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The effects of self-regulation strategies following moderate intensity exercise on ad libitum smoking

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HIGHLIGHTS

- An acute bout of 20 min moderate intensity exercise delays smoking.
- Self-regulation strategies following exercise can prolong smoking delay.
- Goal setting is a powerful strategy in smoking delay.
- Self-regulation strategies can improve exercise-based smoking-cessation interventions.

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ABSTRACT

Introduction: The purpose of the present study was to examine whether self-regulation strategies can further extend the effect of moderate intensity exercise on smoking delay.
Method: Participants were 40 adult smokers who were randomly assigned into two groups: control and self-regulation. A repeated measures design was adopted including a neutral condition (20 min video) and an exercise condition (20 min moderate intensity exercise).
Results: The results showed that smoking delay increased significantly for both groups; however, the increase for the self-regulation group was significantly larger than that of the control group.
Conclusions: The results support the anti-smoking effects of acute exercise; furthermore, they highlight the usefulness of self-regulation strategies, and in particular goal setting, in extending smoking delay. The present findings provide important evidence for the exercise and smoking literature and useful directions for the development of smoking cessation interventions.

1. Introduction

Considering the detrimental effects of smoking on health it is not surprising that the majority of smokers wish to quit smoking (Fiore et al., 2008; Robinson & Harris, 2011). Nevertheless, most, among whom smokers with life-threatening illnesses that may be attributable to smoking, are unable to cope with cigarette cravings and withdrawal symptoms (Stapleton, 1998), thus eventually relapsing early on following the quit attempt (Hughes, Keely, & Naud, 2004). Physical activity has been linked with lower smoking rates in cross sectional (Chiolero, Wietlisbach, Ruffieux, Paccaud, & Cornuz, 2006) and longitudinal studies (Laaksonen, Luoto, Helakorpi, & Uutela, 2002); in addition, it has been suggested as a protective factor in relapse following smoking cessation treatment (Abrantes et al., 2009), thus encouraging health professionals to promote exercise as an alternative form of treatment for smoking cessation (Everson, Taylor, & Ussher, 2010). Nevertheless, the findings from interventions adopting exercise as a means to achieve smoking cessation have provided mixed results (for a review see Ussher, Taylor, & Faulkner, 2014); stressing in particular the limited support for the long-term effects of the treatment and the need to further improve interventions to decrease smoking relapse.

Towards this direction, experimental research testing the acute effects of exercise on smoking behavior has provided guidance for developing more effective interventions, through the examination of features that could potentially increase exercise adherence, such as recommended intensity of exercise (Kurti & Dallery, 2014; Oh & Taylor, 2014), or participants' sense of autonomy (e.g., Taylor, Katomeri, & Ussher, 2005; Zourbanos et al., 2016).

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In considering the acute effects of exercise on smoking, researchers have used a variety of smoking variables as outcome measures, such as urge to smoke and cigarette cravings (e.g., Elibero, Van Rensburg, & Drobes, 2011; Taylor et al., 2005), withdrawal symptoms (e.g., Williams et al., 2011), and importantly, from an ecological perspective, ad libitum smoking (e.g., Faulkner, Arbour-Nicitopoulos, & Hsin, 2010). Overall, relevant reviews (Haasova et al., 2014; Roberts, Maddison, Simpson, Bullen, & Prapavessis, 2012; Taylor, Ussher, & Faulkner, 2007) have supported that cigarette cravings, withdrawal symptoms and negative affect decrease rapidly during exercise and remain reduced for up to 50 min following exercise, and that the effects on cigarette craving are greater for moderate and vigorous intensity exercise, compared to light or no exercise (Haasova et al., 2014). In particular, with regard to ad libitum smoking, Taylor and Katomeri (2007) identified the need for research to examine how exercise may influence smoking behavior, i.e., actual smoking rather than reports of cravings and withdrawal symptoms, which can strengthen the ecological validity of findings. Faulkner et al. (2010), using a within-subject design, examined the effect of a 10 min brisk walking task. They found that following the exercise condition time to first puff was significantly delayed compared to a passive condition. Similar results with varying delay times have been reported by Taylor and Katomeri (2007) following brisk-walking under stress inducing conditions, and by Reeser (1983) following stretch and isometric exercise in heavy smokers.

A potentially valuable feature of smoking cessation programs may be the use of self- regulation strategies (Mann, de Ridder, & Fujita, 2013). Self-regulation is a process where individuals assume the responsibility of learning, by self-monitoring their progress and using strategies that will lead to self- improvement and personal goals (Zimmerman, 2000). People with greater self-regulation ability are committed to healthier behaviors and are more successful in becoming more physically active (de Bruin et al., 2012). The development of self-regulation strategies within exercise-based smoking cessation interventions could potentially help improving the long-term effects of exercise programs on smoking cessation. A number of self-regulation strategies have been used in several smoking cessation programs to help smokers cope with smoking issues, among others, goal setting, self-talk, self-control, self-efficacy, anxiety control, breathing techniques, body-image exposure, etc. (Hassandra, Goudas, & Theodorakis, 2015; Nair, Collins, & Napolitano, 2013; Ussher et al., 2014). Goal setting is a psychological strategy that has been applied successfully to domains such as sport and health promotion for enhancing motivation (Locke & Latham, 2013). Concerning breathing techniques, research has been shown that conscious breathing, that is paying attention to breathing and learning how to handle it, is one of the most effective ways to improve mood and reduce stress (Ma et al., 2017). Cropley, Ussher, and Charitou (2007) reported that a guided body-scan relaxation routine including deep breathing and concentration, significantly reduced withdrawal symptoms including cigarette craving and negative emotion. Self-talk, described as self-instructional training has been a central component of cognitive behavior therapy (Meichenbaum, 1977). Self-talk is considered a key factor to establish cognitive control that could be used as a self- regulatory strategy in all aspects of behavior (Vygotsky, 1962). In the contemporary literature, self-talk strategies have attracted important attention within physical activity context and there is evidence suggesting that self-talk can serve to increase concentration, enhance self-confidence, and regulate mood (Theodorakis, Hatzigeorgiadis, & Chroni, 2008). In addition to these strategies, certain behavioral strategies, such as taking brief walks, which has been shown to delay smoking (Thayer, Peters, Takahaski, & Birkhead-Flight, 1993), and taking sips of water are among the recommendations of the American Cancer Society for enhancing self-regulation for smoking abstinence (American Cancer Society, 2016). In sum, the above evidence encourages the use of self-regulation strategies in combination with exercise as a means to empower the effects of exercise on smoking behavior.

In a relevant study, Hatzigeorgiadis et al. (2016) tested, using a within-subject design, the acute effects of moderate intensity exercise in combination with self-regulation strategies with references to exercising, on smoking delay in physically inactive smokers. Their results showed that smoking delay was significantly larger in both the exercise and the exercise plus self-regulation conditions; in addition, it was shown that the use of goal-setting, breathing exercises, and self-talk in relation to their exercise significantly prolonged smoking delay by approximately 10%, compared to the plain exercise condition. Acknowledging the limitations of their study, the authors identified the possibility of carryover effect and suggested that the adoption of between-subject or mixed designs would further enhance the confidence in the findings. Finally, they suggested that future research should explore the effects of smoking-related, rather than exercise-related, self-regulation strategies on smoking behavior. To address these recommendations, the present study aimed at exploring the potential additive effect of cognitive and behavioral self-regulation strategies targeting smoking delay following exercise. A randomized control trial design was adopted with two groups, control and self-regulation, to assess time to first smoke in two conditions, neutral and exercise.

2. Method

2.1. Participants

Power analysis (software G*Power 3.1.9.2) was calculated to identify the minimum number of participants required to achieve reasonable power. The analysis regarding the exercise effect showed that for an effect size of 1 (averaged effect identified by Taylor et al., 2007 for studies using the smoking ad libitum paradigm), 11 participants would be sufficient to achieve a power of 0.80. The analysis regarding the self-regulation strategies additional effect based on the findings by Hatzigeorgiadis et al. (2016), showed that for an effect size of 0.15, 38 participants would be sufficient to achieve a power of 0.80. Participants were 40 adults (12 males and 28 females), with a mean age of 42.00 (SD = 10.93) years. Participants were physically inactive (as assessed by the International Physical Activity Questionnaire-short form; Craig et al., 2003), adult smokers, who reported smoking on average 22.00 (SD = 7.55) cigarettes per day. The mean score on the Fagerström test for nicotine dependence (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991) was 6.18 (SD = 1.92).

2.2. Procedure

Ethical approval for the current study was granted by the Ethics Review Committee of the institution. Participants were recruited through public advertisement before the onset of the study. Upon recruitment, participants were informed that they should attend two morning sessions, that would last approximately two hours each, a week apart from each other. They were told that for both occasions they would have to abstain from smoking overnight, and that smoking abstinence would be evaluated through a breath test. These instructions were repeated one day before the first session when participants were contacted by phone to confirm the appointment.

Participants, who were blind to the treatment, were randomly assigned into control (n = 20, 15 females) and self-regulation groups (n = 20, 13 females). Participants of both groups were tested in two conditions one week apart at the same week-day and day-time; for both groups the two sessions were conducted in a consistent order: first, the neutral condition where time to smoke was assessed following a video session; second, the exercise condition where time to smoke was assessed following a moderate intensity exercise session. Upon arrival to the laboratory for the first session participants signed consent forms regarding participation requirements and withdrawal rights. One researcher trained in previous experiments and through extensive pilot trials implemented the intervention to all participants, with an assistant

who helped for the recording of the data.

2.2.1. Neutral condition

At the onset of the neutral condition, participants were asked to wear a polar strap (Sports Tester PE 3000, Polar Electro, Kempele, Finland) and rest in a supine position for 10 min. Resting heart rate was recorded using the polar watch and the 55th% of heart rate reserve was estimated using the Carvonen formula. Subsequently, measurements were obtained for height, weight, and exhaled carbon monoxide (CO) levels (PICO Smokerlyser, Bedfont, Rochester, UK). In addition, participants replied two items (I have a desire for a cigarette now, I have an urge for a cigarette) from the Questionnaire of Smoking Urge - brief (QSU-brief; Cox, Tiffany, & Christen, 2001), on a 7-point scale ranging from 1 (none) to 7 (too much). The use of two items only was preferred to reduce the already lengthy and demanding for participants procedures, considering that this measure was only administered for control purposes, rather than as outcome measure.

For the neutral condition, participants of both groups were asked to watch a neutral themed video (history documentary) for 20 min, during which they were not allowed to smoke. Heart rate (HR) was recorded every five minutes. After the completion of the 20 min, participants were informed that they would have to remain at the lab for another 60 min, during which they would continue watching the video; however, they were allowed to smoke whenever they felt like, either in the laboratory room or outdoors. At that time, they were offered water and orange juice, and presented an ashtray. During these 60 min, the time until lighting the first cigarette was recorded.

2.2.2. Exercise condition

Upon arrival for the exercise condition participants were asked to wear the polar strap. As in the neutral condition, exhaled CO levels were measured and smoking urge was assessed. Subsequently, participants were asked to exercise on a cycle-ergometer (Monark874E, Sweden) for 20 min, preceded by a 3 min warm-up. During cycling the experimenter was monitoring participants' heart rate, aiming at maintaining heart rate at 55 ± 5% of heart rate reserve. Accordingly, the experimenter instructed participants to increase or decrease rotations per minute (RPM), so that they remain in the designated heart rate reserve range. During the 20 min, heart rate and power output (Watt) were recorded every five minutes. In addition, participants' Ratings of Perceived Exertion (RPE; Borg, 1970) were assessed every 5 min. During cycling participant could watch a neutral themed video. Upon completion of the 20 min, participants were informed that they would have to remain at the lab for another 60 min, during which they could continue watching the video; however, they were allowed to smoke whenever they felt like. At that time, they were offered water and orange juice, and presented an ashtray. During these 60 min, the time until lighting the first cigarette was recorded.

Upon completion of the cycling task, participants of the self-regulation group were introduced for 5 min to the use of self-regulation strategies, which they could use if they wanted to. In particular, (a) they were given a form where they were asked to set a goal regarding time until smoking their first cigarette; (b) they were provided instructions on how to breath so that they relax; (c) they were provided instruction about self-talk cues they could use to prolong the delay and achieve their goal (e.g. “I set a goal and I will make it”, “I can do that”), and were asked to use these or other cues they thought would help them reaching or overcoming their goal; (d) finally they were instructed to take some sips of water slowly, or take a brief walk outside the laboratory when they felt like smoking. Upon completion of the cycling task, participants of the control group were provided for 5 min' information relating to physiological and psychological effects of exercise.

2.2.3. Social validation

Upon completion of the whole procedure of the exercise condition, participants of the self-regulation group were asked to complete a questionnaire assessing on a 5-point scale (1 = not at all, 5 = very much) which of the self-regulation strategies they used, and to evaluate on a 5- point scale (1 = not at all, to 5 = very much) how useful they thought these strategies were.

2.3. Data analysis

t-tests were calculated to examine differences in demographic and control variables that were assessed. Two-way ANOVAs with one repeated factor and one independent factor were calculated to test (a) for differences in exhaled CO and smoking urge at the onset of the two conditions as a function of condition (neutral, exercise) and group (control, self-regulation) and (b) for differences in control measures during the 20 min treatment (HR at the neutral condition, HR, power output, and RPE at the exercise condition) as a function of time (four 5-min intervals) and group, and (c) differences in time to first smoke following the two conditions as a function of condition and group. The SPSS 18 was used to run all analyses, and the significance threshold was set at 0.05.

3. Results

3.1. Control measures

The analyses regarding demographics and control variables showed no differences between the two groups for age, average cigarettes per day, for smoking dependence, for resting heart rate, and 55% heart rate reserve. In addition, no differences were revealed in exhaled CO levels and smoking urge, at the onset of the two conditions as a function of group. The statistics for the above measures are presented in Table 1.

The analyses regarding control measures during the treatment showed non-significant time by group interactions for HR at the neutral condition, and for HR, power output, and RPE at the exercise condition.

Table 1
Comparisons for demographic and baseline control variables by group.

	Control group (n = 20)		Self-regulation group (n = 20)		Statistics
	M	*SD*	*M*	*SD*	
Age	44.10	11.02	39.90	10.71	$t(38) = 1.22$, $p = .23$
Body mass index	27.84	5.65	27.09	4.40	$t(38) = 0.47$, $p = .64$
Cigarettes per day	20.78	9.01	22.93	7.56	$t(38) = 0.82$, $p = .42$
Nicotine dependence	6.05	1.79	6.30	2.08	$t(38) = 0.41$, $p = .69$
Resting heart rate	67.35	6.79	64.50	7.65	$t(38) = 1.25$, $p = .22$
55% Heart rate reserve	126.53	6.62	128.58	8.66	$t(38) = 0.84$, $p = .41$
Exhaled carbon monoxide – neutral condition	9.40	2.44	9.20	2.40	$F(1, 38) = 0.69$, $p = .41$
Exhaled carbon monoxide – exercise condition	9.30	2.51	8.90	2.53	
Smoking Urge – neutral condition	5.05	1.75	5.22	1.12	$F(1, 38) = 0.81$, $p = .37$
Smoking Urge – exercise condition	5.25	1.24	4.88	1.77	

Table 2
Mean scores and standard deviation for control measures during treatment for the two groups.

	Control group								Self-regulation group							
	min5		min10		min15		min20		min5		min10		min15		min20	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
HR neutral $F(3, 36) = 0.75$, $p = .53$	74.50	20.79	75.65	9.56	75.20	8.55	76.75	8.54	76.75	8.54	75.35	10.18	74.10	11.49	74.10	9.84
HR exercise $F(3,36) = 1.19$, $p = .33$	115.00	12.09	126.75	10.59	132.05	12.00	132.80	8.69	120.75	14.52	128.75	11.72	135.30	10.74	133.50	14.72
PO (Watt) $F(3,36) = 0.01$, $p = .99$	22.87	5.16	24.78	5.28	24.50	7.19	24.00	8.02	25.44	10.32	27.30	11.28	27.27	10.57	26.57	11.41
RPE $F(3,36) = 20.51$, $p = .68$	11.30	2.63	13.25	2.40	14.85	2.83	15.20	2.01	11.70	2.00	13.95	1.82	14.90	2.12	15.15	2.90

Note. HR neutral: heart rate – neutral condition; HR exercise: heart rate – exercise condition; PO: power output; RPE: ratings of perceived exertion.

The statistics for the above measures are presented in Table 2.

3.2. Smoking delay

Analysis of repeated measures (2 × 2) was calculated to test for differences in ad libitum smoking as a function of condition and group. The analysis showed a significant condition by group interaction, $F(1,38) = 5.66$, $p = .02$. Examination of the pairwise comparisons showed that (a) time-to-smoke increased significantly for both groups ($p < .00$) following the exercise condition, and (b) while there were no significant differences in time-to-smoke between the groups for the neutral condition ($p = .61$), for the exercise condition the time-to-smoke for the self-regulation group was longer than that of the control group ($p = .02$). Time-to-smoke for the two groups across the two conditions is presented in Fig. 1.

Participants reported goal setting as the most helpful strategy ($M = 3.70$, $SD = 1.22$), followed by drinking water ($M = 3.66$, SD 0.97); whereas walking, breathing and self-talk were perceived as less valuable (for walking, $M = 2.61$, $SD = 2.10$; for breathing, $M = 2.60$, $SD = 2.11$; for self-talk, $M = 2.43$, $SD = 1.74$).

4. Discussion

Studies exploring the acute effects of exercise on smoking variables have consistently shown that exercise can reduce smoking cravings and withdrawal symptoms, and delay smoking (Roberts et al., 2012; Taylor et al., 2007). Thus, exercise has been suggested as a potential treatment for smoking cessation (Everson et al., 2010). However, the inconsistent findings from exercise-based smoking cessation interventions stress the need to further improve the effectiveness of exercise interventions in particular with regard to their long-term effects (Ussher et al., 2014). On the basis of these findings, the present study explored the use of self-regulation strategies following exercise as a means to extend time to ad libitum smoking. The results showed that moderate intensity aerobic exercise was followed by an important delay in ad-libitum smoking; furthermore, it was found that the use of self-regulation strategies significantly prolonged this delay. In particular, the supplementary use of self-regulation strategies increased smoking delay by approximately 36.6%, compared to plain exercise.

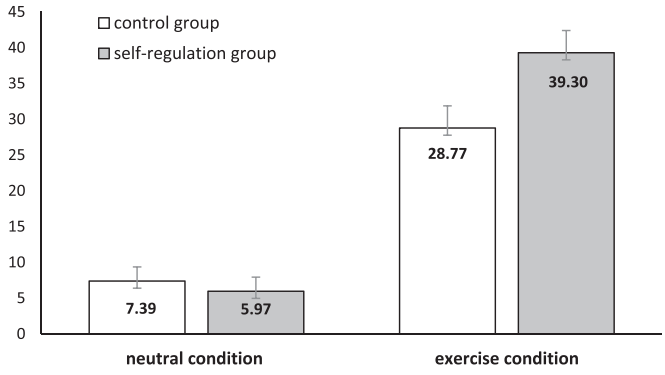

Fig. 1. Time to ad libitum smoking per group per condition.

Self-regulation strategies have been linked with changes in cognition, affect, and behaviour (Timms, Rivera, Collins, & Piper, 2014), and considered effective for improving mental and physical health (Biddle & Mutrie, 2008). Gould, Flett, and Bean (2009) proposed that using mental strategies is a holistic process that may affect self-awareness, self-regulation, mood and emotion, and ultimately enhance well-being. The findings suggest that these strategies indeed helped participants regulating their desire to smoke after the exercise task and taking the additional steps to meet or even surpass the delay goal, which was actually set by them. Goal setting has been found to increase motivation and commitment to goal. Based on the premises of self-determination theory (Deci & Ryan, 2000), that the goals were set by participants themselves may have further increased participants sense of autonomy that has been linked to personal responsibility and commitment to achieve personally valued health goals (Ryan, Patrick, Deci, & Williams, 2008). Breathing is a widely used relaxation technique to enhance self-control and regulate mood (Ma et al., 2017). Finally, self-talk has been found to increase self-efficacy and regulate cognitive and emotional reactions (Theodorakis et al., 2008). Among these cognitive strategies goal-setting was identified as the one that mostly helped participants extending abstinence time. The value of goal setting and its potential immediate effects on motivation and behavior has been globally recognized (Locke & Latham, 2013). The use of breathing and self-talk was reported as less influential. A plausible explanation is that these strategies require more practice before they are mastered and used effectively. Furthermore, among the behavioral strategies, participants identified taking sips of water as mostly helpful in delaying smoking. Considering that self-regulation strategies can be learned through appropriate practice (Zimmerman, 2000), their impact on smoking behavior can be much greater in long-term smoking cessation interventions, where participants are taught and more elaborately practice them over time, thus maximizing their effectiveness. The development and evaluation of such interventions is warranted to confirm such postulations.

Certain attributes of the present research require consideration as potential limitations. First, similarly to most of the studies examining the acute effects of exercise on smoking outcomes, the study was conducted in a laboratory setting under controlled conditions. Regarding exercise, trials involving also outdoors physical activity would enhance our confidence regarding the ecological validity of experimental designs; furthermore, they may yield greater effects. Regarding smoking, to enhance the ecological validity of the results we adopted the smoking ad libitum paradigm; nevertheless, being part of an experimental study may have introduced confounding factors, thus distorting smoking delay times compared to real-life settings. Second, the inclusion of non-active smokers only is also a viable limitation as the results cannot generalize to physically active smokers. Including only non-active smokers, (which is the most typical profile for adult smokers; Deruiter, Faulkner, Cairney, & Veldhuizen, 2008) was preferred to mixed active

and non-active smokers, to better control for the possible effect of exercise experience on smoking delay. Third, it should be noticed that the order of the two conditions for all participants was the same, with the neutral condition implemented first. Counterbalancing the order of conditions could possibly threaten the integrity of the exercise conditions, as participants of the self-regulation group would be likely to use the self-regulation strategies in the neutral condition, if the neutral condition was implemented second.

Overall, despite the issues identified above, the present study provides valuable evidence for the added value of self-regulation strategies on smoking behavior following exercise, thus encouraging further research on the usefulness of combining exercise and self-regulation strategies, and informing practice with regard to the use of self-regulation strategies in exercise-based smoking cessation interventions.

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Contributors

Maria Angeli conducted the experiment and drafted the manuscript. Antonis Hatzigeorgiadis and Yannis Theodorakis developed the idea, designed the experiment, and extensively revised the manuscript. Nikos Comoutos and Ioannis D. Morres contributed to the designing of the study and the preparation of the manuscript. Charalampos Krommidas contributed to the data analysis and the reporting of the results. All authors have read and approved the final manuscript.

Conflict of interest

All authors declare that they have no conflicts of interest.

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