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Acute effect of exercise on alcohol urges and attentional bias towards alcohol related images in high alcohol consumers

Adrian H. Taylor*, Hwajung Oh, Sarah Cullen

College of Life & Environmental Science, University of Exeter, St. Luke's Campus, Heavitree Rd., Exeter, Devon EX1 2LU, UK

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ABSTRACT

Background: Short bouts of exercise can reduce cravings, attentional bias (AB) and substance use among abstaining smokers and snackers. Only one study has shown reduced alcohol cravings following exercise but none have investigated the effects on attentional bias. The aim of the present study was to examine whether a single session of exercise reduces AB towards alcohol-related images and alcohol urges among high alcohol consumers.

Methods: The study involved 20 abstaining (for $\geq$3 days) alcohol drinkers, consuming more than weekly recommendations, with a mean age (SD) = 20.8 (0.8) years. Participants were initially randomised in a counterbalanced cross-over design to undertake either (1) 15 min of brisk walking or (2) 15 min of passive seating on different days. Participants completed an adapted dot probe task, with matched neutral and alcohol images randomly presented for either 200 ms or 1000 ms to respectively measure initial (IAB) or maintained attentional bias (MAB) pre- and post-treatment. The Alcohol Urge Questionnaire (AUQ) was administered before, immediately after, and 5 and 10 min post treatment.

Results: A two-way fully repeated measures ANOVA revealed a significant condition $\times$ time interaction for MAB $F(1, 17) = 6.96$, $p = 0.017$, and AUQ scores $F(1.47, 27.96) = 60.19$, $p < 0.001$. MAB was significantly reduced following the exercise compared with the control condition. Differences in AUQ between conditions were significant at all assessments post treatment.

Conclusions: A short bout of exercise, compared with a passive control condition, may acutely reduce MAB to alcohol cues and alcohol urges, and thus may help with self-regulation of alcohol consumption.

1. Introduction

The consumption of alcohol at a level which is potentially or actually harmful to health occurs among 24% adults in England, particularly among 16–24 year old males (McManus, Meltzer, Brugha, Bebbington, & Jenkins, 2009). A variety of interventions are supported for tackling excessive alcohol consumption and treatment of alcoholism (National Institute of Health and Care Excellence – NICE, 2011). Depending on sport type there is some evidence that more physically active people tend to drink less (Liangpunsakul, Crabb, & Qi, 2010). The potential for exercise to reduce consumption or aid cessation has barely been assessed with rigorously designed studies, and the evidence is weak for an effect of chronic exercise training for reducing alcohol related outcomes (Abrantes, Matsko, Wolfe, & Brown, 2013; Donaghy & Ussher, 2005). Further research is needed to better understand how exercise may help to regulate alcohol consumption in order to design effective interventions.

Heavy alcohol consumption may reflect poor self-regulation over a behaviour that offers reward from which harm ensues (West, 2006). Urges for alcohol may arise from abstinence and environmental cues associated with drinking alcohol. Alcohol cues have been shown to increase cravings and consumption (MacKillop et al., 2010) and elicit activation of limbic and prefrontal regions, including ventral striatum, anterior cingulate and ventromedial prefrontal cortex (Schacht, Anton, & Myrick, 2013). Unless the craving is opposed by a conflicting motivational pressure it may result in alcohol seeking behaviour and consumption. In Robinson and Berridge's Incentive-Sensitization theory (Robinson & Berridge, 1993), a substance-related cue acquires incentive-motivational properties, and thus will 'grab attention' and guide an individual's behaviour towards the incentive. Selectively allocating attention to certain stimuli at the expense of others is known as attentional bias (AB) (Kwak, Na, Kim, Kim, & Lee, 2007; Waters & Feyerabend, 2000) and may be critical in developing and maintaining drug use (Field, Mogg, & Bradley, 2004; Waters, Shiffman,

* Corresponding author. Tel.: +44 (0)13952 264726; fax: +44 (0)13952 264747.
E-mail address: a.h.taylor@ex.ac.uk (A.H. Taylor).

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Bradley, & Mogg, 2003). AB has been positively associated with craving cross-sectionally (Field, Munafo, & Franken, 2009), and greater AB has been associated with a lower likelihood of remaining abstinent from substance use (Bradley, Mogg, Wright, & Field, 2003). Several studies have demonstrated a greater AB for alcohol related stimuli in alcohol dependent participants (Fadardi & Cox, 2006; Murphy & Garavan, 2011; Stormark, Laberg, Nordby, & Hugdahl, 2000) and in heavy compared with light social drinkers (Bruce & Jones, 2004; Field & Powell, 2007; Field & Quigley, 2009).

AB can be measured with a modified version of the Stroop task (Stroop, 1935), the visual dot probe task (MacLeod, Mathews, & Tata, 1986), and eye-tracking technology. The Stroop task may lack face validity in that it captures general inhibition rather than any specific salience of the substance of interest (Bruce & Jones, 2004; Cox, Fadardi, & Pothos, 2006). For example, the task may be to simply assess inhibition, and not necessarily inhibition to a salient cue. Eye tracking technology can be a valuable direct measure of bias but for studies involving repeated pre-post intervention assessments, difficulties with calibration can delay the precise timing when measures are taken. The dot probe task is an indirect measure which has previously been widely used to measure AB towards alcohol and other substances (Field, Mogg, Zetteler, & Bradley, 2004; Field & Quigley, 2009; Townshend & Duka, 2001). The task requires participants to focus on a central cross on a screen which is then replaced by a pair of images, usually one salient to the substance of interest and one neutral. The images disappear after varying (shorter or longer) periods, being replaced by a dot randomly appearing immediately behind one of the images. The task requires the participant to press a left or right button (depending on which side the dot appears) to record reaction time. Differences are calculated for mean reaction time between when the dot appears behind salient versus neutral images; one may expect a more rapid reaction time if the person is looking at a specific (salient) image. Two different attentional processes can be assessed with a dot probe task. Initial attentional bias (IAB) indicates where the first initial shift in visual attention is directed, and is thought to indicate automatic approach tendencies to a substance when the stimuli appears (e.g., within 100–500 ms). Maintained attentional bias (MAB) indicates where visual focus is directed when cues are available for longer (e.g., 500–1000 ms) (Brignell, Griffiths, Bradley, & Mogg, 2009; Field & Cox, 2008; Mogg, Field, & Bradley, 2005). Substance users may be continually drawn to the cue, thus reflecting maintained AB. Such is the relevance and importance of attentional bias to alcohol cues that attentional retraining programmes have been developed with some success at changing alcohol cravings, AB to alcohol cues and alcohol use (Wiers et al., 2006).

There is consistent and strong evidence that a single session of exercise can reduce cigarette cravings (Haasova et al., 2013; Roberts, Maddison, Simpson, Bullen, & Prapavessis, 2012; Taylor, Ussher, & Faulkner, 2007; Ussher, Taylor, & Faulkner, 2012), AB to smoking cues using eye tracking technology (Janse Van Rensburg, Taylor, & Hodgson, 2009; Oh & Taylor, 2013a) and ad libitum smoking (Taylor & Katomeri, 2007), but only one study has reported any effects on alcohol cravings. Ussher, Sampuran, Doshi, West, and Drummond (2004) found that alcohol urges, measured using the Alcohol Urges Questionnaire (AUQ; Bohn, Krahn, & Staehler, 1995), were significantly reduced during, but not after 10 min of moderate intensity exercise, compared with light intensity exercise, among participants undergoing alcohol detoxification at a psychiatric hospital. The findings were rather hard to interpret given a trend towards baseline differences in AUQ between the control and exercise condition, and further replication studies were recommended which have not yet occurred.

Hence, the purpose of the present study was to examine if a single session of exercise reduces AB towards alcohol-related images and alcohol urges among high alcohol consumers. It was hypothesised that abstaining heavy drinkers, when exposed to exercise, would show reductions in AB to alcohol cues and alcohol urges compared to when exposed to a passive control condition.

2. Method

2.1. Sample

Following institutional ethical approval, participants were recruited via advertisement posters and e-mail communication, targeted at both university students and the wider community in Exeter, England. Participants were required to be at least 18 years old (the legal drinking age in the UK), have no contraindications for moderate intensity exercise (confirmed using the Physical Activity Readiness Questionnaire (PAR-Q) (Thomas, Reading, & Shephard, 1992)), and be classified as a heavy drinker (i.e., females consuming at least 14 units of alcohol and males consuming at least 21 units of alcohol per week; NICE, 2011). Potential participants also completed a short self-report questionnaire (adapted from the State & Local Youth Risk Behavior Survey; CDC, 2011) on alcohol consumption using the following 3 items: (a) ‘During the past 30 days, on how many days did you have at least one drink of alcohol’ with a response format (and score) as 0 days (0), 1–2 days (1), 3–5 days (2), 6–9 days (3), 10–19 days (4), 20–29 days (5), and all 30 days (6); (b) ‘During the past 30 days, on how many days did you have 5 or more drinks of alcohol in a row, that is, within a couple of hours?’ with a response format (and score) as 0 days (0), 1–2 days (1), 3–4 days (2), 5–6 days (3), 7–8 days (4), 9–10 days (5), and 11 or more days (6); (c) ‘What is the longest period of time that you can recall that you have gone without an alcoholic drink in the past 2 months?’ with a response format (and score) as 0 days (6), 1 days (5), 2 days (4), 3 days (3), 4–6 days (2), 7–9 days (1), and 10 or more days (0). Those who had a total score from adding the 3 items of at least 10 were invited to take part: This score marked the lower limit for the upper quartile of alcohol consumption of a large student sample in a previous study (Oh, 2008). The target sample size was 20, based on a study on the acute effects of exercise on AB to cigarette cues, which showed a significant reduction compared with a passive control in a counterbalanced cross-over design with 20 regular smokers (Janse Van Rensburg et al., 2009). Also, Ussher et al. (2004) identified significant differences in scores on the AUQ during moderate versus light exercise with a sample of 20 individuals receiving treatment for alcohol abuse. No previous study has examined the acute effects of exercise on AB to alcohol cues upon which to power the present study.

2.2. Experimental design

Twenty healthy volunteers (11 females, 9 males) participated in a within-subject randomised cross-over design. To fully test the effects of exercise, participants were asked to abstain from alcohol for 3 days prior to visiting the laboratory on each occasion to enhance alcohol cravings. This was a novel procedure adopted from other studies attempting to elicit elevated urges to smoke following abstinence.

2.3. Procedures

Upon arrival at the laboratory, participants were provided with verbal and written information about the study and informed consent was obtained. Participants' weight (kg) and height (cm) were recorded to provide descriptive data for the sample. Participants were fitted with a heart rate monitor (Polar Vantage NV, London, England) and randomly assigned to begin with either a passive control treatment or a moderate exercise treatment on their first visit. The second and alternative condition was completed on the subsequent laboratory visit at approximately the same time of day, and usually about a week later. The time for test varied across the day for different participants depending on their availability. Upon arrival on each visit participants were presented with a range of drinks, served in appropriate sized glasses and asked to identify their chosen drink to increase cue-elicited cravings prior to the experimental procedures.

2.4. Measures

Baseline-only measures included an assessment of current levels of exercise using the self-report 7-day recall measure (Blair et al., 1985). Alcohol consumption was assessed as above. Self-efficacy to avoid drinking was measured using the Drinking Refusal Self-Efficacy Questionnaire-Revised (DRSEQ-R) which has been shown to be a valid measure for use in community, student and clinical samples (Oei, Hasking, & Young, 2005). The 22 item scale is used to calculate a total score and subscales for avoidance of drinking for Emotional Relief, Opportunistic Drinking and Social Pressure. Lower scores reflect less confidence to avoid alcohol.

Urges to drink alcohol were assessed at four time points (baseline, immediately following treatment, and 5 and 10 min post treatment) using the Alcohol Urge Questionnaire (AUQ) (Bohn et al., 1995). The AUQ, also used by Ussher et al. (2004), is an eight-item, self-administered state measure, assessing an individual's desire for a drink, expectations of positive effects from drinking, and inability to avoid drinking if alcohol were present. The items are scored on a 7-point Likert-type scale ranging from 'strongly disagree' to 'strongly agree'. A total score for the AUQ is derived by adding responses for each item. The AUQ has been widely used and has been shown to exhibit positive associations with severity of dependence and drinks per week (MacKillop, 2006). The AUQ has been shown to be a valid and reliable way of measuring alcohol cravings (Drummond & Phillips, 2002; MacKillop, 2006).

AB was measured pre- and post-condition using an adapted alcohol visual dot probe task created using E-Prime (Psychology Software Tools). Measurement took approximately 3 min to administer on each occasion. Initially, 40 alcohol-related images with a plain background were matched for object shape and size (e.g., pint glass with lager, wine glass with wine), orientation and luminescence with a neutral image (e.g., pint glass with water, wine glass with water). Paired images were randomly presented on a 37 × 30 cm computer screen for either 200 ms and 1000 ms equally, with alcohol and neutral images presented randomly on either side of the screen. Participants sat approximately 1 M from the screen. 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 60 images: 20 critical pairs (alcohol/neutral images) for 200 ms, 20 critical pairs (alcohol/neutral images) for 1000 ms, 20 filler pairs (neutral/neutral images) of 200 or 1000 ms. Paired images were presented side by side, but randomly displayed on the left or right. Participants were instructed to respond as quickly as possible to a left or right key depending on whether a 2 mm wide dot appeared behind the left or right image. Reaction times (collected using e-prime software) following presentation of images for 200 ms and 1000 ms were used to calculate initial (IAB) and maintained AB (MAB) respectively as previously reported (Field & Quigley, 2009; Miller & Fillmore, 2010). AB for each person and testing session was calculated using the difference between the mean time (ms) to react to the neutral images and alcohol-related pictures (e.g. RT for neutral images − RT for alcohol images).

Table 1
Mean (SD) attentional bias to alcohol-related images from the dot-probe before and after exercise and control conditions.

	Time (ms)	
	Pre-treatment	Post-treatment
Initial AB		
Control	14.79 (41.21)	11.68 (57.64)
Exercise	10.24 (35.47)	−4.19 (44.43)
Maintained AB**		
Control	3.18 (53.22)	10.49 (35.31)
Exercise	21.44 (35.42)	−25.72 (58.12)

Notes. Values are mean (SD). Initial attentional bias: Images presented for 200 ms in dot probe task; Maintained attentional bias: Images presented for 1000 ms in dot probe task. **($p < 0.01$) indicates a significant condition × time interaction.

Positive values indicate an AB orientation towards the alcohol related images, relative to the neutral images.

2.4.1. Control condition

Participants were required to sit passively in the laboratory for 17 min, without access to reading materials, internet or mobile electronic devices, and only spoken to when measures were administered.

2.4.2. Exercise condition

This consisted of a 2 min warm-up followed by a 15 min self-paced walk on a horizontal treadmill. Participants were instructed to 'walk briskly as if you are late for an appointment but not to the point of breathlessness,' as previously used (Taylor, Katomeri, & Ussher, 2005). Participants were asked to maintain a Perceived Rate of Exertion (RPE) between 11 (fairly light) and 13 (somewhat hard) using the 6-20 Borg scale (Borg, 1998) as this is representative of moderate intensity exercise (ACSM, 2009). Heart rate was recorded and participants confirmed RPE every 3 min, in order to determine actual exercise intensity.

2.5. Data analysis

SPSS (version 18.0) was used for all statistical analyses. Data were initially examined for normality. Paired sample *t*-tests were used to identify any differences in baseline measures. We initially examined the effects of order on condition, time and condition × time effects. A two-way fully repeated analysis of variance (ANOVA) was conducted for IAB and MAB. Separate ANCOVAs were conducted to contrast post treatment differences, while controlling for baseline, for the two measures of AB. To assess the effects of exercise compared with a passive condition on AUQ, a series of two-way fully repeated analyses of variance (ANOVA) were conducted, after checking for sphericity and applying Greenhouse–Geisser correction as appropriate. This was followed by planned post hoc *t*-tests (with Bonferroni correction) to identify between and within subject differences, at the respective time points. Previous studies have explored the relationship between self-reported cravings and AB, so we conducted a correlational analysis between scores on the AUQ and both IAB and MAB at baseline (in both conditions), and also between the calculated change scores in AUQ and both IAB and MAB from pre to post treatment.

3. Results

The 20 participants had a mean (SD) age of 20.80 yrs (0.77), body mass index of 22.53 (2.81), and all participated in at least the recommended guidelines of 150 min of moderate or vigorous PA

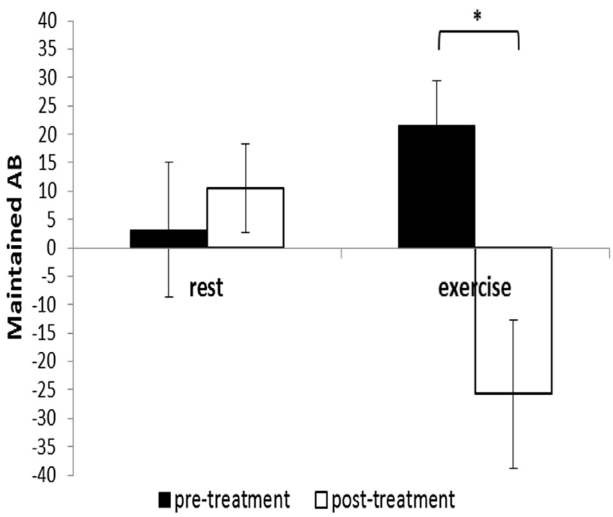

Fig. 1. Mean (SE) maintained attentional bias (in ms) pre and post-treatment for exercise and control conditions.

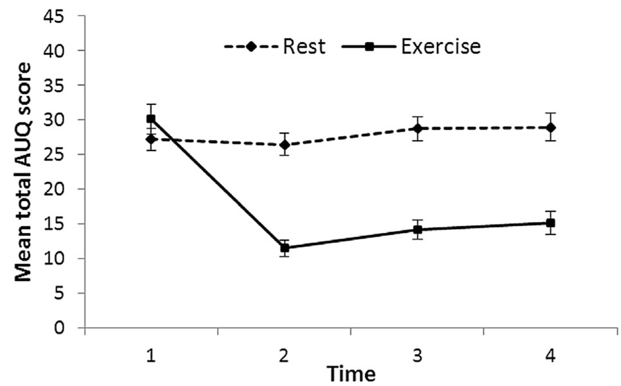

Fig. 2. Mean (SE) Alcohol Urge Questionnaire scores in the exercise and control conditions pre and following treatment. Notes. Time: (1) pre-treatment; (2) post-treatment; (3) post-dot probe task (5 min post-treatment); (4) 10 min post treatment. Treatment differences at T2: $t(19) = 8.77$, $p < 0.001$, 95% CI 11.42–18.58, Effect Size $d = 1.99$; T3: $t(19) = 8.18$, $p < 0.001$, 95% CI 10.79–18.21, Effect Size $d = 2.05$; T4: $t(19) = 6.44$, $p < 0.001$, 95% CI 9.35–18.35, Effect Size $d = 1.69$.

per week. Mean (SD) values for the DRSEQ-R were as follows: Total 70.95 (11.70); Mean item response for Emotional Relief 4.60 (0.87); Opportunistic Drinking 4.51 (1.09); Social Pressure 1.61 (0.46).

The mean (SD) heart and RPE during exercise was 124.80 (11.55) and 12.80 (0.37) (i.e., fairly hard), respectively, and calculated heart rate reserve was 39.1% (6.7).

Two participants had data for IAB at pre-exercise and one of these also had data for MAB at pre-exercise that were identified as outliers. ANOVAs to examine condition and time effects for attentional bias were therefore conducted with data for 18 participants. The mean (SD) IAB, and MAB for pre- and post-conditions are shown in Table 1.

Paired sample *t*-tests revealed there were no significant differences between the two conditions in any baseline AB score. Also, there was no interaction effect of order with condition, time or condition × time.

ANOVAs revealed a significant condition by time interaction for MAB $F(1, 17) = 6.96$, $p = 0.017$, but not for IAB, $F(1, 17) = 0.38$, $p = 0.54$. ANCOVAs (controlling for baseline) showed that MAB was significantly lower after exercise compared with control $F = 4.21$, $p = 0.058$ ($\eta^2 = 0.22$). Fig. 1 shows the mean (SE) MAB at pre and post each condition.

Paired sample *t*-tests revealed no significant baseline AUQ differences between conditions. Also, there was no interaction effect of order with condition, time or condition × time. A fully repeated measures ANOVA revealed a significant condition by time (4 levels; pre-, immediately after, and 5 and 10 min post treatment) interaction effect for AUQ scores $F(1.47, 27.96) = 60.19$, $p < 0.001$. Dependent *t*-tests (with a Bonferroni correction) revealed that alcohol cravings were significantly lower following baseline in the exercise compared with the control condition, at all time points ($p < 0.001$), as shown in Fig. 2.

Correlational analysis revealed no significant relationships between AUQ and either AB measure, both cross-sectionally and in terms of calculated change scores.

4. Discussion

This is the first study to report that a single session of exercise can acutely reduce AB towards alcohol images and self-reported cravings among heavy drinkers. The findings are consistent with similar studies assessing the acute effects of light-moderate intensity exercise on AB towards smoking (Janse Van Rensburg et al., 2009; Oh & Taylor, 2013a) and snacking (Oh & Taylor, 2013a, 2013b), and studies on the acute effects of exercise on self-reported cravings for cigarettes (Haasova et al., 2013), alcohol (Ussher et al., 2004), chocolate (Taylor & Oliver, 2009), and snacking (Oh & Taylor, 2013a). Self-reported measures may be prone to bias if participants are aware that exercise is expected to reduce cravings, so the finding that exercise can also reduce MAB towards alcohol is important. It suggests that exercise impacts on implicit cognitive processes, though theoretically, with images presented for 1000 ms, an element of conscious control over visual attention could take place.

Janse Van Rensburg et al. (2009) also reported that only MAB (for cigarettes), and not IAB, was reduced following exercise. In contrast, Oh and Taylor (2013a, 2013b) found that IAB (for cigarettes and snacks) was reduced following moderate exercise, but MAB (for cigarettes and snacks) was only reduced following vigorous exercise. The substances of interest varied across these studies but each had the aim to identify regular users, and elicit greater baseline cravings through temporary abstinence. The studies also varied in terms of how AB was captured (i.e., visual eye tracking technology and dot probe task) so it may be premature to extrapolate any patterns in the findings. It does appear though that exercise can reduce the salience of alcohol cues, in line with previous research involving other substances.

In the only previous comparable study, Ussher et al. (2004) reported that 10 min of moderate intensity exercise reduced alcohol urges during exercise, but not beyond, compared with a light intensity bout of exercise. The findings were rather hard to interpret given a trend towards baseline differences in AUQ between the control and exercise conditions and also given that the participants were several weeks into an alcohol rehabilitation programme. Cravings may have been reduced if alcohol was not available. In contrast, randomisation in the present study led to comparable scores on the AUQ before the respective conditions. The present study also selected current heavy drinkers, requested a period of abstinence for 3 days, presented actual alcoholic drinks (but did not allow consumption), and engaged participants in the initial dot probe task (with alcohol images) prior to assessing alcohol urges and AB before treatment. While we did not assess the impact of these attempts to elevate cravings and salience of alcohol it is worth noting that baseline values on the AUQ were somewhat higher than those reported by Ussher (mean 28 versus 20.2). Other notable differences in the two studies were that the present study involved

15 min of exercise compared with 10 min in the previous study (at a comparable intensity) and the present study compared exercise with a passive condition rather than a light exercise control condition. Both of these design modifications could have led to the larger and longer lasting effects of exercise in the present study.

The reduction of cravings and AB towards salient images does seem of theoretical and practical relevance to aid those wishing to reduce drinking since strong cravings (Litt, Cooney, & Morse, 2000) and AB towards alcohol cues (Robbins & Ehrman, 2004) may be responsible for relapse. The present findings suggest that brief bouts of exercise may enhance inhibitory control (Field et al., 2009). Further research is needed to determine the role of exercise in building self-control strength, important in self-regulation (Vohs & Baumeister, 2010; West, 2006) and how best to translate the present findings into useful interventions. There is increasing interest in attentional re-training (Schoenmakers et al., 2010) within interventions to reduce the salience of environmental cues. The present study involved young adults with unknown intentions for reducing alcohol consumption and therefore the findings may be limited in their generalizability. There is therefore a need to replicate the present study among those seeking support for reducing alcohol consumption. Further translational research is also needed in which exercise could support attentional retraining as a self-help approach to alcohol reduction, and possibly treatment programmes. This work has begun with the use of exercise assisted reduction then stop (EARS) to support disadvantaged smokers who wish to reduce their smoking but not quit (Taylor et al., 2013). Counselling to use physical activity, alone or alongside structured exercise, may be a useful approach to help reduces urges and AB to alcohol.

The mechanisms that mediate the effects of exercise on alcohol urges during exercise are unclear. Drinking alcohol can be a mood regulating behaviour and used as a coping strategy to reduce negative feelings (Carpenter & Hasin, 1998). Exercise may well enhance affect and mood in a way that reduces drinking urges and salience of alcohol as a source of pleasure and reward. Although mediators were not investigated in this study, a number of neurobiological mechanisms implicated in drug use and potentially modifiable by exercise have been considered, including dopamine, glutamate, norepinephrine, opioids, PKA, extracellular signal-related kinase and brain-derived neurotrophic factor (Smith & Lynch, 2013). This work has primarily been drawn from animal research. For example, wheel running reduces ethanol and alcohol consumption (e.g., Ehringer, Hoft, & Zunhammer, 2009; Ozburn, Harris, & Blednov, 2008; Pichard, Gorwood, Hamon, & Cohen-Salmon, 2009; Werme, Lindholm, Thorén, Franck & Brené, 2002) in addicted rodents.

Acute exercise has also been shown to shift areas of brain activation, in response to smoking images (using functional Magnetic Resonance Imagery) among regular smokers who were abstinent (Janse Van Rensburg, Taylor, Benattayallah, & Hodgson, 2012; Janse Van Rensburg, Taylor, Hodgson, & Benattayallah, 2009b). It is clear that further research is required in order to gain a greater understanding of the neurobiological and psychological mechanisms that underlie the acute effects of exercise on cravings and shifts in AB as demonstrated in the present study. Common neurobiological processes have been reported across different substance users and addictions (Tang, Fellows, Small, & Dagher, 2012), and there is scope to explore how exercise influences these processes in both humans and animal models, relative to cognitive processes such as memory of reward associated with salient cues, and executive functioning and the inhibition of behaviours leading to reward seeking.

There are several limitations to this study. First, participants were not clinically diagnosed alcoholics or seeking treatment, as in the previous study by Ussher and colleagues but we took several steps to include only heavy drinkers. Participant invitation and screening procedures focused our recruitment on heavy drinkers. Rather than administer the Severity of Alcohol Dependence questionnaire, used by Ussher et al. (2004), which seemed inappropriate for our sample, we administered the DRSEQ-R. Lower DRSEQ-R scores are associated with increased alcohol consumption (Oei & Jardim, 2007) and our sample reported values that reflected difficulties in resisting alcohol comparable with heavy drinkers in other studies (Oei et al., 2005). Also, the present sample all met the public health guidelines for weekly physical activity, and further research could consider the possible effects for a less active sample.

Another limitation with the present study is that we did not compare exercise with a distraction control condition to eliminate the possibility that any effects were simply due to distraction rather than exercise. However, several studies in which exercise has been compared with a distracting task (as a control condition) (Daniel, Cropley, & Fife-Schaw, 2006; Ussher, Nunziata, Cropley, & West, 2001), have reported a greater reduction in cigarette cravings and withdrawal symptoms during and following moderate intensity exercise. This suggests that distraction is not the key mechanism. Further studies should be conducted that include distraction control conditions such as film watching, in addition to exercise and passive control controls.

A final limitation is that the visual probe task consisted of simple pairs of images of alcoholic and non-alcoholic drinks. Further research is needed to replicate the present findings using individualised alcohol images for the dot probe tasks, to potentially elicit even greater AB. In the present study all participants viewed images containing pint glasses and wine glasses, but some participants may not normally drink alcohol with such glasses. Also, we only used 40 pairs of images and further research could be conducted with a larger number of trials to determine internal reliability of such tasks (Ataya et al., 2012). Eye-tracking technology could be considered to capture visual AB, using both static and moving images in an attempt to capture a more direct and 'ecologically valid' (Field, Eastwood, Bradley, & Mogg, 2006; Mogg et al., 2005; Oh & Taylor, 2013a) measure of AB.

In summary, a short brisk walk may be an attractive self-help strategy to manage cravings and provide immediate relief for those experiencing alcohol urges. Also, relative to being sedentary, a physically active lifestyle may help shift attention away from alcohol cues (unless participation is linked to greater alcohol consumption), which can trigger cravings and threaten inhibitory control. Studies designed to examine the chronic effects of moderate intensity physical activity as a treatment for alcoholics and for reducing alcohol consumption have focused on structured exercise, with mixed evidence of effectiveness (Abrantes et al., 2013). Further research is needed to explore if an accumulation of daily short bouts of exercise could be beneficial in helping those wishing to reduce alcohol consumption.

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