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Exercise and Smoking: A Literature Overview

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Abstract

The purpose of this review is to summarize the more recent research findings regarding the relationship between exercise and smoking behavior. Reviewed studies have been presented according to themes and research design types. Initially cross-sectional and longitudinal epidemiological studies have been reviewed in order to map findings regarding the correlations between those two behaviors. Moreover, studies exploring variables that function as mediators or moderators between smoking and exercise relationship have been included. Then studies examining the possible preventive effects of exercise on smoking behavior for adolescents are reviewed and implications for developing effective preventive intervention programs are provided. Finally, experimental studies examining the acute and long term effects of exercise on smokers are reviewed in order to conclude if exercise can act as a treatment for smokers to manage withdrawal symptoms and help them quit smoking. Overall, exercise seems to have a protective effect against smoking as well as a supportive effect on smoking cessation treatments. The investigation of the underlying mechanisms behind this relationship and the systematic synthesis of new knowledge on this topic can improve our understanding and inform the development of more effective health promotion programs.

Keywords

Physical Activity, Smoking, Prevention, Treatment

1. Introduction

Physical activity and smoking are among those modifiable behaviors with a great impact on health. Regular

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physical activity enhances prevention of heart-related diseases, hypertension, osteoporosis, diabetes, back pain, respiratory and musculoskeletal problems and metabolic and neurological disorders [1]. Also, depression and anxiety can be reduced through exercise [2] [3]. Regarding smoking, research has shown that it exacerbates the prevalence of various functional problems and leads to serious diseases. According to the World Health Organization, half of regular smokers will die from diseases that are directly attributable to smoking [4].

Research examining physical activity and smoking behaviors concurrently has begun during the 80's [5], with more studies emerging in the last decade. The purpose of this review is to summarize research examining the relationship between exercise and smoking. The reviewed studies are organized along three themes: a) How these behaviors are related? b) Can exercise serve as a preventive factor for future smoking behavior? c) Can exercise be employed as a treatment in smoking cessation programs? It should be noted here that the terms exercise, physical activity and sport have been used interchangeably throughout this review.

The studies are organized in three sections. The first one presents cross-sectional and longitudinal studies examining the relationship between exercise and smoking behaviors in various populations as well as possible mediators or moderators of this relationship. The second section reviews programs for smoking prevention and outlines implications for improving the efficiency of respective programs. Finally, the third section is on exercise as a means to quit smoking and outlines acute and long-term effects of exercise on smokers as well as findings from theory-based respective interventions.

2. The Relation of Exercise with Smoking Behaviors

The relationship between exercise and smoking has been explored employing cross-sectional or longitudinal research designs and by examining the effects of possible moderators or mediators on this relationship.

2.1. Cross Sectional Studies

Cross sectional epidemiological studies show an inverse relationship both for adolescent and adult populations. Regarding adults, an early study of Thorlindsson, Vilhalmsson, & Valgeirsson [6], found that those who took part in various sporting activities smoked less. Similar results were reported by Theodorakis and Hassandra [7] exploring smoking habits in relation to exercise and sport participation of Greek participants, with a mean age of 20.7 years.

Several studies on adolescent populations also showed that physical activity and smoking behavior are inversely related. For example, Marti and Vartiainen [8] reported that frequency of leisure time exercise was inversely related to daily smoking in 1142 Finnish boys and girls 15 years old. Coulson, Eiser and Eiser [9] assessed physical activity and smoking of 932 high school students (12 - 15 years old) with smoking being related to lower levels of physical activity. Similar findings were reported by Holmen, Barrett-Connor, Clausen, Holmen, & Bjermer [10], in a study with 6.811 Norwegian students aged 13 - 19 years old. Another study of Audrain-McGovern, Rodriguez and Moss [11] examined the relationship between changes in physical activity and changes in smoking habits of adolescents. Their results showed that higher physical activity levels of high school students reduced the odds of progressing to smoking. Finally, a more recent study of Leatherdale, Wong, Manske, and Colditz [12], examined how physical activity in youth populations is associated with susceptibility to smoking among never smokers. For the 14.795 students who had never smoked, smoking susceptibility was negatively associated with being highly active. All the above cross sectional studies imply that there is an inversed relationship between smoking and exercise.

A cross sectional approach has several limitations on establishing a clear relationship between measured variables. Studies with a longitudinal design have many advantages in comparison with cross-sectional studies in advancing knowledge, providing information about continuity and prediction, and about within-individual change [13].

2.2. Longitudinal Studies

Longitudinal epidemiological studies indicate that higher levels of physical activity reduced the odds of initiating smoking or increasing smoking [12] and persistent physical inactivity in adolescence relates to adult smoking, even after family-related factors are taken into account [14]. These results imply that higher levels of physical activity may reduce the risk of smoking not only during adolescence but also for later adulthood. A study

tracking adolescents' physical activity and smoking behavior [14] concluded that participants who at baseline exhibited high levels both of smoking and physical activity levels, remained high, and those who had low levels retained these. On a more recent study, [15], investigated continuity and change in smoking behavior of Australian young women and associated attributes over a 10-year period. Moderate and high physical activity levels were associated positively with remaining an ex-smoker, implicating that cessation strategies should examine the role of physical activity in relapse prevention.

The inverse relationship between exercise and smoking behaviors derived mainly from epidemiological studies has generated related research questions, for example, since there is a trend which implies that the more you exercise the less you smoke, what other factors possibly mediate or moderate this relationship?

2.3. Mediation-Moderation

Several factors have been identified as either mediators or moderators of the smoking and exercise relationship. Tart, Leyro, Richter, Zvolensky, Rosen field and Smits [16], evaluated whether people who engage in vigorous-intensity exercise are better suited to regulate negative affective states. Negative affect mediated the relationship between vigorous-intensity physical activity and smoking, accounting for about 12% of this relation. Moreover, these relationships were stronger for individuals with high anxiety sensitivity than for those with low anxiety sensitivity**.**

Motivational variables have also been shown to regulate the relationship between smoking and exercise behavior. A study of Verkooijen, Nielsen and Kremers [17], showed that for males, participation in leisure time physical activity for friendship or competition reasons strengthened the inverse association between physical activity and smoking, whereas, in females, participation for losing weight or gaining self-esteem weakened the inverse association. In addition, enjoyment, health and, for females, friendships and stress relief were associated with less smoking irrespective of participation level, while self-esteem, losing weight and, for males, friendships were unrelated or even positively related to smoking. Thus the association between adolescents' leisure time physical activity and smoking behavior may differ according to the underlying motivation for the activity. Also, Papaioannou, Sagovits, Ampatzoglou, Kalogiannis, and Skordala [18] reported that a personal improvement goal in life was positive predictor of sport and exercise involvement and negative predictor of smoking and truancy two years later.

Global physical self-concept (GPSC), which is defined as a general perception of one's physical self, including appearance and physical activity competence, has been found to have an indirect effect on the relationship between physical activity and smoking to adolescents [19]. This finding suggests that the potential beneficial effects of physical activity on adolescent smoking may depend, in part, on GPSC and an adolescent's perception of his or her physical self may be one important factor to consider in youth smoking interventions.

King, Marcus, Pinto, Emmons, and Abrams, [20], examined the relationship between cognitive–behavioral (self-efficacy, decisional-balance) and motivational mechanisms (stage of change) which have been shown to mediate changes in both exercise and smoking behavior in 332 smokers. They reported that the cognitive mechanisms associated with changes in smoking behavior are related to the cognitive variables (decision balance and self-efficacy) which have been shown to predict changes in exercise behavior. Significant relationships in mediating mechanisms including decisional balance and self-efficacy between smoking and exercise provide preliminary information on how change in one risk behavior may relate to change in another. These associations have implications for future intervention research and for methods research on multiple risk factor interactions.

Overall, negative affect, anxiety sensitivity, emotional vulnerability, reasons for being physically active, personal improvement as a life goal, global physical self-concept, decisional balance and self-efficacy have been detected as mediation or moderation variables on the relationship between physical activity and smoking.

Given the inverse relationship between exercise and smoking and information regarding possible mediators or moderators of this relationship, questions that arise are: a) is it possible to prevent future smoking behavior if we promote exercise, especially in youngsters? and b) can exercise be employed in smoking cessation programs? Most of the above reviewed studies suggest that future youth smoking prevention programs should integrate strategies to promote physical activity in order to prevent smoking (e.g. [11]).

2.4. Exercise for Smoking Prevention

Youth who participate in organized sports at school or in their communities are, in general, less likely to engage

in risky behaviors, such as cigarette smoking and drug use, than non-sports participants [21] although the cultural norms related to some forms of organized or competitive sports may be more or less conducive in encouraging and reinforcing tobacco use by adolescents [22]. This implies that the development of a healthy lifestyle in general (including physical activity) might be the main mechanism of smoking prevention (and other unhealthy behaviors e.g.: drugs) and not the activity per se. There is evidence that supports the incompatibility between those two behaviors, indicating that adolescents who participate in greater levels of physical activity are less likely to smoke, or they smoke fewer cigarettes [6] [9] [21] [23] [24].

Despite calls for interventions that address multiple health behaviors concurrently [12] [25] [26] most of the preventive programs for adolescents target solely smoking behavior or smoking related variables. Addressing two health-related behaviors concurrently, Hassandra, Theodorakis, Kosmidou, Grammatikopoulos, and Hatzigeorgiadis [27], applied a smoking prevention program, named "I do not smoke, I exercise", to 210 students of junior high school. The main focus of this program was the promotion of exercise as an alternative behavior to smoking. Results showed that the program succeeded in changing the students' attitudes, but follow-up assessment 12 months later showed that attitudes towards smoking and interest in information relapsed to the pre-intervention levels although knowledge was sustained. A review of 8 successive applications of this program, showed that it had stronger effects for elementary school students, but when additional activities for smoking cessation were added then positive results for high school students were also reported [28].

The Oslo Youth Study [29] targeted three behaviors: eating habits, physical activity, and tobacco smoking. At the end of the program the intervention group experienced a smoking onset rate of 16.5% and the reference group a rate of 26.9%. Additionally, intervention group students had a significantly larger increase in scores on a smoking knowledge index; they also reported a significantly larger increase in frequent exercise and a significantly smaller increase in consumption of alcoholic beverages. Both the above programs had as a long term effect the increased knowledge of experimental group students about smoking. Additionally, in the study of Tell *et al*. [29] the frequency of exercise was higher in the intervention group. This implies that if students manage to keep their exercise levels high then the probability of adoption of unhealthy behaviors (e.g.: smoking and alcohol) is lower.

Large scale surveys showed that there is a link between tobacco use and other unhealthy behaviors, and that people generally adopt an overall healthy or unhealthy lifestyle [26] [30] [31]. Theodorakis *et al*. [32] examined the healthy and unhealthy behavioral profiles of Greek high school students. Most of the students were clustered on the healthy profile with high scores on healthy attitudes towards lifestyle behaviors (exercise, healthy eating) whereas, the remaining students adopted an unhealthy profile with positive attitudes towards smoking, drugs and violence. It was concluded that students tend to adopt a group of healthy or unhealthy behaviors and therefore interventions aiming to promote healthy lifestyle should target more than one behavior. Similar conclusions have been offered by Coulson, *et al*. [9] who suggested adopting an integrated approach for school-based health education programs rather than treat health behaviors in isolation from each other. According to Lippke, Nigg, & Maddock [33], success in one behavior change can be used to facilitate change in another health-related behavior as well.

A related question regards the form of physical activity that may have the best results in preventing smoking. According to a study of Rodriguez and Audrain-McGovern [19], adolescents with decreasing and erratic levels of team sports participation were more likely to smoke than those with high levels of participation. Further, in the Holmen *et al*. [10] study, participants in individual sports requiring less endurance, especially body-building and fighting sports, were more likely to be daily smokers than nonparticipants. These data suggest that smoking habits associated with different sports should be considered when promoting physical activity for smoking prevention.

There are several intervention programs for adults aiming to raise awareness for the benefits of a physically active style for both physical and mental health and the benefits of quitting smoking on their health. A recent meta-analysis [34] which examined the outcomes of interventions aiming to increase physical activity as part of comprehensive multiple risk factors programs, reviewed 358 reports comprising 99,011 participants. The overall mean effect size for comparisons of treatment groups versus control groups was 0.19 (higher mean for treatment participants than for control participants). Participant characteristics were unrelated to physical activity effect sizes. Exploratory moderator analyses suggested that the characteristics of the most effective interventions were behavioral interventions instead of cognitive interventions, face-to-face delivery versus mediated interventions (e.g., via telephone or mail), and targeting individuals instead of communities.

2.5. Implications for Future Preventive Program Development

The general guidelines of successful interventions aiming to promote healthy behaviors and prevent unhealthy ones apply also to the effectiveness of intervention programs aiming to prevent smoking by promoting physical activity. The combination of program contents, the social setting, and individual dispositional characteristics can have an effect on the effectiveness of the prevention programs and therefore their design and implementation should be sensitive to population characteristics at both the individual and socio cultural levels [35] [36]. A review of reviews of behavioral change interventions aiming to reduce unhealthy behaviors and/or promote healthy behaviors (including physical activity and smoking behavior) concluded that interventions that were most effective across a range of health behaviors included physician advice or individual counselling, and workplace- and school-based activities. Mass media campaigns and legislative interventions also showed small to moderate effects in changing health behaviors [37]. The family status of adolescents also has been found to relate with both smoking and physical activity [30]. Finally, another suggested effective strategy that relates to both physical activity promotion and smoking prevention is the teaching of life skills to intervention groups. According to the World Health Organization [38] an important component of health education programs is a skills-based education including life skills. Therefore the incorporation of skills training especially for school children is necessary in order to effectively promote health related behaviors. Intervention programs who included skills training have reported positive results. For example, in the Sorensen, Gupta, Nagler, and Viswanath [39] study, the intervention group students were significantly more knowledgeable about tobacco and related legislation, reported more efforts to prevent tobacco use among others, and reported stronger life skills and self-efficacy than students in control schools. The life skills component has been used to the smoking prevention program "I do not smoke, I exercise" [27], with positive results, as mentioned earlier.

The need to develop, implement and evaluate public health interventions based on sound health behavioral theories has been well documented [40] [41]. The most popular psychological theories employed to explain the relationship between psychological variables and smoking behavior include: the Social Cognitive Theory [42], the Theory of Planned Behavior [43], the Goal-setting Theory [44], the Health Belief Model [45] the Thrans-theoretical model [46], and the Self-Determination Theory [47] [48]. According to all the previous information it is clear that there is a need for awareness programs in order to promote physical activity and prevent smoking initiation especially to young people. School based awareness programs for all educational levels must be developed in order to promote healthy habits in early ages where the lifelong habits are formed. There is also a need to promote awareness in adults, where the awareness programs should be more focused to different targeted groups and develop interventions according to their needs, e.g. workplaces, or special populations.

3. Exercise as Treatment

The last two decades several studies have been published examining the effects of exercise on smoking cessation. Long term effects of smoking cessation programs that used exercise promotion as an additional aid strategy are less reported in the literature. A clearer understanding of the relationship between exercise and smoking cessation outcomes may improve the design and the effectiveness, of future exercise-based smoking cessation interventions. There are two main groups of experimental studies examining the effect of exercise on smoking related variables; those examining the acute effects and the ones examining the long term effects of an exercise program.

3.1. Acute Effects of Exercise on Smokers

Three reviews have been published since 2007 with a focus on the acute effects of exercise on smoking related measures [49]-[51]. Twelve of the 14 studies that were reviewed by Taylor, *et al*. [51] compared a bout of exercise with a passive condition and reported a positive effect on cigarette cravings, withdrawal symptoms and smoking behavior. The two remaining studies compared two intensities of exercise and showed no differences in outcomes between them. In all these studies cigarette cravings, withdrawal symptoms and negative affect decreased rapidly during exercise and remained reduced for up to 50 minutes after exercise. Cravings and withdrawal symptoms were reduced with an exercise intensity from as high as 60% - 85% heart rate reserve (HRR) (lasting 30 - 40 minutes) to as low as 24% HRR (lasting 15 minutes), and also with isometric exercise (for 5 minutes). It was concluded that even relatively small doses of exercise should be recommended as an aid to

managing cigarette cravings and withdrawal symptoms.

Haasova, *et al*. [49] examined data from 17 studies which compared participants engaging in physical activity against control group participants using post-intervention measures of strength of desire and desire to smoke with baseline adjustments. Despite a high degree of between-study heterogeneity, their results showed that the effects sizes of all primary studies were in the same direction, with physical activity groups showing a greater reduction in cravings compared with controls, implying strong evidence that physical activity acutely reduces cigarette craving. The latest review of Roberts, *et al*. [50], came up with similar results as the two previous ones: cigarette cravings were reduced following exercise with a wide range of intensities from isometric exercise and yoga to activity as high as 80% - 85% heart rate reserve. However, measures of tobacco withdrawal symptoms (TWS) and negative affect increased during vigorous exercise. The authors pointed out that it remains unclear which is the most effective exercise intensity to reduce cravings and what are the underlying mechanisms associated with these effects.

All the above reviews provide strong evidence that exercise sessions have an acute effect on cigarette cravings, but the mechanisms remain quite unclear. All of the reviewed studies come from the behavioral discipline. There are other studies that come from the physiology discipline which might contribute to the understanding of the physiological mechanisms underlying these effects. The Roberts *et al*. [50] review grouped the most recent research findings in three hypothetical explanation scenarios: the affect, biological and cognitive hypotheses.

According to the affect hypothesis, several studies support the claim that an increase in positive affect could result in a decreased desire to smoke. However results from different studies are not consistent about which intensity is most likely to create a positive affect [52]. According to Bock, Marcus, King, Borrelli, and Roberts [53] and Harper [54] a bout of vigorous exercise reduced smokers' negative affect and psychological withdrawal symptoms. Whereas, in the Everson, Daley & Ussher [55] study both moderate and vigorous intensities had similar effects on cravings, but there was an adverse effect on mood. However, in non-acute effects interventions where the exercise intensity was gradually increased [53] [55], which allowed the smokers to adapt to exercise gradually the results may be different. Another way to examine the acute effect of different exercise intensities on mood in this context is to allow the participants to choose the intensity themselves during the exercise session according to the positive or negative mood they experience during exercise in relation to TWS. An experiment with this design might therefore give additional information on the Roberts, *et al*., [50] suggestion to examine the mediating effect of mood on the exercise-craving relationship.

The proposed biological hypothesis as an underlying mechanism on the relation of exercise and TWS is quite equivocal. Some of the biomarkers influenced by both nicotine and exercise include cortisol, autonomic regulation (indexed by heart rate variability), noradrenaline, and adrenaline [56]. The general hypothesis is that exercise acts via the same neurobiological pathway(s) as nicotine to relieve cravings and TWS that cause relapse to smoking [51]. For example, stimulating increases in cortisol with exercise during nicotine depletion could provide an equivalent endogenous endocrine drive as nicotine. If exercise can have an effect in these physiological processes, then perhaps it can reduce the likelihood of smoking relapse, and offer an additional treatment option.

Changes in catecholamines is another area of exploration which is based on previous findings that levels of adrenaline and noradrenaline increase with smoking [57], and smoking cessation results in a decrease of both [58]. Thus, the increase in adrenaline and noradrenaline post-exercise may explain the effect of exercise on cigarette cravings. But, according to Richter and Sutton [59], during single bouts of exercise, the concentration of adrenaline and noradrenaline increases in line with the intensity and duration of exercise, which means that, if the exercise session is short and the intensity is moderate to light then it might be quite difficult for any changes to occur. Lately, this has been partially confirmed by a study which compared the effects of three exercise intensities on the desire to smoke. Findings support the use of vigorous exercise to reduce cigarette cravings, showing potential alterations in a noradrenergic marker [60]. Finally, changes in Heart Rate Variability (HRV) caused by short or long smoking abstinence and how acute bouts of exercise can have an immediate effect on HRV needs to be further examined in future research [61]-[64]. In this direction some later studies are much more supportive, for example, a single session of exercise (e.g.: a self-paced 15-min walk) can attenuate or reduce post-exercise both systolic blood pressure and diastolic blood pressure responses to stress [65] [66]. Korhonen, Goodwin, Miesmaa, Dupuis, and Kinnunen [67], also suggest that even if complete abstinence is not achieved, reduction in tobacco exposure and increase in exercise can improve the cardiovascular risk profile.

The cognitive hypothesis which claims that exercise may influence cognitive demand in such a manner that it acts as a distraction from smoking-related thoughts has not gained support lately since studies showed no effect

of distraction on cigarette cravings [54] [68]-[70]. Roberts *et al*., [50] postulate that expectancy and credibility are two factors that need to be further examined as possible regulating factors to this cognitive hypothesis in future research. Nevertheless, a more recent study showed differing activation towards smoking images following exercise compared to a control treatment and may point to a neuro-cognitive process following exercise that mediates effects on cigarette cravings [71].

It is apparent that in future research examining the acute effects of exercise on TWS, there is a need of integration of different methods and concepts from different disciplines. That way might be possible to avoid the pitfalls of these acute studies in a laboratory setting, where the effects do not necessarily translate to the real world settings.

To that direction it would be interesting to examine how different exercise intensities affect the interaction of physiological, biochemical and psychological mechanisms and what is the optimal level of exercise intensity and physical conditioning which has beneficial effects on physiological (catecholamines, opioids, inflammatory markers) and psychological (perceived self-control, positive mood and levels of feelings of euphoria and pleasure and decreased levels of pressure, stress and depression) indexes? Also, what other variables act as moderators or mediators when participants experience the effects of exercise on TWS from the participants' perspective?

In conclusion, we can postulate that there is strong evidence that an acute bout of exercise reduces cigarette cravings and TWS, although there might be some differences in the magnitude of this effect for light, moderate, or vigorous exercise. The underlying mechanisms associated with the effect of exercise remain unclear. These acute effects should be utilized in smoking cessation programs. Therefore, a review of longer term effects of exercise on smoking cessation follows.

3.2. Long Term Effects of Exercise on Smokers

A narrative review by Ussher, Taylor, and Faulkner [72] on exercise interventions for smoking cessation revealed mixed results. They focused more on studies that provided data for long term effects (more than 6 months). They identified 15 trials, seven of which had fewer than 25 participants in each treatment condition. These studies varied in the timing and intensity of the smoking cessation and exercise programmes. Three studies showed significantly higher abstinence rates in a physically active group versus a control group at the end of the treatment [73]-[75]. One of these studies also showed a significant benefit for exercise versus control on abstinence in a three-month follow up and a benefit for exercise in a 12-month follow up [74]. One study showed significantly higher abstinence rates for the exercise group versus the control group in the three-month follow up but not in the end of treatment or 12-month follow up [76]. An updated review by the same authors [77] concluded that two of the 20 trials offered evidence for exercise aiding smoking cessation in the long term.

In relation to the interventions' components, there is some evidence that additional (to the exercise program) supportive actions are necessary. This support can be either pharmaceutical e.g.: nicotine patches or gums [78]-[80] or counselling sessions, e.g.: cognitive behavioral support [74] [81]. Counselling can help people in organizing their everyday life activities, and direct them to participate in physical activity. Counselling techniques can also be employed to help deal with the desire for smoking and all the associated symptoms, such as sleeping problems, lack of concentration, depression and irritability. Within this approach, the aim of exercise is not necessarily fitness improvement but rather substituting attachment to smoking with attachment to physical activity, which offers a valuable and healthier alternative for smokers who try to quit [82].

It is not clear yet if an exercise program alone is enough to attain long term abstinence. Moreover, there is an on-going debate if the exercise program should start before, at the same time or after a set "quitting day". There are reasonable arguments for all these choices, but it is still unclear what other contributing factors may affect the effectiveness of these different options like, the previous fitness levels, age, motivation or the readiness level. The optimal length and frequency of the intervention sessions is still unclear but according to Marcus, *et al.* [76], at least 110 minutes of activity per week is suggested in order to maintain abstinence.

Regarding the exercise characteristics there are several combinations of type, intensity, frequency and duration that have been tested. Low intensity and frequency e.g.: once per week [76] [83] has provided inconsistent results on abstinence. Moderate and vigorous intensity with a frequency of three times per week for at least 2 months, provided more promising results [73] [84]. However, findings from the longitudinal studies showed that if intensity of exercise is progressively increased through smoking cessation programs smokers tend to adapt

better to higher intensities [53] [54].

There is also an argument whether the supervised or unsupervised kind of exercise is more appropriate to achieve both abstinence and exercise adherence [74]. In order to increase the probability of abstinence at the end of an intervention, supervised exercise sessions look more adequate [74] [78]. But if at the same time the goal is to keep the participants active in order to prevent future relapses then, the addition of self-directed exercise looks more promising [79] [83] [85]. Therefore, a combination of both types may be the preferable choice. There is also a need to examine the effect of booster sessions after the end of the intervention (e.g.: via web-based programs, follow-up telephone counselling, mail out printed material, mobile phone SMS) on the long term exercise adherence and cigarette abstinence.

Several types of exercise have been tested, for example, resistance training [78], isometric exercise [86], t'ai chi classes [87] and yoga [88] for their effectiveness. According to Daniel, Cropley, Ussher & West [68], even very brief bouts of exercise (5 minutes) may be useful as an aid to smoking cessation. The positive effects of the different exercise types on quit smoking might suggest that any kind of exercise is effective or that exercise acts as a placebo effect to the quitting effort, because of the expectations. Nevertheless, if the focus of an intervention is exercise adherence then the individual preferences on the type of exercise might be an additional issue to be explored in future research.

Physical fitness is also considered as a contributing factor to the exercise-smoking relationship [89]. Usually low fitness levels act as a barrier when individuals try to exercise and not smoke. However, previous studies aiming to increase the physical conditioning as well, have reported positive results, although they did not provide long-term follow ups [73] [81] [90]. Nevertheless, physical activity as a smoking cessation aid is beneficial for participants in terms of psychological and general health even without any increases in fitness levels [51] [91]. In addition, regular physical activity increases caloric expenditure, and therefore may increase the metabolic rate and reduce the weight gain associated with smoking cessation [15] [82]. It has also been suggested that during therapy, the combination of appropriate exercise intensity and the use of techniques dealing with negative psychological situations are necessary in order to avoid interrupting the quitting efforts [92]. Findings from another study indicate that imagery-based self-talk exercises aimed at increasing self-compassion might facilitate the self-regulation of compulsive behaviors such as smoking [93]. Several studies have used supervised sessions of exercise in combination with cognitive behavioral strategies with satisfactory results. For example, goal setting, self-monitoring, reinforcement, self-monitoring and pedometers have been employed as motivational tools [80] [90] [94] [95]. A relative factor that has not been examined is the fitness level of the participants on the baseline and if this has an effect on the results of the intervention. The majority of the interventions either do not assess the starting fitness level or they target only sedentary participants.

Apart from assessing the behavioral measures related to the intervention programs aiming to achieve smoking abstinence through an exercise program, a series of psychological constructs have also been assessed, showing interesting results. Self-efficacy has been increased on programs, who involved cognitive behavioral strategies [81]. Depression and perceived stress were not affected by exercise, according to Bize, *et al.* [83], but according to Vickers *et al.* [96] depression was lower on women smokers on the exercise group and increased fitness was associated with fewer depressive symptoms on successful smoking abstinence among women [97]. The latest findings seem to be in accordance with the literature, which supports the claim that exercise reduces mood disturbance, stress and anxiety [98]. But, according to earlier research findings [95], there was a significant increase in Profile of Mood States (POMs) tension and anxiety scores for the active group compared with the controls at four months follow up. Schneider, Spring and Pagoto [99] commenting on these contradictory findings about the effects of exercise on negative affect during smoking cessation stated that exercise may help temper negative affect states for women with heightened smoking-specific weight concern.

Finally, physical activity could be promoted as a cessation aid and as part of a holistic lifestyle change consistent with a non-smoker's identity [100]. In a relevant study [101], participants stated that they perceived exercise as a means that helped them manage their feelings of stress and tension during their effort to quit smoking, and as a way to improve their life by adopting a healthier lifestyle.

Overall, the majority of the above studies focus on either physiological or psychological underlying mechanisms. There is a need for studies to explore both psychological and physiological variables in order to give a more holistic explanation of these mechanisms. Based on the above, it seems that understanding the psychological, biochemical, and physiological factors during smokers' exercise could lead to the development and implementation of an intervention program that combines exercise with applied counselling techniques aiming at

smoking cessation. Therefore, it would be interesting to investigate how a smoking cessation program which incorporate an optimal intensity exercise program in combination with the more updated applied psychological and counselling techniques will affect the participants' physiological (e.g.: the increase of the levels of VO2), biochemical variables (such as β-endorphin) and psychological measures (increased perceived self-control, positive mood and levels of feelings of euphoria and pleasure and decreased levels of pressure, stress and depression)? In addition, it would be useful to examine at the same time what other moderators and mediators affect the exercise and smoking relationship, as they are reported by the subjects (motivation, significant others influence, attitudes, self-confidence)?

3.3. Theory Based Interventions

Behavior change is a multifaceted task and the attempt to change two behaviors at the same time is much more complicated. The need to build interventions on well theoretical grounded models is essential in order to better understand the most effective mechanisms to achieve long term effects on exercise adherence and smoking abstinence. On the other hand, the efficacy of health behavior change programs addressing a single behavior is questionable, as most people usually adopt multiple unhealthy behaviors [31] [102]. Therefore, targeting two behaviors, like exercise and smoking, in interventions may be more effective than focusing only in one.

There is prior research knowledge, well grounded in theory, on both behavior changes separately, which we can build on and test further on the combination of those two behaviors [103]. A theoretical model that has been extensively used on the prediction and explanation of health behaviors is the Theory of Planned Behavior [TPB, 43]. Central of the TPB is that any behavior is codetermined by behavioral intention and perceived behavioral control and that intention to smoke/to exercise can be predicted by attitudes toward smoking/exercise, subjective norms and perceived behavioral control. Intention reflects an individual's decision to exert effort to perform the behavior. On the other hand, Perceived Behavioral Control (PBC) is the extent to which an individual perceives that the behavior is under his/her control.

According to a meta-analysis of the prospective prediction of health-related behaviors with the TPB, its efficacy varies depending on behavior type, with physical activity best predicted, and abstinence behaviors predicted relatively poorly. The age of participants moderated the relations with student samples providing better predictions for physical activity, and adolescent samples giving better predictions for abstinence behaviors. The length of follow-up measures moderated models' relationships with behavior better predicted in the shorter term. Finally, self-report behavior measures were better predicted than objective behavior measures [104]. Armitage & Conner [105] in a review of 185 studies concluded that the TPB accounted for 27% and 39% of the variance in behavior and intention, respectively. When behavior measures were self-reports, the TPB accounted for 11% more of the variance in behavior than when behavior measures were objective. Attitude, subjective norm and PBC account for significantly more of the variance in individuals' desires than intentions or self-predictions, but intentions and self-predictions were better predictors of behavior. Additionally, according to Shiehotta, Scholz & Schwarzer [106] planning, maintenance self-efficacy and action control may be important volitional variables as they served as mediators between earlier exercise intentions and later physical activity. According to another systematic review of Hardeman *et al*. [107] the TPB mainly is used to measure process and outcome variables and to predict intention and behavior on interventions aiming to change health behaviors. Persuasion, information and skill development are the most common behavior change methods. All the above support the effectiveness of the TPB as an adequate theoretical background for behavior change interventions. Nevertheless, in smoking behavior the role of exercise has not been examined satisfactory.

4. Conclusion

Based on the studies reviewed in this paper, it seems plausible to state that exercise can be used both for smoking prevention and for smoking cessation. However, preventive programs should focus on an overall healthy lifestyle including exercise, rather than on smoking solely. Moreover, long-term interventions employing exercise to stop smoking should be coupled with respective counselling strategies.

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