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ORIGINAL ARTICLE

Physical activity improves cardiovascular capacity and prevents decline in lung function caused by smoking: Efficacy of the intermittent and continuous training Program



L'activité physique améliore la capacité cardiovasculaire et empêche le déclin de la fonction pulmonaire causé par le tabagisme : efficacité d'un programme d'entraînement intermittent et continu

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Received 3 February 2018; accepted 27 August 2018

Available online 12 January 2019

KEYWORDS

Training;
Smokers;
Lung function;
Cardiovascular
capacity

Summary

Objective. – The purpose of this study was to identify the potential benefits of both intermittent and continuous training programs in improving cardiovascular parameters and decreased decline in lung function among cigarette or hookah smokers.

Methods. – Fifteen cigarette smokers (CS), 14 hookah smokers (HS), and 14 non-smokers (NS) participated in the low-intensity continuous training (LCT). Eleven CS, 12 HS, and 12 NS participated in the moderate-intensity intermittent training (MIT). The LCT groups performed a 20 to 30-minute continuous exercise at 40% of the VO₂max. The MIT groups performed 6 to 10 sets of 2-minute sprint at 70% of the VO₂max interspersed by a 1-min recovery period. Before and after

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MOTS CLÉS

Entraînement ;
Fumeurs ;
Fonction pulmonaire ;
Capacité
cardiovasculaire

12 weeks of training, lung function and cardiovascular capacity parameters were determined using respectively spirometry and maximal treadmill exercise test.

Results. – The LCT and the MIT programs induced significant increases in the velocity at maximum oxygen uptake ($\dot{V}O_2 \text{ max}$) for NS and CS participants. Similarly, the $VO_2 \text{ max}$ improvement was significant for CS and HS groups who participated in the LCT program ($P < 0.05$ and $P < 0.01$, respectively) and for NS and CS groups that had undergone the MIT ($P < 0.05$). The decrease in rest HR, systolic BP and diastolic BP were also significant after the MIT and LCT protocol. In contrast, there was no difference between the effects of continuous and intermittent training programs on lung function.

Conclusion. – In conclusion, both LCT and MIT programs improve cardiovascular capacity and reduce lung function decline in both cigarette and hookah smokers. These both training programs could have important implications in prevention and defense programs.

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Résumé Objectif Identifier les avantages potentiels de deux programmes d'entraînement intermittent et continu dans l'amélioration des paramètres cardiovasculaires et la diminution du déclin de la fonction pulmonaire chez les fumeurs de cigarettes ou de narguilé.

Méthodes. – Quinze fumeurs de cigarettes (FC), 14 fumeurs de narguilé (FN) et 14 non-fumeurs (NF) ont participé à l'entraînement continu de faible intensité (ECF). Onze FC, 12 FN et 12 NF ont participé à l'entraînement intermittent d'intensité modérée (EIM). Les groupes ECF ont effectué un exercice continu de 20 à 30 minutes à 40 % du $VO_2 \text{ max}$. Les groupes MIT ont effectué 6 à 10 séries de sprints de 2 minutes à 70 % de $VO_2 \text{ max}$ entrecoupées par des périodes de récupération de 1 minute. Avant et après les 12 semaines d'entraînement, les paramètres de la fonction pulmonaire et de la capacité cardiovasculaire ont été déterminés en utilisant respectivement la spirométrie et le test d'effort maximal sur tapis roulant.

Résultats. – Le programme ECF ou EIM a induit des augmentations significatives de la vitesse maximale aérobie (VMA) pour les participants NF et FC. De même, l'amélioration de la $VO_2 \text{ max}$ est significative pour les groupes FC et FN qui ont participé au programme ECF ($p < 0,05$ et $p < 0,01$ respectivement) et pour les groupes NF et FC qui ont subi le programme d'EIM ($p < 0,05$). Les améliorations au niveau de la FC repos ainsi que de la pression artérielle systolique et diastolique étaient également significatives après les protocoles EIM et ECF. En revanche, aucune différence significative n'a été rapportée entre les effets de l'entraînement continu et intermittent sur la fonction pulmonaire.

Conclusion. – En conclusion, les programmes ECF et EIM améliorent la capacité cardiovasculaire et réduisent le déclin de la fonction pulmonaire chez les fumeurs de cigarettes et de narguilé. Ces deux types d'entraînement pourraient avoir des implications importantes dans les programmes de prévention et de défense.

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Introduction

Smoking has significant harmful effects on the lungs function; it is the most important risk factor for development of chronic obstructive pulmonary disease (COPD) [1]. A study has documented lower levels of forced expiratory volume in one second (FEV_1), accelerated loss of lung function and increased respiratory symptoms in smokers compared to nonsmokers [2]. Other studies have suggested that the decline in lung function and lower exercise tolerance, are a foreground major harm among smokers [3]. For that, physical activity has been known to be an essential component of a pulmonary rehabilitation program [4].

Physical activity plays a central role in the prevention, treatment and slowing the progression of some diseases

[5–8]. Although these studies have shown the beneficial effects of physical exercise on physiological symptoms, the question persists as to whether these effects are primarily due to the general physical activity or specific training programs. Our needs require training guidelines, clear and based on sufficient evidence from which we can prescribe the most effective training method. In this context, Ciolac et al. [9] and Gibala et al. [10] consider that continuous training is beneficial for maintaining cardio-respiratory health; however, intermittent exercise may be more effective. In addition, other researchers have suggested that 10 minutes of moderate-intensity intermittent exercise (3 times/session/30 min per day) has provided cardiovascular benefits [11]. Other previous studies have shown that walking intermittent periods improve the aerobic capacity, the

body composition and the blood pressure more than the physical training with continuous exercises [12]. In contrast, a continuous training program with 70–80% of maximum heart rate (30 min/day; 5 days/week), showed an increase in aerobic capacity and improving aspects of physiological well-being in middle-aged sedentary adults [13].

In general, the physiological response to exercise depends in the one hand, on the exercise intensity which must be specific to make the foreseen changes, where appropriate training load can be achieved by manipulating combinations of intensities, mode and duration of training; in the other hand, on the dependence of the metabolic and physiological systems to the different training methods. The training benefits are optimized when programs are designed to meet the individual needs and the participant's abilities [14].

These findings lead us to the idea to identify the potential benefits of physical activity with intermittent exercises compared to continuous exercises in the prevention of smoking harm and to explore the most appropriate activity method for most smokers. Actually, the available studies in the literature, examining the impact of physical training among smokers, are very limited. Therefore, this study aims to identify the effects of the moderate-intensity intermittent training (MIT) compared to low-intensity continuous training (LCT) on lung function and cardiovascular performance among smokers participating to a 12-week training program; and to check the difference between these training programs effects in cigarette smokers compared to hookah ones.

Materials and methods

Subjects

A total of seventy-eight sedentary healthy males, smokers and non-smokers, with the following average characteristics \pm standard deviation (SD) participated in this study: age, 44.1 ± 2.3 years; weight, 72.3 ± 3.2 kg; height, 174.7 ± 1.6 cm. Participants were normolipidemic, nonobese. No subject used nutritional supplements or medications. Presence of any kind of disease or $FEV_1/FVC\% < 70\%$ (27, 28) or involvement in regular physical activity or exercise program during the previous 12 month were also exclusion criteria. Smokers were instructed to refrain from smoking at least one hour prior to reporting to the laboratory as suggested by Dietrich et al. [15]. The subjects were informed in detail about the experimental procedures and the possible risks and benefits of the project, and written informed consent was obtained from each participant. Subjects were informed that they could resign from participation at any time during the study. The study was fully approved by the Research Ethics Committee of the faculty of medicine of Sfax, Tunisia. We consider cigarette smokers, all subjects with consumption ≥ 10 pack-years (PY). We quantified hookah consumption, as in the study of Kiter et al. [16] with Hookah-years (HY) and kg of cumulative tobacco. The tobacco used in a hookah weighs between 10 and 25 grams [17]. In fact, regular hookah smoker subjects are those having consumption greater or equal to 5 HY [18].

Experimental protocol

Subjects were divided into six groups and they were randomized to equal volumes of either continuous or intermittent training program.

Continuous training: a cigarette smokers group (CS, $n=15$); a hookah smokers group (HS, $n=14$) and another nonsmokers group (NS, $n=14$).

Intermittent training: a CS group ($n=11$); a HS group ($n=12$) and another group NS ($n=12$).

All participants were subjected to anthropometric tests sessions, respiratory functional explorations (RFE) and an effort test before and after the training program.

Variables and measuring procedures

Anthropometric measurements

Body weight was measured to the nearest 100 g with a calibrated electronic scale (TANITA TBF.350 model), and height was measured to the nearest 1 mm with a fixed stadiometer. Body mass index (BMI) was calculated with the formula: $[BMI (kg \cdot m^{-2}) = Weight (kg) / Height^2 (m^2)]$.

Lung function assessments

A portable spirometer (MIR Spirobank G USB Spirometer, Rome, Italy) was used to assess the lung function of participants. Standard procedure requires forced vital capacity (FVC) and FEV_1 which should be measured from a series of at least three forced expiratory curves [19]. Therefore, this study requires participants to perform three correct manoeuvres. Participants completed the spirometry assessment seated with a nose clip attached and a mouthpiece placed into the mouth and expired hard and quickly until all air is expelled. Pulmonary function variables included: forced vital capacity (FVC), FEV_1 , FEV_1/FVC ratio, forced expiratory flow at 50 of FVC ($FEF_{50\%}$) and $FEF_{25-75\%}$. Results were expressed as percentages of the predicted value to allow comparison of results across participants.

Cardiovascular capacity assessment

All participants underwent a treadmill maximal exercise test (COSMED Pulmonary-Function Equipment 37 Via dei Piani di monte Savello I-00040 Rome, Italy). This maximum test until fatigue consists on increasing the speed of $1 km \cdot h^{-1}$ every 2 minutes after warm up of 5 minutes with a speed of $6 km \cdot h^{-1}$ until the participant could no longer continue. $\dot{V}O_2$ max is reached when oxygen consumption remains at steady state despite an increase in workload. Heart rate using (Polar Electro Oy, Kempele, Finland) was monitored throughout the test and was recorded at the conclusion of every two-minute stage. The oxygen consumption ($\dot{V}O_2$ max) was continually recorded and measured in real time using oxygen analyzer (Fitmate, version 1.2 PRO COSMED). At the end of the test a detailed report will be printed. Verbal encouragement was provided throughout the test to ensure that the maximal effort was achieved.

Recovery test

During recovery, the heart rate, using (Polar Electro Oy, Kempele, Finland), was recorded every minute for 5 minutes

Table 1 Changes (Δ) in cardiovascular values in pre- vs. post-training program.

Parameters	Continuous			Intermittent			ANOVA
	NS	CS	HS	NS	CS	HS	
Rest HR (bpm)	$-2 \pm 2^*$	$-3 \pm 3^{**}$	$-2 \pm 3^*$	$-3 \pm 4^*$	$-3 \pm 3^*$	$-2 \pm 4^*$	NS
Diastolic BP (mmHg)	-0.7 ± 2	-1.3 ± 2.7	$-2.4 \pm 3.4^{**}$	-2 ± 4.3	$-3.1 \pm 4.6^*$	-1.8 ± 3.3	NS
Systolic BP (mmHg)	-1.7 ± 4.2	$-2.7 \pm 3.1^*$	$-2.5 \pm 2.7^*$	$-1.8 \pm 2.7^*$	$-2.3 \pm 3.2^{**}$	$-1.8 \pm 2.3^*$	NS
$v\dot{V}O_2$ max ($\text{km}\cdot\text{h}^{-1}$)	$0.24 \pm 0.38^*$	$0.25 \pm 0.35^*$	0.18 ± 0.39	$0.71 \pm 1^{**}$	$0.65 \pm 0.85^*$	0.44 ± 0.56	^a
$\dot{V}O_2$ max ($\text{mL}\cdot\text{min}\cdot\text{kg}^{-1}$)	0.38 ± 0.59	$0.52 \pm 0.69^*$	$0.65 \pm 0.87^{**}$	$1.66 \pm 3.26^*$	$1.83 \pm 2.57^*$	1.48 ± 2.1	^a
Recovery Index	$0.44 \pm 0.4^*$	$0.47 \pm 0.6^*$	$0.98 \pm 0.8^{***}$	$1.24 \pm 1.3^*$	$1.55 \pm 2.5^{**}$	0.94 ± 1.5	NS

$\dot{V}O_2$ max: maximum oxygen uptake; $v\dot{V}O_2$ max: velocity at maximum oxygen uptake; Rest HR: rest heart rate; ns: non-significant; NS: nonsmokers; CS: cigarette smokers; HS: hookah smokers.

^a Significant difference compared to continuous exercise at $P < 0.05$.

* Significant difference in pre- vs. post-program at $P < 0.05$.

** $P < 0.01$.

*** $P < 0.001$ respectively.

after maximal exercise. The data were directly downloaded and saved to the software.

The recovery index calculation is based on 2 data: the regression coefficient (to clearly highlight the speed of recovery) and the correlation coefficient (to reveal the regularity of the recovery).

Training protocol

The training period lasted three months, with 3 sessions per week during 20 minutes (first month), 25 minutes (second month) and 30 minutes (third month). The increase in training load was ensured by increasing in the working time and the distance covered in each session. All training sessions were conducted on running track of 400 m at the Higher Institute of Sport and Physical Education under the supervision of specialist trainers.

Continuous training

The training was performed continuously, three times per week at an intensity of 40% of $\dot{V}O_2$ max. Participants were asked to run with a continuous rhythm respecting the sound beeps and requested time.

Intermittent training

Participants were asked to run 6 to 10 times/session, 2-minute periods at an intensity of 70% of $\dot{V}O_2$ max interspersed with recovery periods of 1 minute.

Statistical analysis

Statistical tests were processed using the STATISTICA Software (StatSoft, France). The data are expressed as mean \pm standard deviation (SD). Once the assumption of normality had been confirmed by the Shapiro–Wilk W-test and homogeneity of variances with Levene's test, parametric tests were performed. One-way analysis of variance (ANOVA) was used to indicate inter-group differences in the baseline subjects' characteristics. Inter- and intra-group comparisons were analyzed using a two-way ANOVA with repeated measures (group vs. training). Least Significant

Different (LSD) post-hoc analysis was used to identify significant group differences that were indicated by one-way and two-way ANOVA. To assess the data practical significance, effect sizes were calculated as partial eta-squared, η_p^2 .

Statistical significance for all analyses was set at $P < 0.05$.

Results

Intra-group changes in cardiovascular performance after continuous vs. intermittent training

After the MIT or LCT period, participants showed variable improvements (Table 1). Significant changes in rest heart rate were observed among all participants, with decreases ranging from -2 ± 2 bpm to -3 ± 4 bpm. Similarly, there was a decrease of systolic blood pressure (SBP) for smokers groups ($0.05 < P < 0.01$). The decrease in diastolic blood pressure (DBP) was significant only for the HS group after the LCT program ($P < 0.01$) and CS group following the MIT ($P < 0.05$), a decrease of -2.4 ± 3.4 mmHg and -3.1 ± 4.6 mmHg, respectively.

The training program with continuous or intermittent exercises induced significant increases in the velocity at maximum oxygen uptake ($v\dot{V}O_2$ max) for all nonsmokers and cigarette smokers with greater extent in subjects who performed the MIT protocol. ANOVA showed a significant principal effect of exercise type [F (1, 62) = 5.44; $P = 0.023$; $\eta_p^2 = 0.081$] (Fig. 1).

Similarly, the $\dot{V}O_2$ max improvement was significant for CS and HS groups which participated in the LCT program ($P < 0.05$ and $P < 0.01$ respectively) and for NS and CS groups that have undergone the MIT ($P < 0.05$). ANOVA showed a significant difference between the effects of the intermittent training compared to the continuous training [F (1, 72) = 5.3; $P = 0.025$; $\eta_p^2 = 0.079$] (Fig. 2).

Regarding the recovery index (RI), the results explored in Table 2 showed improved recoveries for all subjects of the six groups (improvement varies between $+0.44 \pm 0.4$ and 1.55 ± 2.5); however, ANOVA showed a non-significant exercise type effect [F (1, 72) = 3.25; $P = 0.076$; $\eta_p^2 = 0.05$].

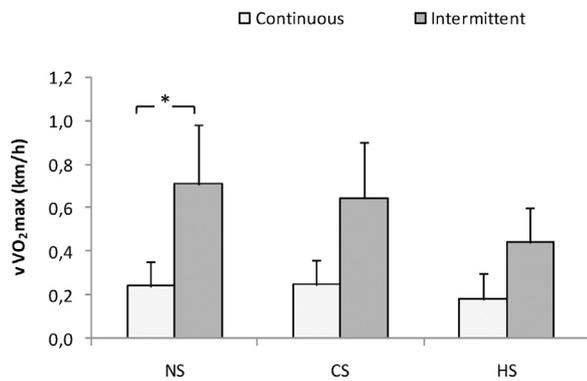


Figure 1 Improvement rate (Δ) of the velocity at maximum oxygen uptake ($vVO_2\max$) after LCT vs. MIT program; NS: nonsmokers; CS: cigarette smokers; HS: hookah smokers; *: significant difference compared to continuous exercise at $P < 0.05$.

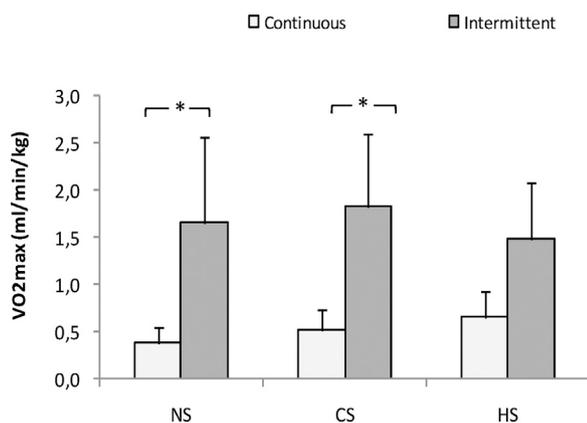


Figure 2 Improvement rate (Δ) of maximum oxygen uptake ($VO_2\max$) in pre- vs. post-program; NS: nonsmokers; CS: cigarette smokers; HS: hookah smokers; *: significant difference compared to continuous exercise at $P < 0.05$.

In addition, the LCT program induced a significant decrease in blood pressure (BP) and rest heart rate (rest HR). The result was a significant reduction in systolic BP of -2% for the CS and -1.8% for the HS and only a significant decrease of -2.5% in diastolic BP for the HS group.

Similarly, decrease in rest HR, systolic BP and diastolic BP were also significant after the MIT protocol; however, ANOVA showed no significant difference between the effects of the LCT compared to the MIT program.

Intra-group changes in lung function after continuous vs. intermittent training

The improvement rate (Δ) of lung function parameters of the six groups in pre- vs. post-program are summarized in Table 2.

The three-months training period with continuous exercises, showed changes in respiratory parameters; however they vary according to the groups. These changes did not show any significant difference in the PEF, FEV₁/FVC and FEF_{25-75%} measured after the LCT. The latter produced a significant increase of FVC in all participating smokers. The changes in this parameter for both CS and HS groups, corresponded to an increase of $1.7 \pm 2.21\%$ ($P < 0.01$) and $1.3 \pm 1.7\%$ ($P < 0.05$) respectively. In addition, all participants enjoyed a significant increase in FEV₁ ($P < 0.05$) after the LCT program; it was $+1.8 \pm 2.7\%$ of the predicted value of NS participants, $+1.9 \pm 2.1\%$ of CS subjects and $+1.7 \pm 2\%$ for the HS group. Similarly, the FEF_{50%} of subjects of the three groups followed the same trend, with statistically significant differences ($P < 0.05$). After the MIT protocol, there was a significant change in FEV₁ only for the CS group ($P < 0.05$) with an increase of $5.8 \pm 9.2\%$. As well, we recorded a significant increase in PEF only for smoker groups and no significant change in the FVC and FEF for the three groups. Comparing the effects of the LCT with the MIT, the ANOVA showed a non-significant exercise type effect for all investigated parameters. There was no difference in the effects of continuous vs. intermittent training, despite that the CS and the HS participants tended to have the best improvement in FEV₁ between six groups after the period of MIT (respectively $+5.8\% \pm 9.2$ and $+4 \pm 6.4\%$) (Fig. 3).

With regard to the PEF, the ANOVA showed a significant tobacco effect [$F(2, 72) = 4.28$; $P = 0.018$; $\eta_p^2 = 0.121$] and significant Exercise \times Tobacco interaction [$F(2, 72) = 3.5$; $P = 0.036$; $\eta_p^2 = 0.101$] (Fig. 4).

Table 2 Improvement rate (Δ) of spirometric parameters in pre- vs. post-program.

Parameters	Continuous				Intermittent			ANOVA
	NS	CS	HS	NS	CS	HS		
FEV ₁ (%)	$1.8 \pm 2.7^*$	$1.9 \pm 2.1^*$	$1.7 \pm 2^*$	0.5 ± 7.8	$5.8 \pm 9.2^*$	$4 \pm 6.4^*$	NS	
FVC (%)	0.8 ± 1.6	$1.7 \pm 2.2^{**}$	$1.3 \pm 1.7^*$	1.9 ± 8.8	4.4 ± 9.6	3.6 ± 9	NS	
PEF (%)	0.7 ± 1.8	1.1 ± 1.7	0.7 ± 2	-1.4 ± 5.8	$3.9 \pm 3.8^{**}$	$3.4 \pm 3.9^*$	^a	
Tiffeneau index (%)	0.01 ± 0.01	-0.01 ± 0.03	0 ± 0.04	-0.01 ± 0.13	0.02 ± 0.1	0 ± 0.08	NS	
FEF _{50%} (%)	$1.1 \pm 2.2^*$	$1 \pm 2.4^*$	$1.6 \pm 2.5^*$	0.5 ± 4.1	0.8 ± 3.5	0.9 ± 5.2	NS	
FEF _{25-75%} (%)	0.9 ± 2.2	0.9 ± 1.7	1 ± 2.3	2.2 ± 4.4	1.8 ± 6.6	2.3 ± 5.8	NS	

FVC: forced vital capacity; FEV₁: forced expiratory volume in 1 second; PEF: peak expiratory flow; FEF_{50%}: forced expiratory flow at 50% of FVC; FEF_{25-75%}: forced expiratory flow at 25 to 75% of FVC; NS: nonsmokers; CS: cigarette smokers; HS: hookah smokers.

^a Significant difference compared to nonsmokers at $P < 0.05$.

* Significant difference in pre- vs. post-program at $P < 0.05$.

** $P < 0.01$.

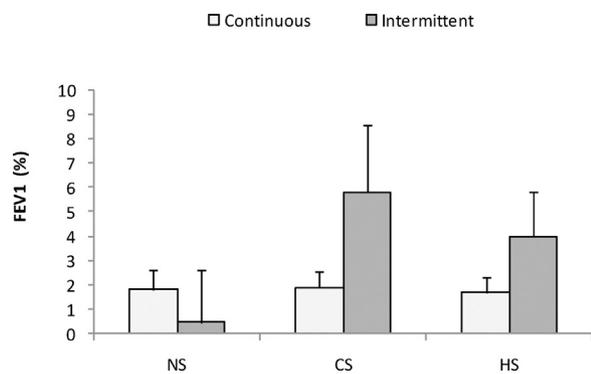


Figure 3 Improvement rate (Δ) of forced expiratory volume in 1 second (FEV_1) in pre- vs. post-program; NS: nonsmokers; CS: cigarette smokers; HS: hookah smokers; no difference in the effects of continuous vs. intermittent training.

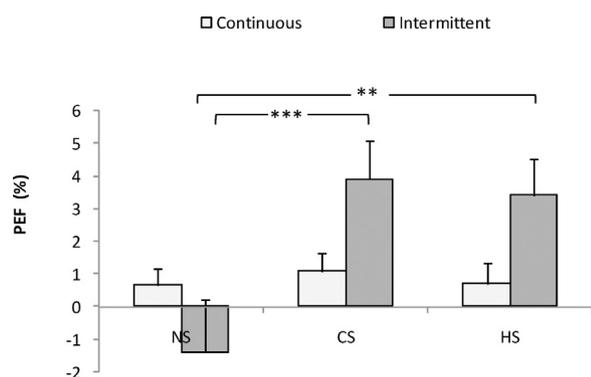


Figure 4 Improvement rate (Δ) of peak expiratory flow (PEF) in pre- vs. post-program; NS: nonsmokers; CS: cigarette smokers; HS: hookah smokers; **, ***: significant difference compared to nonsmokers at $P < 0.01$ and $P < 0.001$, respectively.

Discussion

It is generally accepted that people with high levels of physical activity tend to have higher levels of physical fitness and cardiorespiratory capacity [20]. The analysis of the effects of LCT compared to the MIT program on exercise tolerance, sense of breathlessness and physiological well-being of smoker subjects, revealed that the two methods induce improvements with similar magnitude.

According to this study, the LCT or the MIT program was strongly associated with better performance the treadmill maximal exercise test and improved exercise tolerance. This finding is consistent with other studies using intermittent exercise [21–23] and continuous exercises [21,24]. These improvements were accompanied by considerable increase in $\dot{V}O_2$ max and the RI among all participants. However, in the HS group, we found a greater improvement of these two recorded-values following the LCT, whereas their improvements were not significant after the MIT period (Table 2). These results may explain improved aerobic capacity reflecting that after training, muscles have better oxygen use compared to before training by improving cardiovascular and respiratory systems. These results are somewhat similar to those reported by other previous studies [11,22,25,26]. In this context, Daussin et al. [24] showed

a significant increase in $\dot{V}O_2$ max of subjects who participated in a continuous training program for 8 weeks. In addition, our findings support the results of MacDougall et al. [21], Harmer et al. [23] and Macfarlane et al. [13], who reported significant increases in $\dot{V}O_2$ max after different training programs. However, a related study was conducted by Mazoochi et al. [27] showed no effect of a continuous training on $\dot{V}O_2$ max. The findings of this study confirm those of Denis et al. [28].

The resulting favorable changes from continuous training on the systolic and the diastolic BP are consistent with the study of Laterza et al. [29] and different to the conclusions of Ferrier et al. [30]. These results may indicate the importance of physical activity to counteract one of the major risk factors for cerebrovascular accident, heart and renal failure... Similar results to our findings were reported by Westhoff et al. [31]; their report reveal a significant decrease in systolic (8.5 ± 8.2 mmHg) and diastolic BP (5.1 ± 3.7 mmHg). This partial difference in results might be partly explained by the diversity of protocols implemented and individual responses to exercise. Therefore, our results reveal that the LCT program product certainly the same effect as MIT.

The lung function variables were improved after the LCT and MIT protocols for most smoker participants, particularly FEV_1 , FVC and PEF, which were substantially increased in smokers without any difference in the FEV_1/FVC . This gives to the thought that pulmonary efficiency is low for all participants. These results are concurrent with those published by Burchfiel et al. [32] and Cheng et al. [33] and consistent with the conclusions of Mehrotra et al. [34], which reported better lung function in active subjects compared to sedentary ones. The smoker groups have seen increases in their respiratory capacity, more significantly compared to the nonsmoker groups. This result is consistent with the findings of several previous studies [35,36].

In light of these results, we suggest that MIT and LCT slightly influence these spirometric variables and reduce relatively the decline in lung function. These findings may explain the decrease in chronic inflammatory lesions of the respiratory tract leading to potential progression to chronic obstructive pulmonary disease (COPD) (the first chronic respiratory disease of smokers). The beneficial physical activity effect on lung function was independent of smoking method and was almost similar for both training types (no significant difference between the two types of training for all the explored values). Interestingly, in a short-term protocol, Biersteker et al. [37] observed no physical training effect on physical fitness and lung capacity.

In summary, the analysis suggests that MIT program is associated with a considerable improvement in cardiovascular performance for most smoker subjects, but the change in lung function contributed little to this association for all participants after 12 weeks intervention. In contrast, the LCT provides objective data supporting the use of a training program with continuous exercises to improve lung function of smoker subjects. This type of training slows the decline in lung function, relieves the bad symptoms, improves exercise tolerance and reduces the lung disease exacerbation. These findings are consistent with the results of Cheng et al. [33], who reported that exercise is an important component of pulmonary rehabilitation and may be associated

with physiological and psychological benefits. Therefore, a mixed training Protocol (Combined continuous and intermittent exercises) may have a more transparent effect in the prevention of lung disease due to smoking. Although smoking cessation is certainly an important way to reduce the decline in lung function, the combination of these two training methods with exercise intensities tailored to the abilities of participants, appears to be beneficial and can be linked to a slower decline in lung function due to smoking.

Conclusion

The intermittent training improves, in smokers, aerobic capacity and modifies the cardiovascular parameters in a way that approximates the continuous training. After 12 weeks, both training methods slightly reduce the decline in lung function. However, the MIT program was more effective than the LCT to increase the $\dot{V}O_{2\max}$ and $v\dot{V}O_{2\max}$. The rest HR and RI were significantly increased under the main effect of the two training methods.

This study could have important implications for prevention and defense programs. Other training methods are necessary to advance our conclusions. We wish that the training programs with mixed exercises can improve more favorably the lung function and life quality and prevent lung disease in smokers unable or unwilling to quit.

Disclosure of interest

The authors declare that they have no competing interest.

Acknowledgement

This study was supported by a grant from the laboratory of pharmacology, medicine faculty of Sfax, Tunisia. Moreover, the authors wish to express their sincere gratitude to Dr. Trabelsi Khaled and Pr. Chtourou Hamdi for their valuable help in planning and realizing the experimental protocol.

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