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Cardiopulmonary adaptation following a training period of 16 weeks. Six-minute walking test and the assessment of exercise responses in sedentary adult smokers

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ABSTRACT: ***Purpose.*** *Examine the effect of physical activity after 16 weeks training, on life quality and cardiorespiratory responses through the 6 min walking test in sedentary adult smokers.* ***Methods.*** *Sixty five sedentary smokers and non-smokers participated in this study. We consider cigarettes smokers; all subjects who consumed greater than or equal to 10 pack-years (PA). A 6MWT was performed, pre-and post-training program. The subjects were divided into 2 equal groups. The first cigarette smokers group (SG) and the second non-smokers group (NSG). The two groups were subjected to a drive period of 16 weeks.* ***Results.*** *A significant decrease in dyspnoea similar to the resting HR and systolic BP (SBP) ($p < 0.01$ and $p < 0.05$ respectively). For smokers group, resting HR and SBP are significantly higher than those of non-smokers at the beginning and end of the study ($p<0.001$). Similarly, we recorded in these groups lowered values of diastolic BP (DBP) but is significant only for subjects SG ($p < 0.05$). Cigarette smokers showed a decrease in Max HR (beats. min^{-1}) at the end of the protocol (142.2 ± 2.9 before vs. 138.3 ± 1.2 after), significantly higher than non-smokers (138.9 ± 1.7 pre test vs. 137.7 ± 1.2 post test). Oxygen saturation (O2.S), both groups' cigarettes smokers and non-smokers are homogeneous at the beginning and the end of the study revealed no significant difference.* ***Conclusion.*** *Important changes in the body tolerance at exercise in sedentary adult smokers undergo a training program for 4 months. This program is to provide alternatives several for reducing tobacco. Also we can conclude that the 6MWT is an interesting way of assessing exercise tolerance in adult smokers.*

Keywords: *smokers; non-smokers; six-minute walking test; cardiopulmonary fitness.*

I. INTRODUCTION

Smoking is the leading cause of preventable death in the world, with an estimated number of 4.9 million deaths per year [1-2]. It is also a major cardiovascular risk factor via the one hand, the nicotine which causes an increase in myocardial oxygen demand and secondly, by functional anemia induced by increased uptake of carbon monoxide on the hemoglobin. Finally, tobacco also has a harmful effect on peripheral muscle [3-4]. These various effects result in decreased exercise tolerance [5-6].

Smoking was associated with lower cardiovascular capacity [7-8-9], impaired the heart response to exercise [10-11], which are both significant predictors of all-cause mortality [12-13].

So far, the interventions of tobacco harm reduction have focused on the use of innovative tobacco products, reducing the consumption of tobacco and on pharmaceutical medicaments. Therefore, there is a need to broaden the range of potentially effective strategies of harm reduction for smokers unable or unwilling to quit. We would like that physical activity has the potential to become such a strategy so that it can delay the onset of disease and premature death initiated by tobacco.

Benefits cardiovascular, respiratory and muscular of fitness training in healthy subjects have been widely noted [14].

The comparison made by Silva et al [15] between a group subject to a workout program for 3 months and a control group shows a significant improvement in the distance covered in 6 min (355 m) in the intervention group. Another study by Oka et al [16], observed the benefits of physical activity continued for 3 months. It showed a significant decrease of fatigue and improved physical capacity and life quality. Also, Beneke et al [17] observed a significant improvement in VO2 max (18%) and an increase in spontaneous walking speed (70%) in 16 men undergoing a training program for 3 weeks.

Regular use of a laboratory test to assess the subjects' progress after a period of physical activity seems difficult for disabled individuals and it is complex, requiring skilled personnel and expensive equipment [18]. Therefore, other more simple and inexpensive.

6-minute walking test (6MWT) is a valid method, simple and safe, often used to regularly assess the exercise functional capacity and the effects of rehabilitation programs for individuals with cardio-pulmonary problems [19]. Actually, the 6MWT is considered as the more relevant test that reflect physical activities of daily living and cardiopulmonary
fitness [20-21].

To our knowledge, no study has administered this test to assess the training program effect on exercise tolerance and cardiorespiratory fitness among smokers' sedentary adults.

The study objectives are:

- Determine if active smokers respond significantly better to an effort compared before training program.
- Examine the effect of physical activity on life quality and cardiorespiratory responses through the 6 min walking test.

II. METHODS

2.1. Subjects

Sixty five sedentary smokers and non-smokers in good health participated in this study. Their mean values of age, height and weight were respectively 44.7 ± 4.5 years, 174.3 ± 2.3 cm, 71.3 ± 2.7 kg. After receiving a complete verbal description of protocol, risks and benefits of the study, the subjects provided written consent to an experimental protocol approved by the Researsh Ethics Committee of the Faculty Medicine's, from University of Sfax in Tunisia.

the smokers cigarette subjects have been recruited on the basis of the number of cigarettes per day and career period. We consider cigarette smokers; all subjects who consumed greater than or equal to 10 pack-years (PA) and an average score of tobacco dependence of 4.33 ±1.67 measured by the Fagerström Nicotine Dependence Scale [22].

The subjects were divided into 2 equal groups. The first cigarette smokers group (SG) and the second non-smokers group (NSG). The two groups were subjected to a drive period of 16 weeks.

2.2. Materials and measured parameters

2.2.1. Anthropometric measures

Mass (kg) of the subjects was measured with a calibrated electronic scale and standing height (m) was measured with a stadiometer fixed. Also a score out of ten representing the dyspnoea level (Borg scale dyspnoea). Resting heart rate (HR) and oxygen saturation (O2.S) were measured by a pulse oximeter type NONIN model 9847 before 15 minutes test start.

Subjects were asked to indicate their level of dyspnea perception using a modified 12 point Borg scale.

2.2.2. The 6 min walking test (6MWT)

The 6MWT was performed, pre-and post-training program at the Higher Institute of Sport and Physical Education of Sfax (ISSEPS) in a corridor 30 meters long. 65 Subjects were asked to walk as far down the length of the corridor, at their own pace, for 6-min. Subjects were informed of the time elapsed every 60 s.

Subjects were allowed to stop if they developed symptoms of dyspnea, chest pain, leg cramps or dizziness, but were encouraged to continue walking as soon as they could. At the end of the test, each subject's heart rate, blood pressure, oxygen saturation and Borg value was measured, and the maximum predicted heart rate (Max HR) was calculated (Max HR = 220 - age). All tests were conducted and supervised by the same technician at each of the two sites.

2.2.3. Training program

The training period lasts 16 weeks at an intensity of 70 -80% HRmax and is designed to improve aerobic capacity in our subjects. Thus, three workouts that lasts 1h30min each were planned and carried out in collaboration with the physical education teachers in a gym and outside the laboratory

During these workouts various modes of exercise, including running, swimming, aerobics and traditional games were offered to smokers one hand for stimulate their motivation and other to seek a wide variety their other muscle groups. During these sessions heartbeat were monitored by sport-tester (Polar Electro KY, Kempele, Finland) in order to keep this intensity target.

2.3. Statistical analysis

All data were presented as means values and standard deviation.

A paired Student's t-test was used to analyze within group changes. The differences between the two groups (SG) and (NSG) were compared by unpaired Student's t-tests. Tukey's post hoc test was used to compare means and to evaluate the relationships between various parameters. Analysis was performed using StatView software and the significance threshold was set at $P < 0.05$.

III. RESULTS

Our training program induced in both groups SG and NSG a significant decrease in dyspnoea similar to the resting HR and systolic BP (SBP) ($p < 0.01$ and $p < 0.05$ respectively). The LSD test for post-hoc comparisons allowed us to conclude that in smokers group, resting HR and SBP are significantly higher than those of non-smokers at the beginning and end of the study. ($p < 0.001$) (Table1).

Similarly, we recorded in these groups lowered values of diastolic BP (DBP) but is significant only for subjects SG ($p < 0.05$). The applications of LSD test in Post-hoc comparisons of means showed no significant difference in DBP values at the beginning and the end of the protocol.

The ANOVA showed a significant improvement of VO2max, 6MWD and recovery index (RI) in both groups SG ($p < 0.001$, $p < 0.001$ and $p < 0.01$ respectively) and NSG ($p < 0.01$, $p < 0.001$ and $p < 0.01$ respectively). On these variables, smokers group compared to non-smokers, revealed a significant difference at the beginning of the study ($p < 0.05$, $p < 0.001$ and $p < 0.05$ respectively) and only significant statistically RI at the end of the study ($p < 0.05$). (Graphic.1-2-3)

According to Table 3, cigarette smokers showed a decrease in Max HR (beats. min^{-1}) at the end of the protocol (142.2 ± 2.9 before vs. 138.3 ± 1.2 after), significantly higher than non-smokers (138.9 ± 1.7 pre test vs. 137.7 ± 1.2 post test). Concerning tobacco effect, the LSD post-hoc test shows that at the beginning of the study, the Max HR of SG is significantly lower than that of NSG.

As regards oxygen saturation (O2.S), both groups' cigarettes smokers and non-smokers are homogeneous at the beginning and the end of the study revealed no significant difference. Similarly, the ANOVA showed no significant improvement in urinary cotinine values of the two groups SG and NSG after a period of 16 training weeks (Table 2). However, we recorded, by LSD test Post-hoc, a significant differences between SG and NSG before and after our program training ($p < 0.001$).

IV. DISCUSSION

At the end of the training period proposed in our subjects, changes in cardio-respiratory capacity have been illustrated and therefore represent our main results. These are characterized by a reduction in the resting HR, BP and dyspnoea. Thus, the improvement of the average walking distance of 6 min, VO_2 max and recovery index of all of our subjects, all groups combined, is 39 m 3.6 ($ml.kg^{-1}. min^{-1}$) and 1.45 respectively. Our findings are concomitant with the results of previous studies [23-24].

Studies related the effects of training period on cardiorespiratory capacity of smokers and non-smokers showed variable changes [25-26-27-28].This discrepancy may be explained by the diversity of executed protocols (number of sessions, intensity and duration of protocol) and the response and adherence individualized for each subject.

Even if comparisons of our results with the progress of these studies are difficult because of the difference of populations and employed measures, it appears that our training program enables significant improvements in cardiorespiratory capacity sometimes larger than previous studies.

To our knowledge, this study is the first that was used to evaluate the exercise tolerance by 6MWT in sedentary adults' smokers in a training program. In addition of their effects on body composition, our training program has also beneficial effects on exercise tolerance of our subjects. Thus, we recorded during the program in all subjects decreased HR and dyspnoea associated with an increase in walking distance of 6MWT, reflecting an improvement in their physical abilities.

It is well accepted that HR is a tolerance indices of the body in exercise that varies by the according distance [29]. In our study the improvement of cardiovascular fitness was observed at rest during the 6MWT and during the post-exercise recovery. It is not only the result of a decrease of walking HR but VO2max was significantly higher after the training period.

Presumably the training period generates an adaptation of the body of our subjects who had an impact on their tolerance to muscular exercise. Our observations are consistent with the study of Oka et al [30], who observed the benefits of physical activity of 4 months. It showed a significant decrease of fatigue and improved physical capacity and life quality.

Our study also shows a significant improvement walking distance (WD) achieved during the 6MWT after the training period. This improvement is $+51.2 \pm 36.3$m or +9.4% and $+26.7 \pm 17$m or +4.6% respectively in SG and NSG. Our results join the findings of Silva et al [15]. The performance of 6MWT is the result of many workouts during which the realization of scheduled and regular exercises, generates significant metabolic and mechanical stimuli. As a result, the physiological processes involved in the production of metabolic and mechanical energy can improve and allow a better exercise tolerance, the basic of performance improvement [17]. In this context, the optimal training is to find exercises providing the most effective stimuli, thus ensuring a balance progression / regression favorable to smokers. Based on these principles, we can assume that (WD)

improved in all groups is not only the result of a reduction in the HR and increased VO_2max, but rather is related to better regulation metabolic and physiological.

The basic perception of the effort difficulty estimated by the Borg scale is not important. Indeed, all of our subjects are not dyspnoeic in 6MWT. The training program induced a significant decrease of dyspnoea score at SG and NSG ($p < 0.01$ and $p < 0.05$ respectively). These results are consistent with the HR decrease and the WD increase of 6MWT, witnessed a better body tolerance of our subjects at exercise. It seems that the training period causes cardiopulmonary adaptations with oxygen saturation (O_2S) relatively stable in both groups during the training program.

V. CONCLUSION

We have in this study an important changes in the body tolerance at exercise in sedentary adult smokers undergo a training program for 4 months. This program is to provide alternatives several for reducing tobacco.

It is clear from our results that the training program induces, on one hand, a HR and SBP decrease and secondly, an increase of VO2max, RI and walking distance of 6MWT. These changes vary by groups with a better response from SG.

This program also causes physiological changes in the body of our subjects who are characterized by a decrease in dyspnoea and HR; an improved WD and RI during the 6MWT witness a better their body tolerance at exercise. We can conclude that the 6MWT is an interesting way of assessing exercise tolerance in adult smokers.

The study results have provided answers to some questions, but some issues remain to be clarified and could be the object of our perspectives. It would be more interesting that a study be accompanied by biochemical and hormonal results.

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RESULTS TABLES

Table1. Anthropometric characteristics before and after the 4 month program in SG and NSG group (mean ± standard deviation)

Parameters	SG (n=33)		NSG (n=32)	
	Before	After	Before	After
Age (y)	44.7±4,5		41.7±0.7	
Height (m)	1,74±0,04		1,79±0,03	
Weight (kg)	71,3±2,7	72,5±1,9	76.1±1,2	75,8±11,4
BMI ($kg.m^{-2}$)	30,3 ± 2,9	28,5±2,6 **	31,3±4,6	30,4±4,5 *
Resting. HR($beats.\ m^{-1}$)	91,5± 2,3 ###	85,6 ±2.1 **###	78,4±4,2	75,7±3,2*
Systolic. BP (mmHg)	138±3 ###	136±2**###	131±3	129±3*
Diastolic. BP (mmHg)	87 ± 5	84±3 *	85±6	83±3

Legend: SG, smokers group; NSG, non-smokers group; HR, heart rate; BMI, body mass index; BP, blood pressure; * p<0, 05; ** p<0, 01; *** p<0,001 after versus before training program; # p<0,05; ## p<0, 01; ### p<0,001compared to non-smokers in the same condition.

Table2. Urinary cotinine results before and after 16 weeks program in smokers and non-smokers groups (mean ± standard deviation)

Parameters	SG (n=33)		NSG (n=32)	
	Before	After	Before	After
urinary cotinine(µg/mL)	4,314±1,082###	4,094±0,912###	0,035±0,012	0,044±0,01

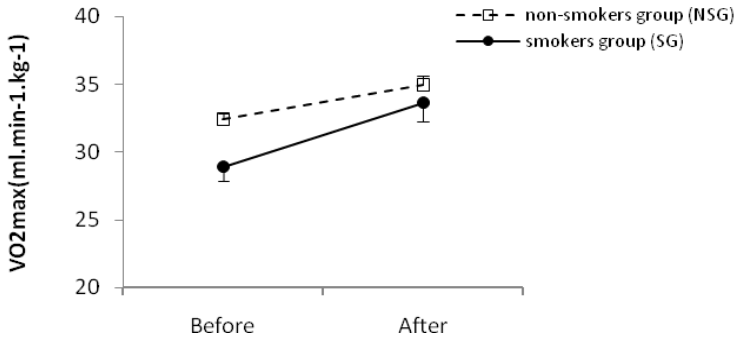
Legend: SG, smokers group; NSG, non-smokers group; * p<0, 05; ** p<0, 01; *** p<0, 001 before versus after training program; # p<0, 05; ## p<0, 01; ### p<0,001 compared to non-smokers in the same condition.

Table3. 6MWT data of population before and after the 4 month program in smokers and non-smokers groups (mean ± standard deviation)

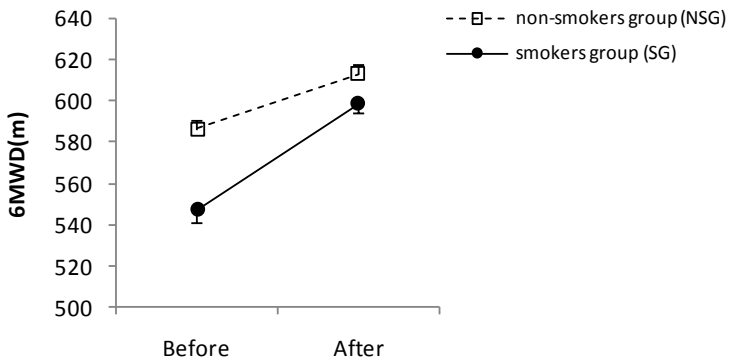
Paramètres	SG (n=33)		NSG (n=32)	
	Before	After	Before	After
RPE Borg	3.6±0.7	2.7±0.3**	3.1±0.8	2.6±0.5*
VO2max (ml.min-^{1}.kg-^{1})	28,9±3,5$^{\#}$	33,6±4,3***	32,4±1,6	34,9±2,6**
6MWD (m)	547,3±21,5$^{\#\#\#}$	598,6±14,9***	586,3±16,8	613±16***
$O_{2.}$S	97,8±1,4	98,3±0,9	98,1±0,8	97,9±0,8
Max.HR (beats. m^{-1})	142,2±2,9$^{\#\#\#}$	138,3±1,2***	138,9±1,7	137,7±1,2
RI(recovery index)	15,5±1$^{\#}$	17,1±0,4**$^{\#}$	16,6±1,3	17,9±0,7**

Legend: RPE Borg, Borg Scale for ratings of perceived exertion; VO2max, maximum oxygen uptake predicted from 6min walking distance; Max HR, maximum heart rate; 6MWD, 6min walking distance; O2.S, oxygen saturation;* p<0, 05; ** p<0, 01; *** p<0, 001 after versus before training program ; $^{\#}$ p<0, 05; $^{\#\#}$ p<0,01; $^{\#\#\#}$ p<0,001 compared to non-smokers in the same condition

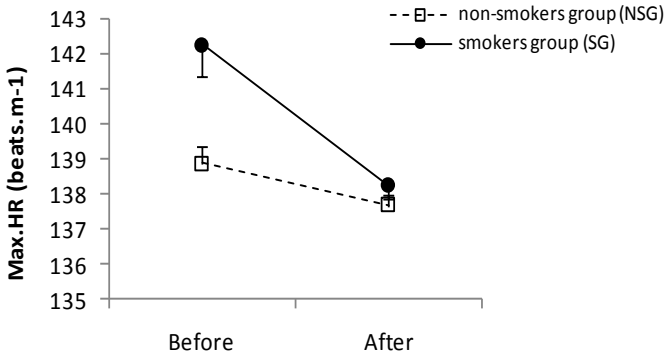
RESULTS GRAPHIC



Graphic 1: VO2 max (ml.kg^{-1}.min-^{1}) of SG and NSG before versus after training program



Graphic 2: 6MWD (m) of SG and NSG before versus after training program



Graphic 3: Max HR (beats.m^{-1}) of SG and NSG before versus after training program