

Adrian H. Taylor · Magdalena Katomeri ·
Michael Ussher

Acute effects of self-paced walking on urges to smoke during temporary smoking abstinence

Received: 23 April 2004 / Accepted: 26 January 2005 / Published online: 21 April 2005
© Springer-Verlag 2005

Abstract *Rationale:* Recent research highlights the need to extend our understanding of how exercise may aid smoking cessation, through exploration of different modes, intensity and duration of exercise. *Objectives:* The purpose of the study was to examine the effects of a 1-mile self-paced walk on different measures of urges to smoke following temporary smoking abstinence. *Methods:* In a within-subject counterbalanced design, following 15 h of smoking abstinence, participants ($N=15$) exercised or sat passively on separate days. A single-item measure of strength of desire to smoke (West and Russell in *Psychopharmacology* 87:407–415, 1985) was administered during, immediately post, and at 10 and 20 min post-treatment. The two-factor Questionnaire for Smoking Urges (QSU; Tiffany and Drobes in *Br J Addict* 86:467–1476, 1991), involving intention and desire to engage in smoking behaviour which is anticipated as pleasant, enjoyable and satisfying (desire-behave), and anticipation of relief from negative affect through smoking (desire-affect relief), was administered before and 20 min post-treatment. *Results:* A two-way repeated-measures MANOVA revealed a significant overall interaction effect for time by condition for strength of desire to smoke, and the two QSU scales. Two-way repeated-measures univariate ANOVAs revealed significant interaction effects for time by condition for each of the three urges to smoke measures. Planned contrasts revealed that exercise reduced cigarette cravings for up to 20 min after exercise, in comparison with the control condition. ANCOVAs revealed

mixed support for independent effects of exercise on all measures of urges to smoke. *Conclusion:* A self-paced walk, at a low intensity, lasting 15–20 min can have a rapid and measurable positive effect on both single and multi-item measures of urges to smoke, lasting at least 20 min, during temporary smoking abstinence.

Keywords Smoking cessation · Exercise · Withdrawal · Cigarette cravings

Introduction

Most attempts to quit smoking are unaided (West et al. 1999), resulting in 1-year abstinence rates of only 2–4% (Hughes et al. 1992). The most effective aids to smoking cessation, combining behavioural support with nicotine replacement therapy (NRT) or bupropion, may improve 1-year abstinence by around 15% (Jorenby et al. 1999; Silagy et al. 2004). With approximately 70% of smokers wishing to quit at any one time, any additional aid to quitting may prove useful in lowering the risk of cancer and coronary heart disease (CHD) associated with smoking (Department of Health, 2000). Specific populations (e.g. pregnant smokers) may also value non-pharmacological aids to smoking cessation (Ussher and West, 2003).

Several reasons have been proposed for high relapse rates following attempts to stop smoking, including failure to cope with withdrawal symptoms, negative affect and cigarette cravings (Hughes et al. 1994; Piasecki et al. 2000; Shiffman et al. 1996). The severity of desire to smoke reliably predicts relapse in smokers who are trying to stop (West et al. 1989). Interventions providing effective coping resources through temporary enhancement of affect are therefore worthy of further study, and recent interest has focused on the effects of exercise on smoking abstinence (e.g. Ussher et al. 2000, 2001, 2003).

Addiction to cigarettes, like other addictions, is likely to engage the reward centres of the brain, and treatments (e.g. bupropion) have been developed to target the pleasure and reward pathways in the mesolimbic system and nucleus

A. H. Taylor (✉) · M. Katomeri
School of Sport and Health Sciences,
University of Exeter,
Exeter, Devon, EX1 2LU, UK
e-mail: A.H.Taylor@exeter.ac.uk
Tel.: +44-139-2264747

M. Ussher
Department of Community Health Sciences (Psychology),
St George's Hospital Medical School,
Cranmer Terrace,
University of London,
London, SW17 0RE, UK

accumbens (Hurt, 1999). Exercise in rodents (particularly wheel-running, which is self-paced) has been shown to engage the same centres and to compete successfully with addictive substances including amphetamine (Kanarek et al. 1995), cocaine (Cosgrove et al. 2002) and ethanol (McMillan et al. 1995). Given that exercise has been found to have a positive influence on affect in humans (Ekkekakis, 2003; Ekkekakis and Petruzzello, 2000; Ekkekakis et al. 2000; Morgan, 1997; Taylor, 2000), it is reasonable to propose that probably due to its affective influences, it might provide effective competition against smoking urges in humans.

Four studies (Daniel et al. 2004; Pomerleau et al. 1987; Thayer et al. 1993; Ussher et al. 2001) reported on the acute effects of exercise on urges to smoke and tobacco withdrawal symptoms, using single items corresponding to each withdrawal symptom, during temporary abstinence. Pomerleau et al. (1987) and Thayer et al. (1993) reported positive effects of exercise on urges to smoke and withdrawal symptoms following only brief (30–45 min) smoking abstinence. After 15 h of smoking abstinence, Ussher et al. (2001) reported that 10 min of moderate intensity [40–60% heart rate reserve (HRR)] stationary cycling resulted in reduced reports of strength of desire to smoke (West and Russell, 1985) relative to two passive control groups. The effects lasted up to and including the final assessment at 10 min post-exercise, with effect sizes for the exercise vs rest condition equal to 0.78, 0.90, 0.87 and 0.76 during, post, 5 min post- and 10 min post-treatment, respectively. Daniel et al. (2004) replicated the study by Ussher et al. and compared the effects of 5 min of moderate (40–60% HRR) or light (10–20% HRR) intensity cycling, or a passive control condition, on urges to smoke, following 11–15 h of smoking abstinence. The moderate-intensity exercise significantly reduced strength of urge to smoke up to and including 5 min post-treatment with effect sizes for the moderate-intensity exercise vs rest condition equal to 0.54, 0.47, 0.27 and 0.14, during, post, 5 min post- and at 10 min post-treatment, respectively. In comparison with light exercise, the moderate condition reduced strength of desire during and up to and including the final assessment. The light-intensity condition had no effect on urge to smoke compared with the passive control condition.

Whilst these initial studies by Ussher et al. (2001) and Daniel et al. (2004) have helped to identify a useful paradigm to explore the effects of exercise on urges to smoke, with some encouraging results, several methodological issues have emerged, which raise concerns about internal and external validity.

Firstly, all four of the above studies assessed tobacco cravings with the use of single items (desire to smoke and strength of desire to smoke). At this early stage in the present line of research, it is essential that accumulating evidence is founded on more than one single measure. Shiffman et al. (2004) recently noted that multi-item measures of tobacco withdrawal and cravings are likely to perform better than single items, based on psychometric principles. Shiffman et al. (2004) also considered whether urge to smoke was a uni- or a multi-dimensional construct. Tiffany and Drobes (1991), in developing the Questionnaire for Smoking Urges

(QSU), proposed that cravings should be construed as two-dimensional: namely an intention and desire to engage in smoking behaviour which is anticipated as pleasant, enjoyable and satisfying (desire-behave), and anticipation of relief from negative affect through smoking (desire-affect relief). Whilst Shiffman et al. (2004) note that there may be evidence that the two scales of the QSU are sensitive to cessation of smoking, less is known about their sensitivity to detect the effects of aids to smoking cessation. Sayette et al. (2000) suggested that further evidence was needed to support the independence and sensitivity of the two dimensions in the Tiffany and Drobes scale—issues which will be considered in the present study.

Secondly, the four previous studies on the acute effects of exercise on tobacco cravings have employed between-subject designs and in these studies randomisation was shown to eliminate group differences at baseline on the variables assessed. However, there may be as yet unidentified confounding variables. The within-subject design used in the present study is intended to limit such influences and reduce the risk, at an early stage of this line of research, of potential bias by broadening the range of evidence from different research designs.

Thirdly, previous experimental studies have examined the effects of fixed-intensity exercise on urges to smoke. Theoretically, Self-Determination Theory (Ryan and Deci, 2000) posits that when participants are given choice and control, more positive affective responses are likely. Consequently, if enhanced affect is an important mediator in reducing urges to smoke, then it is possible that self-paced exercise may be more advantageous than fixed-intensity exercise for reducing cigarette cravings. Therefore, in the present study self-paced exercise is investigated.

Fourthly, the studies by Ussher et al. (2001) and Daniel et al. (2004) have involved cycling, at moderate intensity. Walking is the most popular and convenient form of physical activity, often undertaken at low-moderate intensity. In order to establish guidelines for the use of exercise for reducing urges to smoke, and to generalise to this form of exercise, research is needed to examine the effects of walking on cravings.

Fifthly, the duration of acute effects of exercise on affect have been widely considered in the literature, with evidence suggesting an effect lasting up to several hours. The well-controlled studies by Ussher et al. (2001) and Daniel et al. (2004) involved a follow-up no longer than 10 min. It is necessary to establish whether exercise only causes a short-lived reduction in urges to smoke (i.e. up to 10 min) or whether this effect can be sustained over a longer period. It is also conceivable that follow-ups beyond 10 min post-exercise could reveal elevated urges to smoke in response to exercise. In addition, the longer the observed effects last after exercise, one may be less inclined to offer distraction as the primary mechanism for any effects on cravings. The present study therefore aimed to identify if the positive effects of exercise on urge to smoke could extend to at least 20 min post-treatment.

Finally, studies by Daniel et al. and Ussher et al. focused on sedentary populations. Smokers tend to be less active

than the general population and it may be that exercise provides a greater challenge and possibly distraction from urges to smoke following abstinence. It is therefore important to also determine the effects of exercise on urges to smoke amongst those who are typically more physically active.

The purpose of the present study was to investigate whether a self-paced 1-mile walk would reduce urges to smoke (assessed by a single, and also a multi-item/multi-dimensional measure of urges), and whether any effects would be maintained for at least 20 min, post-exercise. Analyses also attempted to determine if the respective measures of urges to smoke were independently influenced by exercise, or if a single item may be sufficient to capture any effects.

Materials and methods

Participants

Participants were recruited through public advertisements and were screened by telephone. Participants had to be 18–50 years of age, smoking at least ten cigarettes daily, not pregnant, and not receiving any psychiatric treatment or suffering any medical condition that was contraindicated for physical activity (Thomas et al. 1992). Using intercorrelations between levels, and effect sizes from Daniel et al. (2004) and Ussher et al. (2001), we estimated that for a within-subject design, with a power of 0.8, and alpha of 0.05, a sample size of 15 participants was needed to detect differences on the primary outcome variable of ‘strength of desire to smoke’ (Maxwell and Delaney, 2004; Vonesh and Schork, 1986). During recruitment, one respondent was excluded due to a restricting medical condition, resulting in 15 healthy volunteers, ten male and five female (age, $\bar{x}$ = 25.6 years SD = 6.5; smoking daily, $\bar{x}$ = 16.6 cigarettes SD = 10.6).

Design and procedure

The study was approved by the University’s Research Ethics Committee, and all participants gave their informed consent prior to the study. Participants were asked to abstain from smoking for 15 h (from the previous evening) and to attend two laboratory sessions at approximately the same time, in the afternoon on different days. Previously it was demonstrated that this period of abstinence is sufficient to induce heightened cigarette cravings in moderately heavy smokers (Daniel et al. 2004; Ussher et al. 2001). Expired carbon monoxide (CO) levels were used to confirm abstinence (<10 ppm) upon arrival at the testing (Bedfont Smokerlyzer). After explaining the protocol and taking background and baseline measures, participants were, within a crossover design, randomly assigned (by random numbers) to begin with either a walking or passive condition, to control for order effects. During both conditions, participants wore a POLAR advantage Heart Rate monitor and data were downloaded to a PC for calculation of exercise in-

tensity. Throughout the sessions, the interaction between investigator and participant was kept to a minimum.

Exercise condition After a brief familiarisation with the treadmill lasting approximately 1 min, the exercise session consisted of a 2-min warm-up at 4 km/h, followed by 1-mile of brisk walking on a horizontal treadmill at a preferred intensity, and 2 min cool-down at 4 km/h. It was estimated that the 1-mile walk would take 15–20 min. Participants were instructed to briskly walk as if to catch a bus, but not to the point of breathlessness, and were able to request the investigator to decrease or increase the pace throughout the session as desired. Every 2 min during the walk, participants provided an oral Rating of Perceived Exertion (RPE) using the 6–20 Borg scale (Borg, 1998), with the scale positioned in front of the treadmill in large font. Immediately after the exercise session participants remained seated in the laboratory for 20 min.

Control condition The control condition involved passive waiting (sitting quietly) without access to reading material, for 40 min, and completion of the same measures as in the exercise condition, at equivalent time points. Previous studies confirmed that passive sitting, as a control condition for examining the acute effects of exercise on urges to smoke, produces relatively stable measures over the duration of a 20-min experiment (Daniel et al. 2004; Ussher et al. 2001).

Measures Background data were collected for age, gender, weight, height and average number of cigarettes smoked per day. Nicotine dependence was assessed using the Fagerström Test for Nicotine Dependence (FTND; Heatherton et al. 1991). Levels of physical activity were assessed by self-report using a 7-day recall of physical activity measure (Blair et al. 1985).

Strength of desire to smoke was assessed using a 7-point scale (1=not at all, 4=somewhat, 7=extremely) which has acceptable validity and reliability (West and Russell 1985; West and Hajek, 2004) and sensitivity to change following exercise (Daniel et al. 2004; Ussher et al. 2001). In addition, urges to smoke were assessed using the 32-item Questionnaire on Smoking Urges (QSU; Tiffany and Drobes, 1991). This assesses two manifestations: intention and desire to engage in smoking behaviour which is anticipated as pleasant, enjoyable and satisfying (desire-behave), and anticipation of relief from negative affect through smoking (desire-affect relief). According to Tiffany and Drobes (1991), both manifestations (desire-behave and desire-affect relief) co-exist and they argue that conceptualisations emphasising only drug appetite effect or drug withdrawal and negative affect, in the generation of smoking urges, may be incomplete. Items were scored as outlined by Tiffany and Drobes (1991).

Procedures The single ‘strength of desire to smoke’ item was administered at five measurement times: prior to, at mid-point of, immediately after, then at 10 and 20 min post-treatment. The QSU was administered only at baseline and

at 20 min post-treatment because of the time needed for administration and concern that a lengthy survey may serve as a prompt for smoking urges.

Statistical analysis

For statistical analyses SPSS version 10 was used. A two-way repeated-measures MANOVA was performed with strength of desire to smoke, and the two QSU scales as dependent variables, to identify an overall condition $\times$ time interaction. Two-way repeated-measures univariate ANOVAs were then performed to identify the main effects of time, condition and time $\times$ condition interaction effects, for each dependent measure. Both multivariate and univariate analyses were conducted with time as two levels (baseline and at 20 min post-intervention) because the QSU measures were only taken at these time points. Planned contrasts were performed to examine differences between conditions at 20 min post-treatment, for all three measures of urge to smoke.

In order to determine the independence of the effects of exercise on the dependent variables, we conducted a series of one-way univariate ANCOVAs (with time at two levels), with change in each dependent variable as a covariate.

Internal reliability for the two QSU scales was good with Cronbach alpha values of 0.90 and 0.95, for intention and desire to engage in smoking behaviour (desire-behave) and anticipation of relief from negative affect through smoking (desire-affect relief), respectively. Due to the small sample size, we checked for violations of assumptions for all outcome variables. Values for skewness and kurtosis all fell within an acceptable range. Also, Mauchly's test confirmed sphericity for all the univariate repeated-measures ANOVAs.

Results

The participants' baseline characteristics were as follows: mean FTND score, 4.0 (SD=3.1); mean expired air CO (ppm) following abstinence, 6.4 (SD=2.6); mean time doing moderate or vigorous physical activity, 398.7 (SD=247.8) min/week. The mean self-selected intensity of walking was equivalent to a light-intensity heart rate reserve of 24.5% (SD=7.6, range 12.1–41.5) and an RPE rating of 10.8 (SD=1.49, fairly light, range 7.1–12). (A mean resting heart rate during the passive condition was used to determine heart rate reserve; ACSM, 2000.) Walking 1 mile took on average 17.8 min (SD=2.8), ranging from 15 to 23 min and 20 s.

Table 1 shows the mean and standard deviation for the QSU scales (standardised for the number of items in each scale). Figure 1 shows the mean for strength of desire to smoke for both conditions at each assessment.

Paired *t* tests revealed no significant differences in baseline scores between the conditions on strength of desire to smoke or urge to smoke variables. Also, there were no order effects on baseline measures (or on the effects of the exercise).

Table 1 Mean (SD) for strength of desire to smoke and two Questionnaire for Smoking Urges scales for control and exercise conditions over time

Time	0 min	10 min	20 min	30 min	40 min
	$\bar{x}$ (SD)				
QSU: desire-behave					
Control	5.5 (1.2)				5.4 (1.4)
Exercise	5.9 (1.2)				3.9 (1.1)
QSU: desire-affect relief					
Control	4.2 (1.1)				4.3 (1.1)
Exercise	4.8 (1.0)				3.2 (1.3)
Strength of desire to smoke					
Control	5.6 (1.3)	5.5 (1.2)	5.7 (1.2)	5.4 (1.3)	6.3 (1.7)
Exercise	5.8 (1.4)	1.7 (0.9)	1.3 (0.6)	2.1 (1.1)	3.4 (1.9)

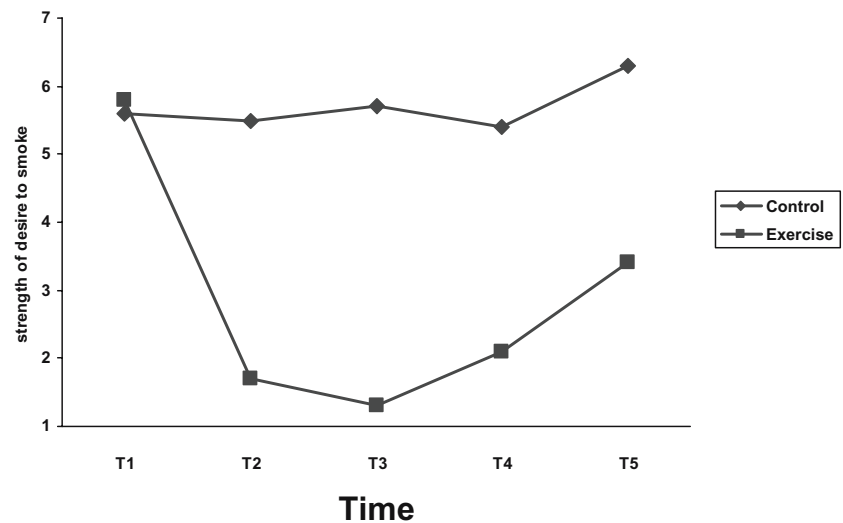
Exercise took place between 0 and 20 min

The omnibus MANOVA revealed a significant overall interaction effect of condition by time, Wilk's lambda=0.24, $P<0.001$, $F_{1, 14}=45.6$, $P<0.001$. Separate two-way univariate ANOVAs, revealed significant condition $\times$ time interactions for strength of desire to smoke ($F_{1, 14}=30.4$; $P<0.001$), and QSU scales, desire-behave ($F_{1, 14}=17.3$; $P=0.001$) and desire-affect relief ($F_{1, 14}=19.5$; $P=0.001$). In each case, planned contrasts revealed that the exercise condition scores were significantly lower at follow-up, compared with baseline. Effect sizes (using Cohen's formula), calculated by comparing means (for control and exercise condition) at the 20-min follow-up, with a pooled standard deviation at follow-up, were 1.3, 1.0 and 2.2, for desire-behave, desire-affect relief, and strength of desire to smoke, respectively.

In order to determine the independent effects of each of the three urge to smoke measures, we conducted a series of two-way repeated-measures univariate ANCOVAs, as in the main analyses but with the addition of a change score (from baseline to follow-up at 20 min post-treatment) as the covariate. The adjusted *F* value for the condition $\times$ time interaction effect, and also the partial eta squared values for the analyses without and with the covariate are reported.

With desire-behave as the dependent variable and strength of desire to smoke as the covariate, there was a significant interaction effect ($F_{1, 13}=9.3$; $P<0.01$) and partial eta squared values decreased from 0.55 to 0.42. With desire-behave as the dependent variable, and desire-affect relief as the covariate there was a significant interaction effect ($F_{1, 13}=7.3$; $P=0.02$) and partial eta squared values decreased from 0.55 to 0.36. With desire-affect relief as the dependent variable and desire-behave as the covariate, there was a significant interaction ($F_{1, 13}=11.7$; $P<0.01$) and partial eta squared values decreased from 0.58 to 0.47. With desire-affect relief as the dependent variable and strength of desire to smoke as the covariate, there was no significant interaction effect ($F_{1, 13}=2.9$; $P=0.11$) and partial eta squared values decreased from 0.58 to 0.18. With strength of desire to smoke as the dependent variable and desire-affect relief as the covariate, there was no significant

Fig. 1 Strength of desire to smoke over time, for exercise and control conditions. *T1* Baseline, *T2* 10 min, *T3* 20 min, *T4* 30 min, *T5* 40 min. Exercise took place between *T1* and *T3*



interaction between condition and time ($F_{1, 13}=3.2$; $P=0.09$) and partial eta squared values decreased from 0.69 to 0.19. With strength of desire to smoke as the dependent variable and desire-behave as the covariate, there was a significant interaction effect ($F_{1, 13}=27.3$; $P<0.001$) and partial eta squared values decreased from 0.69 to 0.68.

Discussion

As hypothesised, following 15 h of smoking abstinence, walking for a mile (or approximately 17 min) at a preferred intensity, reduced urges to smoke. This is the first study to show the positive effects of low intensity exercise on urge to smoke lasting beyond the period of exercise, and certainly as long as 20 min post-treatment. The effect size (even at 20 min post-exercise) for strength of desire to smoke was larger than previously reported by Daniel et al. (2004) and Ussher et al. (2001) at any time point in their studies. The effect sizes for the two multi-item QSU scales were also large.

Sayette et al. (2000) and Shiffman et al. (2004) called for further evidence that the QSU scales provide any additional information about the effects of aids to smoking cessation, beyond single item measures. It is worth noting from the present study that the baseline mean item value for desire-behave was significantly ($P<0.01$) greater than for desire-affect relief, and similar to those reported by Tiffany and Drobes (1991) after 6 h of abstinence (i.e. desire-behave; 5.9, desire-affect relief; 4.0, respectively). Following item analysis, Tiffany and Drobes (1991) claimed that this provided support for two separate dimensions of urges to smoke. Also, the ANCOVAs supported the notion that exercise acts independently on both QSU scales, with a significant interaction between condition and time remaining when controlling for the other scale. Effects on desire-behave also appeared to be independent of the strength of desire to smoke. However, effects on desire-affect relief were not independent of effects on the single item, strength of desire to smoke.

Three issues emerge from this. Firstly, a single-item and a multi-item measure of urge to smoke appear to capture different effects resulting from a single session of exercise. Secondly, this distinctiveness was only evident for a multi-item measure that encapsulated an intention and desire to engage in smoking behaviour which is anticipated as pleasant, enjoyable and satisfying. Thirdly, exercise appeared to uniquely influence the anticipation of relief from negative affect through smoking, and also the desire to engage in smoking behaviour which is anticipated as pleasant, enjoyable and satisfying, thus supporting Tiffany and Drobes' (1991) justification for a two-dimensional concept of urges to smoke. Further research is needed to replicate the present findings and to understand how well the QSU scales predict smoking behaviour after temporary abstinence (and relapse amongst quitters), compared with single items for urge to smoke.

Exercise may reduce both the need to enhance affect by smoking and also the desire to remove negative affect associated with smoking abstinence. Enhanced exercise-related affect, as suggested from human and animal studies, may act as a buffer for both these responses, and provide coping resources during smoking cessation. Further research is needed to determine if exercise also provides a buffer during subsequent cue-elicited cravings, and if so, for how long. Evidence suggests that smoking cues elicit acute urges to smoke (Dols et al. 2000) and future studies could explore if exercise could be used to attenuate such responses. Also, given the evidence that smoking may act as both a stimulant and relaxant (see Parrott, 1998 for a review), further research could consider if exercise increases arousal and reduces emotional stress as a replacement for nicotine, and if so what is the optimal dose of exercise to provide such effects. Certainly, the literature supports such effects with low-moderate-intensity exercise amongst non-smokers (Ekkekakis et al. 2000; Taylor, 2000; Thayer et al. 1993).

The mechanism involved in reducing urge to smoke is not clear. The Daniel et al. (2004) and Ussher et al. (2001) studies both suggested that distraction was an unlikely mech-

anism for the observed effect from moderate-intensity exercise. Attention to somatic cues during exercise becomes greater as intensity increases (Borg, 1998), but is not linear: only at vigorous or high intensities, above what is commonly called the ‘ventilatory threshold’, are particularly strong informational processing demands likely to be evident. Therefore, both low- and moderate-intensity exercise may have relatively similar information processing demands, or capacity to provide a distraction from desire to smoke. If distraction were the main explanation, then one may have expected light intensity exercise to also reduce desire to smoke in the Daniel et al. study. Daniel et al. argued that if the effects were mediated through distraction, then one would have expected any reduced urge to smoke during exercise would soon disappear following cessation of exercise, which was clearly not the case in the present study. An alternative interpretation of the findings for the Daniel et al. study is that exercise only acts as a distraction once a certain threshold of exercise intensity is reached, such that very light exercise provides little if any distraction. To fully explore the role of distraction, future studies of exercise and cigarette cravings could include control conditions entailing standard cognitive distractions, such as reading or computer tasks during exercise.

If exercise reduces cigarette cravings through pleasure and reward pathways in the mesolimbic system, then one way to examine this mechanism would be to administer a dopamine antagonist, such as Olanzapine (Hutchison et al. 2004). If exercise still reduces cravings in the presence of such an antagonist, then this specific mechanism could be eliminated. This paradigm could also be extended to examine if a dopamine antagonist (vs placebo) would, following exercise, have any effect on responses to cue-elicited cravings. Thayer et al. (1993) conducted the only study to have potentially examined the effects of exercise on cue-elicited cravings. After a 45-min period of nicotine deprivation, those who did a 5-min walk, compared with non-exercisers, reported lower urge to smoke and had a net 8-min delay before smoking their next cigarette. Their study, conducted in a naturalistic environment, did not involve the recording of any cues that may have elicited cravings, so it is unknown if walkers and inactive participants experienced similar cues. There is clearly scope to manipulate craving cues in controlled conditions and determine if and how exercise attenuates any urge to smoke and smoking behaviour.

It is important to consider if the observed effects would be generalisable to other settings and populations. Importantly, the exercise was self-paced in the present study, which may add to the external validity of the findings. There is, however, no consensus in the literature on how to instruct participants to engage in ‘self-paced’ or ‘preferred intensity’ exercise. The present study attempted to capture the notion of ‘self-paced’ walking, with some constraints on intensity (i.e. ‘not out of breath’), over a set distance (1 mile) and pace (‘as if walking for a bus or meeting’). The present study may not have fully captured the notion of self-paced walking with generalisability to natural settings, but our standardised instructions enable replication

in future research. Further research is needed to understand what factors influence choice of exertion level amongst smokers and to compare the acute effects of fixed-intensity vs self-paced exercise within the same study.

The participants were more physically active over the previous week than in the Daniel et al. and Ussher et al. studies, which suggest that the effects may be generalisable to both sedentary and considerably more active populations. Despite similar periods of deprivation and scores on the FTND (compared with the Daniel et al. and Ussher et al. studies), reports of strength of urge to smoke appeared to drop to lower levels during and following exercise, relative to baseline, than reported by Ussher et al., as well as remaining lower for a longer duration. It may be that physically active smokers are also more confident in an exercise setting and gain greater positive affect from the experience. Whilst further studies may contrast the effects of exercise between active and inactive populations, a comparison between findings from the present and previous studies suggest only small differences, with significant reductions in cravings for both.

In the present study, participants were not quitters, but were experiencing 15 h of temporary smoking abstinence. Further research is needed to investigate the effects of exercise on cravings at different stages of abstinence. Also, further naturalistic studies, with real-time assessment (Shiffman et al. 1996), are needed to understand how short self-paced walks can be used to manage these symptoms over days and weeks of abstinence. Given the strong evidence for conventional treatments to aid quit attempts (e.g. NRT, bupropion), exercise should be largely seen as adjunctive to these treatments. For pregnant and post-partum smokers who are trying to quit, many of whom may prefer not to use pharmacological agents (Ussher and West, 2003), exercise may serve as an aid to smoking cessation (Ussher et al. 2004). Research is needed to investigate how exercise and pharmaceutical aids interact to affect urges to smoke.

In conclusion, this study adds to existing evidence that exercise can have an acute positive effect on urges to smoke. The internal and external validity of such evidence has been extended by inclusion of multi-item and multi-dimensional measures, a within-subject design, the use of self-paced low-moderate intensity walking, observation of effects up to at least 20 min post-exercise, and inclusion of a more active population. Conceptually, the findings suggest that urge to smoke may be a multi-dimensional concept, indicated by different ratings on the two QSU scales, and unique effects of exercise on each as indicated by ANCOVAs. Also, exercise appears to have a unique effect on a multi-item measure that encapsulates an intention and desire to engage in smoking behaviour which is anticipated as pleasant, enjoyable and satisfying, in contrast to a single item of strength of desire to smoke. Further research is needed on the psychological and physiological mechanisms involved. Walking is a convenient form of exercise and this may provide a popular low-effort and cheap option to reduce urges to smoke during smoking cessation.

References

- American College of Sports Medicine (ACSM) (2000) Guidelines for exercise testing and prescription, 6th edn. Lea & Febiger, Philadelphia
- Blair SN, Haskell WL, Ho P, Paffenberger P, Vranizan K, Farquhan JW, Wood PD (1985) Assessment of habitual physical activity by seven day recall in a community survey and non control experiments. *Am J Epidemiol* 122:794–804
- Borg GAV (1998) Borg's perceived exertion and pain scales. Illinois Human Kinetics, Champaign, Ill
- Cosgrove KP, Hunter RG, Carroll ME (2002) Wheel-running attenuates intravenous cocaine self-administration in rats: sex differences. *Pharmacol Biochem Behav* 73:663–671
- Daniel J, Cropley M, Ussher M, West R (2004) Acute effects of a short bout of moderate versus light intensity exercise versus inactivity on tobacco withdrawal symptoms in sedentary smokers. *Psychopharmacology* 174:320–326
- Department of Health (2000) Statistics on smoking: England, 1978 onwards. Crown Publishers, London
- Dols M, Willems B, van den Hout M, Bittoun R (2000) Smokers can learn to influence their urge to smoke. *Addict Behav* 25:103–108
- Ekkekakis P (2003) Pleasure and displeasure from the body: perspectives from exercise. *Cogn Emot* 17:213–239
- Ekkekakis P, Petruzzello SJ (2000) Analysis of the affect measurement conundrum in exercise psychology. I. Fundamental issues. *Psychol Sport Exerc* 1:71–88
- Ekkekakis P, Hall EE, Van Landuyt LM, Petruzzello SJ (2000) Walking in (affective) circles: can short walks enhance affect? *J Behav Med* 223:245–275
- Heatherton T, Kozlowski L, Frecker JR, Fagerstrom K (1991) The Fagerstrom test for nicotine dependence: a revision of the Fagerstrom Tolerance Questionnaire. *Br J Addict* 86:1119–1128
- Hughes J, Gulliver SB, Fenwick JW, Valliere WA, Cruser K, Pepper S, Shea P, Solomon LJ, Flynn BS (1992) Smoking cessation among self-quitters. *Health Psychol* 11:331–334
- Hughes J, Higgins S, Bickel W (1994) Nicotine versus other withdrawal syndromes: similarities and dissimilarities. *Addiction* 89:1461–1470
- Hurt RD (1999) New medications for nicotine dependence treatment. *Nicotine Tob Res* 1 Suppl 2:S175–S179
- Hutchison KE, Rutter MC, Niaura R, Swift RM, Pickworth WB, Sobik L (2004) Olanzapine attenuates cue-elicited craving for tobacco. *Psychopharmacology* 175:407–413
- Jorenby DE, Leishow S, Nides M, Rennard SI, Johnston JA, Hughes AR, Smith SS, Muramoto ML, Daughton DM, Doan K, Fiore MC, Baker TB (1999) A controlled trial of sustained release bupropion, a nicotine patch, or both for smoking cessation. *N Engl J Med* 340:685–691
- Kanarek RB, Marks-Kaufman R, D'Anci KE, Przypek J (1995) Exercise attenuates oral intake of amphetamine in rats. *Pharmacol Biochem Behav* 51:725–729
- Maxwell SE, Delaney HD (2004) Designing experiments and analyzing data: a model comparison perspective. Lawrence Erlbaum, London
- McMillan DE, McClure GY, Hardwick WC (1995) Effects of access to a running wheel on food, water and ethanol intake in rats bred to accept ethanol. *Drug Alcohol Depend* 40:1–7
- Morgan W (1997) Physical activity and mental health. Taylor and Francis, London
- Parrott, AC (1998) Nesbitt's Paradox resolved? Stress and arousal modulation during cigarette smoking. *Addiction*, 93:27–39
- Piasecki TM, Niaura R, Shadel WG, Fiore MC, Baker TB (2000) Smoking withdrawal dynamics in unaided quitters. *J Abnorm Psychol* 109:74–86
- Pomerleau O, Scherzer HH, Grunberg NE, Pomerleau CS, Judge J, Fetig JB, Burleson J (1987) The effects of acute exercise on subsequent cigarette smoking. *J Behav Med* 10:117–127
- Ryan RM, Deci EL (2000) Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am Psychol* 55:68–78
- Sayette MA, Shiffman S, Tiffany ST, Niaura R, Martin CS, Shadel WG (2000) The measurement of drug craving. *Addiction* 95 (S2):S189–S210
- Shiffman S, Paty JA, Gnys M, Kassel JD, Hickcoc M (1996) First Lapses to smoking: within-subjects analysis of real time reports. *J Consult Clin Psychol* 64:366–379
- Shiffman S, West R, Gilbert DG (2004) Recommendation for the assessment of tobacco craving and withdrawal in smoking cessation trials: SRNT Work Group on the assessment of craving and withdrawal in clinical trials. *Nicotine Tob Res* 6:599–614
- Silagy C, Lancaster T, Stead L, Mant D, Fowler G (2004) Nicotine replacement therapy for smoking cessation. Cochrane database of systematic reviews, 3. Update Software, Oxford
- Taylor AH (2000) Physical activity, stress and anxiety: a review. In: Biddle SJH, Boutcher S, Fox K (Eds) Physical activity and psychological well-being. Routledge, London, pp 10–45
- Thayer R, Peters D, Takahashi P, Birkhead-Flight A (1993) Mood and behaviour (smoking and sugar snacking) following moderate exercise: a partial test of self-regulation theory. *Pers Individ Differ* 14:97–104
- Thomas S, Reading J, Shepard RJ (1992) Revision of the physical activity readiness questionnaire. *Can J Sport Sci* 17:38–45
- Tiffany TS, Drobos DJ (1991) The development and initial validation of a questionnaire on smoking urges. *Br J Addict* 86:1467–1476
- Ussher M, West M (2003) Interest in nicotine replacement therapy among pregnant smokers. *Tob Control*, 12:108–109
- Ussher M, Taylor AH, West R, McEwen A (2000) Does exercise aid smoking cessation? A systematic review. *Addiction* 95:199–208
- Ussher M, Nutziati 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 MH, West R, McEwen A, Taylor AH, Steptoe A (2003) Efficacy of exercise counselling as an aid for smoking cessation: a randomised controlled trial. *Addiction* 98:523–532
- Ussher M, West R, Hibbs, N (2004) A survey of pregnant smokers' interest in different types of smoking cessation support. *Patient Educ Couns* 54:67–72
- Vonesh EF, Schork MA (1986) Sample sizes in multivariate analysis of repeated measurements. *Biometrics* 42:601–610
- West R, Hajek P (2004) Evaluation of the Mood and Physical Symptoms Scale (MPSS) to assess cigarette withdrawal. *Psychopharmacology* 177:195–199
- West R, Russell M (1985) Pre-abstinence smoke intake and smoking motivation as predictors of severity of cigarette withdrawal symptoms. *Psychopharmacology* 87:407–415
- West R, Hajek P, Belcher M (1989) Severity of withdrawal symptoms as a predictor of outcome of an attempt to quit smoking. *Psychol Med* 19:981–985
- West R, McEwen A, Bolling K (1999) Smoking cessation and harm minimisation strategies in the general population. Health Education Authority, London

Copyright of Psychopharmacology is the property of Springer Science & Business Media B.V.. The copyright in an individual article may be maintained by the author in certain cases. Content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.

Copyright of Psychopharmacology is the property of Springer Science & Business Media B.V.. The copyright in an individual article may be maintained by the author in certain cases. Content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.