Bradley, & Mogg, 2009; Field & Cox, 2008; Mogg et al., 2005). The former is thought to indicate approach tendencies to a substance, but there is less clarity on the meaning of the latter. Substance users may consciously seek to avoid visual contact with substance images (i.e., avoidance) but others may be continually drawn to the cue, thus reflecting enhanced maintained AB. There is, nevertheless, a need for further research on AB and food cues,

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using a range of methods (e.g., eye tracking technology, modified dot probe task, event-related potential), and with specific food which may have strong attention capturing properties.

Several factors may influence craving and AB to food cues, such as individual differences and duration of deprivation from the specific food (Brignell et al., 2009; Nijs & Franken, 2012). Different responses between low and high body mass index groups on food cues have been reported in the literature (Nijs, Muris, Euser, & Franken, 2010). In a review paper, Volkow, Wang, and Baler (2011) reported that obese, compared with normal weight people, showed increased activation of reward-related brain regions (e.g., NAc, ACC, amygdala, hippocampus) when they were exposed to high-calorie foods. Ferriday and Brunstrom (2011) found that after cue exposure an overweight group showed greater response and greater motivation to consume food than a normal weight group. In an AB study, overweight females tended to have greater IAB to food in the hunger condition and gazed longer at food in the fed condition compared with normal weight females (Castellanos, Charboneau, Dietrich, et al., 2009): But this and other studies (e.g., Nijs et al., 2010; Werthmann et al., 2011) have not focused on AB among people with specific food interests. In a study involving habitual chocolate cravers, cue elicited cravers had greater AB to chocolate cues (Kemps & Tiggemann, 2009), with greater difficulty in disengaging from images (i.e., MAB).

In chocolate studies, to elicit craving, participants have been asked to abstained from eating chocolate for 1–2 days (Tapper et al., 2010), and it may be that an even longer-term abstinence (e.g., a week) elicits greater cravings. There is no biochemical verification test to confirm chocolate abstinence (unlike checks for smoking and alcohol abstinence) but many people do self-report abstaining during Lent and may be a useful population to examine chocolate cravings and AB. Also, involving naturally abstaining participants may provide greater generalizability than studies involving experimentally manipulating abstinence.

An increase in global obesity has been attributed to an increase in energy intake rather than a decline in total energy expenditure (Westerterp & Speakman, 2008), though there has been an increase in sedentary behaviour. Indeed sedentary time has been inversely associated with cardiometabolic (Henson et al., 2013) and mental health (Teychenne, Ball, & Salmon, 2010), and also with poor self-regulation of snacking, independent of hunger and appetite (Taylor & Ussher, 2013). If humans associate physical movement with reward and pleasure then sedentary time may lead to alternative conditioned reward seeking behaviours from food and other hedonic behaviours.

The enhancing effect of exercise on self-regulation of substance use (i.e., smoking and alcohol) has received considerable recent interest (Taylor, 2013; Haasova et al., 2013; Ussher, Sampuran, Doshi, West, & Drummond, 2004). Although the acute and chronic effects of exercise on hunger and appetite have been reported (e.g., Hopkins, King, & Blundell, 2010), few studies have examined the effect of exercise on food craving and snacking, among regular snackers. These few studies have reported that exercise reduces chocolate consumption in a work-simulation situation (Oh & Taylor, 2012), chocolate craving (Taylor & Oliver, 2009), visual attentional bias (using eye tracking technology) to snack food video clips (versus matched clips with neutral images) among abstinent smokers who reported frequent snacking (Oh & Taylor, 2013) and urge to snack (Thayer, Peters, Takahashi, & Birkhead-Flight, 1993). In the study by Oh and Taylor (2012) there was a trend for the greatest ad libitum consumption to occur after a 'low demand' (rather than 'high demand') mental task and rest (rather than exercise), which may suggest that boredom or deactivation may allow on-going thoughts about chocolate (even with none present). Thus increased cravings and attentional bias to such cues may eventually lead to a failure in self-regulation. All the above studies involved normal weight samples and only a few days of self-reported abstinence (except Thayer's study which involved no manipulated abstinence). If chocolate cravings and AB are greater among overweight and obese, and among those with longer abstinence, there may be greater scope to observe if a short bout of physical activity can have an effect on these chocolate outcomes.

Thus, the main aim was to assess whether a 15-min brisk walk, compared with a passive rest condition, decreased both IAB and MAB to chocolate images, using the dot probe task, and self-reported craving for chocolate. Secondary aims were to examine if any effects of exercise were moderated by weight, duration of abstinence, the tendency to be an emotional eater, and trait chocolate cravings.

We therefore hypothesised that brisk walking will cause a decrease in AB and subjective cravings for chocolate among abstinent regular chocolate eaters, compared with a passive control condition who have time to think about chocolate. It was expected that the effects may be more evident among those who are overweight/obese or have a strong craving after a longer period of abstinence.

Methods

Participants

Following approval by the Institutional Ethics Committee, participants were recruited through public messages (posted on walls and through email communication) or were given a flyer on the street and were screened by telephone. Previous research had revealed that overweight/obese individuals did not tend to respond to simple adverts, so we explicitly worded adverts to request those who had weight concerns. Similarly, specific adverts were circulated to target those abstaining from chocolate consumption during Lent. All participants who were 18–45 years of age were eligible for the study if they ate at least 100 g of chocolate (i.e., 2 chocolate bars) per day and responded in favour of having an interest in chocolate, using the following questions: "How would you describe the experience of eating chocolate?"; "I often have cravings for sweets", and "I often have craving for chocolate" using a 6-point Likert scale (1 = *very unpleasant or strongly disagree*, 6 = *very pleasant or strongly agree*). The value for each item was added and participants were eligible if their total score was greater than 12 out of a possible 18. An upper age limit of 45 years was used to comply with laboratory testing procedures to minimise risk when working with obese participants.

A previous pilot study (Taylor, Oliver, & Janse van Rensburg, 2009) informed our sample size calculations. They reported an effect size of 0.88 for the difference in AB to snack food following a 15 min moderate intensity cycle v. 15 min rest. We estimated that for a within-subject design, with a power of 0.95, and alpha of 0.05, a sample size of at least 19 per group would be needed to detect differences in AB to snacking images, involving a within-subjects design.

Procedures

Eligible participants were initially asked to record a 3-day chocolate diary then abstain from snacking on the 4th day guided by previous research (Tiggemann, Kemps, & Parnell, 2010). Participants who were planning to or were actually abstaining from chocolate during Lent were required to be abstinent for at least 1 week. After eating a normal meal (breakfast or lunch), they were asked not to eat, drink (except water) or exercise for 2 h prior to coming to the lab for each session. Upon arrival on Day 1, participants provided written informed consent. Height, weight, and physical activity (using the 7-day recall of Physical Activity questionnaire;

Blair et al., 1985) were measured. Chocolate diaries were collected to check abstinence from chocolate consumption. Trait chocolate craving was measured by the modified Food Chocolate-Craving Questionnaire-Trait (FCCQ-T) (Cepeda-Benito et al., 2000), which consists of 39 items on a 6-point scale from 1 (never or not applicable) to 6 (always).

The participants completed the Physical Activity Readiness Questionnaire (ACSM, 2009), to confirm that they could safely complete a short bout of moderate intensity physical activity. After the baseline screening and measurements, participants were asked to choose their favourite chocolate bar from a basket of fun-size wrapped chocolate bars and to write down the name of the chocolate bar, to induce chocolate craving. Participants then rated state chocolate cravings during the testing session at the following times: pre (i.e., after 1st dot probe task); during, immediately after, 5 min after (i.e., after 2nd dot probe task) and 10 min after treatment. Each group (normal, overweight, and 'Lenters') were randomly assigned, in a counterbalanced cross-over design, to engage in two conditions: 15 min being passive or a brisk walk, on separate days, at least 4 days apart. Treatment sessions were carried out in the room adjacent to where AB was measured. At the start of each session, participants were fitted with a heart rate monitor which was worn throughout the session to assess exercise intensity.

AB was measured by the visual dot probe task. The participants were seated at a desk in front of a computer and asked to do the experimental task before and after treatment. After the 2nd visual dot probe task, participants were seated for 5 min in a quiet room. After that, the level of chocolate craving was recorded. At the end of the 2nd laboratory session, participants received a small payment for their participation in the study.

Exercise treatment

The exercise session consisted of a 2 min warm-up, followed by a 15 min semi self-paced brisk walk on a treadmill. To monitor the participants' exercise intensity, heart rate and Rating of Perceived Exertion (RPE; 6-20 Borg Scale) (Borg, 1998) were used. Participants were instructed to walk at a level between 11 (*fairly light*) and 13 (*somewhat hard*) 'as if late for a bus or appointment, but not to the point of breathlessness.' RPE was reported by participants every 3 min and heart rate (HR) was automatically collected every 15 s.

Passive treatment

Participants were required to sit passively and quietly at a desk for 15 min with no access to reading materials, computers or phones. No food related stimuli were in view.

Measures

AB

AB was assessed using a modified visual dot probe task (Kemps & Tiggemann, 2009) with chocolate-related pictures. The chocolate and neutral images were used in a previous study (Taylor et al., 2009). They consisted of carefully selected pictures of just a chocolate bar, someone eating chocolate, a chocolate box, a display stand of chocolate in a shop, designed to be of relevance to most regular chocolate consumers. Neutral images were non-emotional and non-food items (e.g., office supplies). The images were considered for their shape, size, and luminescence before matching as a pair. Each trial began with a central black fixation cross on a white background for 1000 ms, followed by a pair of images, which were presented for either 200 ms (to capture IAB) or 1000 ms (to capture MAB). After 5 practice trials, 60 critical trials were displayed. Each block contained 2 buffer trials and 60 images: 20 critical pairs (chocolate/neutral images) for 200 ms, 20 critical pairs (chocolate/neutral images) for 1000 ms, 20 filler pairs (neutral/neutral images) of 200 and 1000 ms. Paired images were presented side by side, but randomly displayed on the left or right. After the pair of images disappeared, a 2 mm wide black dot probe appeared randomly behind where one of the images had been. The participants were required to respond as quickly as possible to the probe by pressing a designated key on a computer keyboard for left and right. The dot probe was displayed until a response was made. Reaction time (RT) and errors performed were collected using E-Prime software. Differences in RT to the dot probe when appearing behind the chocolate v neutral image were calculated, to determine AB.

Chocolate craving

Participants marked a cross on a 100 mm visual analogue scale in response to the question "How much do you crave chocolate at this very moment?") (Smeets, Roefs, & Jansen, 2009). A value from 0 to 100 was calculated.

Data analysis

For all statistical analyses, SPSS (version 18) was used. We initially cleaned AB reaction time (RT) data. A total of 1.7% of responses were incorrect, and 4.3% of data were identified as outliers (i.e., when RT was <200 ms, or >2000 ms, or ±2SD of the mean) and these data were excluded. Baseline values for FCCQ-T, AB, and chocolate craving, were compared using a one-way ANOVA to identify possible group (normal weight, overweight, Lent) differences prior to each session. Each group was compared for achieved level of exercise intensity (using HR and RPE) as a manipulation check, using a one-way ANOVA. Next, the outcomes were analysed in a 3-way mixed ANOVA to identify any moderating effect of sample group (normal or overweight and temporarily abstinent or Lenters) on condition (exercise or rest) $\times$ time (as described above) interactions. The analysis plan was that if there were no moderating effect of sample group then the main and interactive effects of condition and time on self-reported craving and AB would be analysed with a 2-way fully repeated ANOVA. Following any significant interaction effect, post hoc paired *t*-tests were conducted to determine post treatment differences between conditions and also changes from pre-treatment to subsequent assessments for both conditions. The significance level was set at $p < 0.05$ for all statistical tests, and Bonferroni correction was applied when multiple *t*-tests were administered.

Results

A total of 20 normal weight (BMI < 25) and 21 overweight females (BMI > 25) both undergoing temporary chocolate abstinence, and 17 females (12 normal weight and 5 overweight) abstaining from chocolate during Lent (i.e., religious period when many abstain from snack food) for at least one week, with mean age (SD) of 29.6 (11.5) years took part.

The participants' background characteristics are shown in Table 1. BMI was significantly different among three groups as expected. FCCQ-T was significantly higher in the TA overweight group and the Lent group, compared with the TA normal weight group, $p < 0.01$.

Mean (SD) values of baseline score of outcome variables, and HR and RPE are shown in Table 2. The results revealed that there were no significant differences between groups at baseline for any of the outcome variables, and all groups exercised at a similar intensity. The overall mean (SD) for HR, RPE, and % of HR reserve (HRR) during exercise was 123.1 bpm (14.7), 12.5 (0.5), and 43.9% (12.8),

Table 1
Mean (SD) baseline scores for age, BMI, trait chocolate cravings, and daily energy expenditure.

Variables	Mean (SD) score		
	Normal weight –TA ($N = 20$)	Overweight–TA ($N = 21$)	Lent–Abstainers ($N = 17$)
Age (years)	23.90 (6.87)[a]	38.14 (11.56)[a,c]	25.88 (9.67) [c]
BMI (kg/m^2)	22.44 (1.88)[a]	30.62 (4.38)[a,c]	22.68 (2.88) [c]
FCCQ-T	108.70 (24.71)[a,b]	133.95 (31.14)[a]	132.12 (27.18) [b]
Daily EE (kcal/kg/d)	35.42 (1.78)	34.68 (2.92)	34.01 (1.80)

Abbreviations: TA, temporarily abstinent; FCCQ-T, trait chocolate craving; daily EE, daily energy expenditure (kcal/kg/d).
[a] Significant difference between normal weight-TA and overweight-TA (with Bonferroni correction, $p < 0.01$).
[b] Significant difference between normal weight-TA and lent-abstainers (with Bonferroni correction, $p < 0.01$).
[c] Significant difference between overweight-TA and lent-abstainers (with Bonferroni correction, $p < 0.01$).

Table 2
Baseline means (SD) for the outcome variables, and exercise intensity by sample group.

Baseline	Normal weight $N = 20$	Overweight $N = 21$	Lent $N = 17$
AB (ms)			
IAB	14.69 (50.03)	18.27 (40.46)	14.66 (34.72)
MAB	10.46 (29.75)	32.86 (67.67)	10.78 (40.63)
Chocolate craving (VAS)	46.46 (23.10)	39.99 (29.73)	54.09 (25.06)
Resting HR (bpm)	74.56 (9.86)	77.43 (9.19)	72.97 (12.14)
Exercise HR (bpm)	121.83 (14.89)	128.51 (13.83)	117.81 (14.05)
Exercise RPE	12.59 (0.34)	12.55 (0.45)	12.38 (0.60)

Notes: VAS (Visual Analogue Scale; 0–100); HR, heart rate; RPE, Rating of Perceived Exertion (6–20).

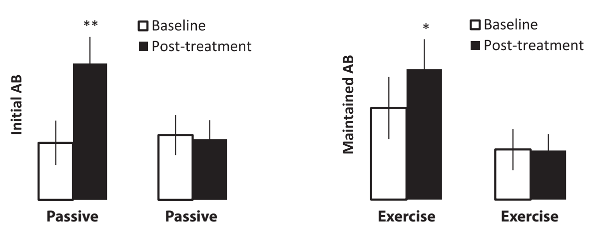

Fig. 1. Mean (SEM) initial and maintained attentional bias (ms) over time, by condition. *Note*. $^{**}p < 0.01$; $^{*}p < 0.05$ refers to contrast between passive condition and exercise condition at post-treatment.

confirming that participants exercised at a moderate exercise (ACSM, 2009).

Group (i.e., normal or overweight, or Lenters) did not moderate condition x time interactions for AB or chocolate craving. Therefore, the main and interactive effects of condition and time for each outcome was assessed with data from all 3 groups combined. Session order did not interact with any outcome variables at baseline. Dependent t-tests showed that there was no significant baseline difference between conditions for any outcome measure.

ANOVAs revealed that there was a significant interactive effect of condition × time for IAB, ($F(1,57) = 6.39$, $p < 0.05$, and only a main effect of condition for MAB, ($F(1,57) = 4.80$, $p < 0.05$ (see Fig. 1).

Dependent t-tests showed that IAB was significantly greater in the passive control, compared with the exercise condition at post-treatment, $t(57) = 2.78$, $p < 0.01$ (95% CI 5.53 to 34.21, ES $d = 0.42$). However, in the passive condition, IAB was significantly increased compared with baseline, $t(57) = -2.84$, $p < 0.01$ (95% CI −35.43 to −6.14, ES $d = 0.42$), with no change in the exercise condition. The mean (SD) of the change scores of IAB were 20.78 (55.69) in the passive condition and −1.11 (42.54) in the exercise condition.

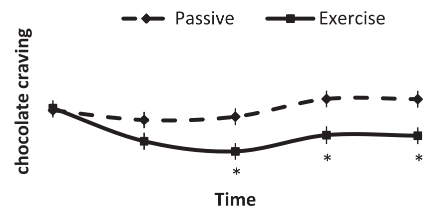

Fig. 2. Mean (SEM) chocolate craving over time by condition. *Note*. Time 1 = pre-treatment; 2 = during-treatment; 3 = immediately after-treatment; 4 = 5 min after-treatment; 5 = 10 min after-treatment; $^{*}p < 0.001$ refers to significant difference in chocolate craving between passive and exercise conditions.

ANOVAs revealed a significant interactive effect of condition × time for chocolate craving, $F(2.34,133.9) = 14.44$, as shown in Fig. 2.

Dependent *t*-tests revealed that chocolate craving was significantly lower after exercise, compared with rest, at immediately after treatment ($t(57) = 3.67$, $p = 0.001$, 95% CI 7.26–24.67, ES $d = 0.54$), 5 min after treatment ($t(57) = 3.76$, $p < 0.001$, 95% CI 7.77 to 25.51, ES $d = 0.55$) and 10 min after treatment ($t(57) = 4.15$, $p < 0.001$, 95% CI 8.69–24.90, ES $d = 0.57$). In the exercise condition, compared to baseline, chocolate craving was significantly lower at mid ($t(57) = 4.68$, $p < 0.001$), immediately after ($t(57) = 5.26$, $p < 0.001$), 5 min after ($t(57) = 4.68$, $p = 0.001$), and 10 min after treatment ($t(57) = 4.11$, $p < 0.001$). In the passive condition, there was no change from baseline to any follow-up assessment. The mean (SD) change (from pre to post treatment) for craving was −2.96 (20.70) in the passive condition and −19.91 (28.82) in the exercise condition.

Discussion

This is the first study to examine the effects of moderate intensity exercise on chocolate craving and AB to chocolate-related cues among normal and overweight/obese regular chocolate eaters who had abstained from chocolate snacking for different periods. A 15 min bout of moderate intensity exercise significantly reduced chocolate craving and IAB to chocolate images, compared with 15 min of being passive. The present study complements previous studies that have shown that a brief bout of physical activity reduces actual chocolate consumption (Oh & Taylor, 2012), chocolate cravings (Taylor & Oliver, 2009), and IAB and MAB to snack food (among abstaining smokers) (Oh & Taylor, 2013) and high energy snacking urges (Thayer et al., 1993).

The differences in IAB post-treatment appeared to be due to absolute increases in AB from pre to post being passive, rather than reductions from pre to post walking. Participants in the control condition had un-wrapped a chocolate bar, watched images of chocolate in the initial dot probe task and then been required to sit without any distractions for 15 min. The Elaborated Intrusion (EI) Theory (Kavanagh et al., 2005) may help to explain how these initial cues could increase salience of images (i.e., IAB). Deliberately trying to suppress thoughts of chocolate while sitting may have provided an opportunity for continued thoughts and cravings about chocolate. Induced chocolate cravings have previously been associated with greater AB to food cues (Kemps & Tiggemann, 2009). Future studies could also ask participants in the control condition what they were thinking about.

One possible explanation for the observed differences between the two conditions was that concentrating on treadmill walking did help to suppress thoughts about chocolate and seemingly the initial attraction to chocolate images. Future studies should compare exercise and passive conditions in which participants are required to have a cognitive focus on thoughts unrelated or related to chocolate, or allowed freedom of thought to determine any effects on attentional bias to determine how exercise interacts with cognitive mechanisms. Previous studies have only tried to eliminate distraction as an explanation for exercise by comparing it with conditions such as watching a video (Ussher, Nunziata, Cropley, & West, 2001) and performing cognitively demanding tasks (Daniel, Cropley, & Fife-Schaw, 2006) on cigarette cravings.

Although the present findings suggested only a significant treatment effect on IAB, the effect size was also moderately large for MAB (indicating a reduction in AB). However, this is consistent with another study (Oh & Taylor, 2013) on the effects of acute moderate and vigorous physical activity on AB to short video clips showing snack food versus neutral objects, using eye-tracking technology. Vigorous intensity exercise significantly reduced both IAB and MAB, whereas cycling, at a comparable intensity to the walking in the present study, only reduced IAB. In the same study, moderate intensity exercise did reduce both IAB and MAB to smoking related video clips, and self-reported cravings were also reduced in both conditions, compared with rest.

A single bout of exercise has now also been widely shown to reduce self-reported cravings (Taylor, Ussher, & Faulkner, 2007; Haasova et al., 2013; Ussher et al., 2001), AB for cigarettes (Janse Van Rensburg, Taylor, & Hodgson, 2009; Taylor & Katomeri, 2007), and alcohol (Ussher et al., 2004). Also, animal studies have shown that exercise reduces self-administered use of substances, such as amphetamine, ethanol and cocaine, possibly by decreasing the positive-reinforcing effects of these substances (Smith & Lynch, 2011). The precise mechanisms remain unknown but shifts in regional brain activation observed after exercise, compared with rest, associated with viewing images of cigarettes (among abstinent smokers) (Janse Van Rensburg, Taylor, Benattayallah, & Hodgson, 2012; Janse Van Rensburg, Taylor, Hodgson, & Benattayallah, 2009), may provide the basis for further exploration of neuro-cognitive processes and food cravings. Recent papers provide some evidence to support this (Cornier, Melanson, Salzberg, Bechtell, & Tregellas, 2012; Evero, Hackett, Clark, Phelan, & Hagobian, 2012).

We expected that the overweight/obese group would have stronger cravings and AB at baseline, based on previous studies, and speculatively this could have led to greater effects of a bout of physical activity, compared with a passive condition. However, no differences were found between groups at baseline, and group did not moderate the effects of exercise on outcomes. Castellanos et al. (2009) used eye tracking technology together with a dot probe task (with stimuli exposure duration of 2000 ms) to examine AB for food-related images among normal weight and obese people. They did not find any differences between normal weight and an obese group who were in a state of hunger, though this may have been due to the focus on maintained AB. On the other hand, when participants had recently eaten, obese individuals had a greater AB (from eye tracking data) towards general food images (e.g., ice cream, pizza, apples, broccoli) compared with normal weight. A direct comparison cannot be made with the present study that focused solely on chocolate images among regular chocolate eaters who were abstinent from chocolate.

We was also hypothesised that longer abstinence from eating chocolate (i.e., at least a week during Lent) may lead to greater baseline (state) chocolate cravings than temporarily abstinence. However, we did not find this even though those abstaining for longer did have higher trait chocolate cravings. It may be that beyond a day, additional abstinence does not lead to further increases in cravings for chocolate. Also, abstinence did not moderate the observed effects of exercise on self-reported cravings and AB.

There are several limitations of the present study. Firstly, females are more likely to crave food and prefer snack food than males so it is unclear if the findings would generalise to males. Also, we did not seek to control for the potential effects of menstrual cycle on cravings. Future studies could seek to involve women at a time in the cycle when cravings may be at their greatest, though with the present cross-over design, with at least 4 days between treatment sessions, this would be a challenge. Secondly, although the AB task in the present study used a similar number of images to previous studies there is scope for future studies to tailor the presentation of images to the chocolate preferences of each participant. Thirdly, Nijs and Franken (2012) raised concern about the validity of using the dot probe task to capture MAB, suggesting that rapid eye wandering between salient and neutral image may occur up until the stimulus disappears and the dot appears. It may be that the greater measurement error due to the greater scope for random eye movement between images reduced the opportunity to detect differences after the exercise and control conditions. Fourthly, we do not know what the short-term test–retest reliability is for the measures of AB, and measurement error may have contributed to a lack of power to detect differences between the conditions for MAB. Further research is needed to explore the validity and reliability of the measures used. Lastly, the effects of only a short bout of moderated intensity exercise was examined in the present study: Further studies are needed to explore dose response effects, involving different intensities and durations of exercise on snack food cravings and AB to images.

The findings in this study imply that a short bout of physical activity, compared with rest, could help to regulate dysfunctional eating among normal or overweight/obese females. The presence of chocolate, for some, provides a continual challenge in daily life to resist snacking. Sedentary behaviour and boredom (Koball, Meers, Storfer-Isser, Domoff, & Musher-Eizenman, 2012) may lead chocolate cues to grab attention and place susceptible individuals with a need to exert greater self-control. In contrast, short bouts of physical activity may prevent increases in AB and reduce chocolate cravings. The clinical significance of the findings are that regular short bouts of physical activity may reduce snacking behaviours that can contribute to weight gain (Bes-Rastrollo et al., 2010) and less weight loss during an attempt to reduce weight (Kong et al., 2011). The relative reduction of IAB to chocolate images (e.g., chocolate adverts, chocolate packets, watching others eat chocolate) after such physical activity may mean an enhanced ability to inhibit a conditioned response associated with pleasure and reward.

Conclusion

A short bout of moderate intensity exercise suppressed attentional bias for chocolate cues and subjective chocolate craving for normal and overweight/obese, and short and longer abstainers, relative to sitting unoccupied. Disrupting sedentary time with short walks may reduce sub-conscious snacking.

References

American College of Sports Medicine (ACSM). (2009). *ACSM's Guidelines for Exercise Testing and Prescription* (8th ed). NY: Lippincott Williams & Wilkins.

Avena, N. M., Rada, P., & Hoebel, B. G. (2008). Evidence for sugar addiction. Behavioral and neurochemical effects of intermittent, excessive sugar intake. *Neuroscience and Biobehavioral Reviews, 32*, 20–39.

Berteus Forslund, H., Torgerson, J. S., Sjostrom, L., & Lindroos, A. K. (2005). Snacking frequency in relation to energy intake and food choices in obese men and women compared to a reference population. *International Journal of Obesity, 29*, 711–719.

Bes-Rastrollo, M., Sanchez-Villegas, A., Basterra-Gortari, F. J., Nunez-Cordoba, J. M., Toledo, E., & Serrano-Martinez, M. (2010). Prospective study of self-reported usual snacking and weight gain in a Mediterranean cohort. The SUN project. *Clinical Nutrition, 29*, 323–330.

Blair, S. N., Haskell, W. L., Ho, P. J., Paffenbarger, R. S., Jr., Vranizan, K. M., Farquhar, J. W., et al. (1985). Assessment of habitual physical activity by a 7-day recall in a community survey and controlled experiments. *American Journal of Epidemiology, 122*, 794–804.

Borg, G. A. V. (1998). *Borg's perceived exertion and pain scales*. Champaign: Human Kinetics.

Bradley, B. P., Mogg, K., Wright, T., & Field, M. (2003). Attentional bias in drug dependence. Vigilance for cigarette-related cues in smokers. *Psychology of Addictive Behavior, 71*, 66–72.

Brignell, C., Griffiths, T., Bradley, B. P., & Mogg, K. (2009). Attentional and approach biases for pictorial food cues. Influence of external eating. *Appetite, 52*, 299–306.

Bruinsma, K., & Taren, D. L. (1999). Chocolate. Food or drug? *Journal of the American Dietetic Association, 99*, 1249–1256.

Castellanos, E. H., Charboneau, E., Dietrich, M. S., et al. (2009). Obese adults have visual attention bias for food cue images. Evidence for altered reward system function. *International Journal of Obesity, 33*, 1063–1073.

Cepeda-Benito, A., Gleaves, D. H., Fernandez, M. C., Vila, J., Williams, T. L., & Reynoso, J. (2000). The development and validation of Spanish versions of the State and Trait Food Craving Questionnaires. *Behavior Research and Therapy, 38*, 1125–1138.

Cornier, M. A., Melanson, E. L., Salzberg, A. K., Bechtell, J. L., & Tregellas, J. R. (2012). The effects of exercise on the neuronal response to food cues. *Physiology Behavior, 105*, 1028–1034.

Daniel, J. Z., Cropley, M., & Fife-Schaw, C. (2006). The effect of exercise in reducing desire to smoke and cigarette withdrawal symptoms is not caused by distraction. *Addiction, 101*, 1187–1192.

Evero, N., Hackett, L. C., Clark, R. D., Phelan, S., & Hagobian, T. A. (2012). Aerobic exercise reduces neuronal responses in food reward brain regions. *Journal of Applied Physiology, 112*, 1612–1619.

Ferriday, D., & Brunstrom, J. M. (2011). 'I just can't help myself'. Effects of food-cue exposure in overweight and lean individuals. *International Journal of Obesity, 35*, 142–149.

Field, M., & Cox, W. M. (2008). Attentional bias in addictive behaviors. A review of its development, causes, and consequences. *Drug and Alcohol Dependence, 97*, 1–20.

Field, M., Maunafo, M. R., & Franken, I. H. A. (2009). A meta-analytic investigation of the relationship between attentional bias and subjective craving in substance abuse. *Psychological Bulletin, 135*, 589–607.

Haasova, M., Warren, F. C., Ussher, M., Janse Van Rensburg, K., Faulkner, G., Cropley, M., Byron-Daniel, J., Everson-Hock, E. S., Oh, H., & Taylor, A. H. (2013). The acute effects of physical activity on cigarette cravings. Systematic review and meta-analysis with individual participant data (IPD). *Addiction, 108*, 26–37.

Henson, J., Yates, T., Biddle, S. J., Edwardson, C. L., Khunti, K., Wilmot, E. G., et al. (2013). Associations of objectively measured sedentary behaviour and physical activity with markers of cardiometabolic health. *Diabetologia, 56*, 1012–1020.

Hetherington, M. M. (2001). Chocolate. From adoration to addiction. In M. M. Hetherington (Ed.), *Food cravings and addiction* (pp. 295–325). London: Leatherhead Publishers.

Hetherington, M. M., & MacDiarmid, J. I. (1993). "Chocolate addiction". A preliminary study of its description and its relationship to problem eating. *Appetite, 21*, 233–246.

Hopkins, M., King, N. A., & Blundell, J. E. (2010). Acute and long-term effects of exercise on appetite control. Is there any benefit for weight control? *Current Opinion in Clinical Nutrition Metabolic Care, 13*, 635–640.

Janse Van Rensburg, K., Taylor, A. H., Benattayallah, A., & Hodgson, T. (2012). The effects of exercise on cigarette cravings and brain activation in response to smoking-related images. *Psychopharmacology (Berl), 221*, 659–666.

Janse Van Rensburg, K., Taylor, A. H., & Hodgson, T. (2009). The effects of acute exercise on attentional bias towards smoking-related stimuli during temporary abstinence from smoking. *Addiction, 104*, 1910–1917.

Janse Van Rensburg, K., Taylor, A. H., Hodgson, T., & Benattayallah, A. (2009). Acute exercise modulates cigarette cravings and brain activation in response to smoking-related images. An fMRI study. *Psychopharmacology (Berl), 203*, 589–598.

Kavanagh, D., Andrade, A., & May, J. (2005). Imaginary relish and exquisite torture. The elaborated intrusion theory of desire. *Psychological Review, 112*, 446–467.

Kemps, E., & Tiggemann, M. (2009). Attentional bias for craving-related (chocolate) food cues. *Experimental Clinical Psychopharmacology, 17*, 425–433.

Koball, A. M., Meers, M. R., Storfer-Isser, A., Domoff, S. E., & Musher-Eizenman, D. R. (2012). Eating when bored. Revision of the emotional eating scale with a focus on boredom. *Health Psychology, 31*, 521–524.

Kong, A., Beresford, S. A., Alfano, C. M., Foster-Schubert, K. E., Neuhouser, M. L., Johnson, D. B., Duggan, C., Wang, C. Y., Xiao, L., Bain, C. E., & McTiernan, A. (2011). Associations between snacking and weight loss and nutrient intake among postmenopausal overweight to obese women in a dietary weight-loss intervention. *Journal of American Dietetic Association, 111*, 1898–1903.

Mogg, K., Bradley, B. P., Field, M., & De Houwer, J. (2003). Eye movements to smoking-related pictures in smokers. Relationship between attentional biases and implicit and explicit measures of stimulus valence. *Addiction, 98*, 825–836.

Mogg, K., Field, M., & Bradley, B. P. ((2005). Attentional and approach biases for smoking cues in smokers. An investigation of competing theoretical views of, addiction. *Psychopharmacology (Berl), 180*, 333–341.

Nijs, I. M., & Franken, I. H. (2012). Attentional processing of food cues in overweight and obese individuals. *Current Obesity Reports, 1*, 106–113.

Nijs, I. M. T., Muris, P., Euser, A. S., & Franken, I. H. A. (2010). Differences in attention to food and food intake between overweight/obese and normal weight females under conditions of hunger and satiety. *Appetite, 54*, 243–254.

Oh, H., & Taylor, A. H. (2013). Self-regulating smoking and snacking through physical activity. Health Psychology. http://dx.doi.org/10.1037/a0032423.

Oh, H., & Taylor, A. H. (2012). Brisk walking reduces ad libitum snacking in regular chocolate eaters during a workplace simulation. *Appetite, 58*, 387–392.

Robinson, T. E., & Berridge, K. C. (1993). The neural basis of drug craving. An incentive-sensitization theory of addiction. *Brain Research Reviews, 18*, 247–291.

Rodríguez, S., Warren, C. S., Moreno, S., Cepeda-Benito, A., Gleaves, D. H., Fernández Mdel, C., & Vila, J. (2007). Adaptation of the food-craving questionnaire trait for the assessment of chocolate cravings. Validation across British and Spanish women. *Appetite, 49*, 245–250.

Rozin, P., Levine, E., & Stoess, C. (1991). Chocolate craving and liking. *Appetite, 17*, 199–212.

Smeets, E., Roefs, A., & Jansen, A. (2009). Experimentally induced chocolate craving leads to an attentional bias in increased distraction but not in speeded detection. *Appetite, 53*, 370–375.

Smith, M. A., & Lynch, W. J. (2011). Exercise as a potential treatment for drug abuse. Evidence from preclinical studies. *Frontiers in Psychiatry, 2*, 82.

Tapper, K., Pothos, E. M., & Lawrence, A. D. (2010). Feast your eyes. Hunger and trait reward drive predict attentional bias for food cues. *Emotion, 10*, 949–954.

Taylor, A. H., Oliver, A., & Janse van Rensburg, K. (2009). The acute effects of exercise on visual attentional biases to chocolate-related images. In Paper presented at International Society of Sport Psychology conference, Morocco, June 2009.

Taylor, A. H., & Katomeri, M. (2007). Walking reduces cue-elicited cigarette cravings and withdrawal symptoms, and delays ad libitum smoking. *Nicotine & Tobacco Research, 9*, 1183–1190.

Taylor, A. H., & Oliver, A. (2009). Acute effects of brisk walking on urges to eat chocolate, affect, and responses to a stressor and chocolate cue. An experimental study. *Appetite, 52*, 155–160.

Taylor, A. H., Ussher, M. H., & Faulkner, G. (2007). The acute effects of exercise on cigarette cravings, withdrawal symptoms, affect and smoking behaviour. A systematic review. *Addiction, 102*, 534–543.

Taylor, A. H., & Ussher, M. (2013). Physical activity as an aid to smoking cessation. In P. Ekkekakis (Ed.), *Handbook on physical activity and mental health* (pp. 449–464). New York: Routledge.

Teychenne, M., Ball, K., & Salmon, J. (2010). Physical activity, sedentary behavior and depression among disadvantaged women. *Health Education Research, 25*, 632–644.

Thayer, R. E., Peters, D. P., III., Takahashi, P. J., & Birkhead-Flight, A. M. (1993). Mood and behavior (smoking and sugar snaking) following moderate exercise. A partial test of self-regulation theory. *Personality and Individual Differences, 14*, 97–104.

Tiggemann, M., Kemps, E., & Parnell, J. (2010). The selective impact of chocolate craving on visuo-spatial working memory. *Appetite, 55*, 44–48.

Ussher, M., Nunziata, P., Cropley, M., & West, R. (2001). Effect of a short bout of exercise on tobacco withdrawal symptoms and desire to smoke. *Psychopharmacology, 158*, 66–72.

Ussher, M., Sampuran, A. K., Doshi, R., West, R., & Drummond, D. C. (2004). Acute effect of a brief bout of exercise on alcohol urges. *Addiction, 99*, 1542–1547.

Volkow, N. D., Wang, G. J., & Baler, R. D. (2011). Reward, dopamine and the control of food intake. Implications for obesity. *Trends in Cognitive Sciences, 15*, 37–46.

Weingarten, H. P., & Elston, D. (1990). The phenomenology of food cravings. *Appetite, 15*, 231–246.

Werthmann, J., Roefs, A., Nederkoorn, C., & Jansen, A. (2013). Desire lies in the eyes. Attention bias for chocolate is related to craving and self-endorsed eating permission. *Appetite*, pii: S0195-6663(13)00313-9. 10.1016/j.appet.2013.06.087.

Werthmann, J., Roefs, A., Nederkoorn, C., Mogg, K., Bradley, B. P., & Jansen, A. (2011). Can(not) take my eyes off it. Attention bias for food in overweight participants. *Health Psychology, 30*, 561–569.

Westerterp, K. R., & Speakman, J. R. (2008). Physical activity energy expenditure has not declined since the 1980s and matches energy expenditure of wild mammals. *International Journal of Obesity, 32*, 1256–1263.