# 39 - EFFECT OF THE SMOKING ON CARDIOVASCULAR RESPONSES TO SUBMAXIMAL EXERCISE IN YOUNG WOMEN

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## INTRODUCTION

According to the World Health Organization (WHO) smoking is the chief, single avoidable cause of death in the whole world. It is considered as one of the biggest challenges of public health of the modern world. Currently, there are about 1.2 billion smokers in the world, whereas 200 million are women (Health Department, 1998). It is important to point out that concerning world-wide trends of smoking prevalence, a slow reduction in smoking prevalence among men in most countries is observed. On the other hand there is a growing trend of smoking prevalence among women (WHO).

Carvalho (2000) reported that tobacco has more than 4.720 chemical substances. Nicotine is one of those substances and it is responsible for addiction, increase of heart rate (HR) and blood pressure (BP), thus forcing the heart of a smoker to exert a bigger force under adverse conditions. Hollmann and Hettinger (1989) state that smoking a single cigarette can raise HR between 10/20 bpm above normal and it takes between 15/45 minutes for HR to go back to its original rate. Smoking affects physical performance, especially in aerobic exercises. Studies show that maximum oxygen consumption and anaerobic capacity are reduced in smokers of different ages (Fukuba et al., 1993; Louie, 2001; Bernaards et al., 2003).

Despite broad consensus that smoking represents a cardiovascular risk factor and that it reduces the functional capacity of smokers, cardiovascular function alterations by tobacco use have been studied predominantly among men. As a result, the objective of the present study was to investigate the effect of tobacco use in arterial pressure and resting cardiac frequency, during graded submaximal physical exercise and recovery period of young, smoking women.

## MATERIALS AND METHODS

This study was conducted on 14 healthy, sedentary women who had benn previously selected. They did not make use of any medicine. The women were divided in two groups: smoking women (SW, n=7), 21 + 0.8 years old, body weight 59 + 7 kg, who have been smoking between 10 and 20 cigarettes per day for 7 + 1.4 years and non-smoking women (NSW, n=7), 21 + 2 years, body weight 66 + 10 kg. The experimental procedures were carried out in accordance with the rules of the Committee of Ethics in Research (Resolution CNS, 196/96). All the procedures and evaluations were carried out at the Human Movement Laboratory of the University São Judas Tadeu in São Paulo -SP.

Systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) were measured noninvasively in young, smoking and non-smoking women at rest, during the accomplishment of submaximal bicycle ergometric test and after a 5-minute recovery period. The pressure-rate (PR) was calculated as the product between HR and SBP (Farinatti and Leite, 2003). All the measurements in the volunteers were conducted in a seated position and the upper limbs were kept in the same level as the heart. After the resting measurements, the 14 women were submitted to a suitable Astrand sub-maximal bicycle test (up to 85% of the maximum HR calculated by the formula: maximum HR = 220 - age), with load increments of 50 Watts every 3 minutes. BP and HR measurements were obtained along the last minute of each load. Special care was taken to avoid noise and motor interference during the test.

The statistical analysis was performed with Windows software SPSS 12.0. All the results are presented as mean standard error (SEM). One-way or two-way repeated measurements analysis of variance (ANOVA) followed by Student-Newman-Keuls test were used to compare the results. The differences were considered significant when $p<0,05$.

## RESULTS

Table 1 presents the values of systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR) and pressure rate (PR) of the non-smoking and smoking women at rest. DBP, HR and RP were higher among SW when compared to NSW. SBP values were similar between the studied groups at rest.

**Table 1. Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Heart Rate (HR) and Pressure Rate (PR) at rest.**

| | SBP (mmHg) | DBP (mmHg) | HR (bpm) | PR (bpm.mmHg) |
|---|---|---|---|---|
| **Non-smokers** | 108 ± 12 | 67 ± 5 | 73 ± 5 | 7768 ± 1340 |
| **Smokers** | 110 ± 5 | 75 ± 2 * | 85 ± 12 * | 9504 ± 1374 * |

Values represent mean standard deviation. *p<0,05 vs. non-smoking women.

As it can be observed in table 2, SBP, HR and PR all increased, whereas DBP remained the same in response to exercise load increment among NSW and SW. The NSW group presented greater SBP and PR values around the 9th minute (50 Watts) in comparison to the 6th minute (25 Watts) of the submaximal test. This fact was not observed among the SW group. Moreover, SBP values were less in the last exercise load (50 Watts) among SW in relation to NSW. DBP was higher throughout all exercise training periods among SW when compared to NSW. Statistically significant differences in the responses of HR and PR in the different intensities of exercise were not been observed between the groups (Table 2).

**Table 2. Sistolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Heart Rate (HR) and Pressure rate (PR) during exercise.**

| | SBP (mmHg) | DBP (mmHg) | HR (bpm) | PR (bpm.mmHg) |
|---|---|---|---|---|
| **Non-smokers** | | | | |
| 0 Watts – 3rd min. | 132 ± 7 | 66 ± 5 | 131 ± 13 | 17191 ± 2439 |
| 25 Watts – 6th min. | 148 ± 11 † | 66 ± 6 | 152 ± 15 † | 22766 ± 3993 † |
| 50 Watts – 9th min. | 160 ± 8 †‡ | 63 ± 3 | 166 ± 10 † | 26777 ± 2648 † |
| **Smokers** | | | | |
| 0 Watts – 3rd min. | 133 ± 4 | 75 ± 2 * | 140 ± 12 | 18470 ± 2035 |
| 25 Watts – 6th min. | 142 ± 4 † | 74 ± 1 * | 157 ± 10 † | 22497 ± 1848 † |
| 50 Watts – 9th min. | 150 ± 5 *† | 76 ± 1 * | 166 ± 11 † | 24869 ± 1895 † |

Values represent mean standard deviation. *p<0,05 vs. non-smoking women at the same exercise stage; † p<0,05 vs. 0 Watts (3rd min) in the same group; ‡ p<0,05 vs. 25 Watts (6th min) in the same group.

SBP values were similar after a 5-minute recovery period between the studied groups. However, DBP, HR and DP were higher among the SW group in comparison to the NSW group (Table 3).

**Table 3. Sistolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Heart Rate (HR) and Pressure rate (PR) during recovery.**

| | SBP (mmHg) | DBP (mmHg) | HR (bpm) | PR (bpm.mmHg) |
|---|---|---|---|---|
| **Non-smokers** | 111 ± 8 | 66 ± 7 | 90 ± 7 | 9789 ± 790 |
| **Smokers** | 116 ± 8 | 72 ± 1 * | 108 ± 10 * | 12458 ± 1823 * |

Values represent mean standard deviation. *p<0,05 vs. non-smoking women.

**DISCUSSION**

The study of the hemodynamic alterations due to the use of tobacco has been constantly investigated. However, the results among studies that investigated chronotropic and pressor responses of smokers to exercise are inconsistent. The ideal situation is to compare the responses to exercise between smokers and non-smokers considering age, level of similar physical activity and body composition. Moreover, special attention as to be given to studies that use both genders since it has already been proven that women and men present important physiological differences. This study investigated the effects of tobacco use among young smoking women. In order to achieve this objective, BP and HR were measured at rest and by pressor and chronotropic responses during submaximal exercise tests. The results of the present study present strong evidence that young smoking women have higher DBP HR and PR in comparison to young non-smoking women at rest. Furthermore, the pressor responses presented alterations during the submaximal exercise tests among SW. In the recovery period, greater DBP, HR and PR were observed among SW in relation to NSW.

The increase of BP and HR due to tobacco use has been attributed to the activation of the sympathetic nervous system by releasing noradrenaline and adrenalin (Cryer et al., 1976). In addition, Laustiola et al. (1988) have evidenced the activation of the renin-angiotensin-aldosterone system at rest and during exercise between a smoking monozygotic twin and its non-smoking sibling, thus suggesting that this could be one of the mechanisms involved in the typical arterial vasoconstriction among chronic smokers. However, other authors do not agree with such findings (Benowitz et al., 2002). They point out other mechanisms that have been demonstrated and correlated with the hemodynamic damages among smokers, including the inhibition in the production of prostacyclins by endothelial cells, platelets activation and the release of vasopressin (Nadler et al., 1983; Davis et al., 1985; Benowitz, 1988).

Benowitz et al. (2002) have demonstrated that healthy smoking men, who have had this habit for 23 years in average, present greater DBP and HR along a 24-hour period while making use of tobacco than when the same individuals were submitted to a 5- day abstinence period. Moreover, they found that DBP only increased during the day, which was the time when the men smoked, and HR was higher both during the day and at night. No alterations in SBP were observed. It is important to point out that both the BP and HR alterations and their respective values observed by Benowitz et al. (2002) have also been observed in the present study.

The assessment of BP and HR during physical exercise and recovery have been routinely used as indicators for prescribing physical training and monitoring cardiovascular responses to physical activity, as well as, for detecting symptoms and cardio-respiratory alterations that are only observed when an organism is submitted to strenous situations. Like other studies, the present work showed similar responses to acute exercise, such as, an increase in SBP and HR, and consequently, an increase in cardiac work (PR=PAS x FC) and the conservation of DBP values in the group of non-smoking women (Brum et al., 2004).

There are few research studies that relate physical performance and the habit of smoking. However, it is widely accepted that tobacco causes limitations to physical exercise (Sue et al., 1985), mainly aerobic ones (Chatterjee et al., 1987). Furthermore, studies have shown that the aerobic and anaerobic power responses are reduced among smokers of several age groups (Fukuba et al., 1993 and Knapik et al., 1993). Hirsch et al. (1985) demonstrated that VO2max and anaerobic threshold may be acutely reduced in apparently healthy smokers immediately after smoking in comparison to a 5-hour smoking interval because of the carbon monoxide and the high level of nicotine.

In the present study no alterations in chronotropic response to exercise were observed among SW as compared to NSW. In this regard, Kobayashi et al. (2004) demonstrated similar chronotropic responses between smoking and non-smoking healthy men in all exercise stages, either submaximal or maximum. SBP increased among SW during the submaximal test; however, in the last exercise load the SBP was less among SW than NSW. This finding can be interpreted by SW having more difficulty in maintaining the demand. Considering that both groups presented similar HR values during different work loads, a lower SBP among SW may be attributed to a reduction in systolic volume due to a greater after-load or because of impaired cardiac contractility. In fact, DBP values were higher for 50 Watts among SW. This fact may indicate that there is an in the after load. Furthermore, long-term tobacco exposure in healthy individuals has been associated with alterations in myocardium perfusion induced by an interaction between endothelial and autonomic impairments. Thus, oxygen supply can adversely affected by coronary vasoconstriction (Moliterno et al., 1994), changes in the elastic properties of the aorta (Ohtsuka et al., 1994), and alterations impair myocardium performance (Stefanadis et al., 1998). However, it is important to point out that Behr et al. (1981) did not observe significant alterations in the cardiac function during submaximal exercise among young smoking men.

During the recovery period, SBP presented similar values between the groups. However, DBP, HR and, consequently, PR were higher in this period among SW in relation to NSW. Young smoking men also presented a slower return of HR values back to basal levels after exercise (Kobayashi et al, 2004). This delayed recovery of HR, as well as the increased DBP in the recovery period, among smokers might be related to chronotropic and inotropic effects of the cathecolamines available after exposition to nicotine (Burn, 1960).

The results of the present study demonstrate that healthy, young, smoking women present alterations in hemodynamic parameters at rest, in response to submaximal exercise and in the exercise recovery. Additional studies are needed to confirm which physiological mechanisms are involved in such disturbs among women. Such insight will contribute to the search of more effective pharmacolologic or non-pharmacologic interventions to combat some of the adverse effects caused by tobacco use among women.

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**EFFECT OF THE SMOKING ON CARDIOVASCULAR RESPONSES TO SUBMAXIMAL EXERCISE IN YOUNG WOMEN**

**SUMMARY**

According to the World Health Organization (WHO) smoking is the chief, single avoidable cause of death in the whole world. Cigarette smoking affects the cardio-respiratory function thus reduceing the capacity of physical exercise. The objective of the present study was to verify the effect of the tobacco smoking on cardiovascular responses to graded submaximal physical exercise among sedentary female smokers. Systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) were measured noninvasively in young, non-smoking women (NSW, n=7) and smoking women (SW, n=7) at rest, during the accomplishment of submaximal bicycle ergometric test and recovery period. At rest, DBP and HR were higher in the SW group (75 ± 2 mmHg and 85 ± 12 bpm) when compared to the NSW group (67 ± 5 mmHg and 73 ± 5 bpm). During exercise, SBP and HR increased in the studied groups. DBP was higher in the SW group (~15%) in relation to the NSW group in all periods of exercise training. During the recovery period both DBP and HR were higher in the SW group when compared to the NSW group. These results show that young, smoking women present alterations in hemodynamic parameters at rest and in response to submaximal exercise. **KEY WORDS:** Tobacco, ergometric test, women.

**EFFET DE LA FUMEE DANS LES REPONSES CARDIO-VASCULAIRES A L'EXERCICE SUBMAXIMUM DANS JEUNES FEMMES**

**RÉSUMÉ**

Selon l'Organisation Mondiale de la Santé (OMS) le tabagisme est la principale cause de décès évitable dans le monde entier. La fumée touche la fonction cardio-respiratoire en pouvant réduire la capacité d'exercice physique. L'objectif de la présente étude a été vérifier l'effet de la fumée dans les réponses cardio-vasculaires à l'exercice physique progressive submaximum dans des femmes sédentaires fumeuses. La tension artérielle systolique (PAS) et diastolique (PAD) et la fréquence cardiaque (FC) ont été des mesures de forme non envahissante dans des jeunes femmes non fumeuses (MNF, n=7) et fumeuses (MF, n=7), dans repos, pendant la réalisation de l'essai submaximum dans bicyclette ergométrique et dans la récupération. Dans repos, PAD et FC ont été plus grandes dans MF (75 ± 2 mmHg et 85 ± 12 bpm) quand comparées avec MNF (67 ± 5 mmHg et 73 ± 5 bpm). Pendant l'exercice, PAS et FC ont augmenté dans les groupes étudiés. PAD a été plus grande dans MF (~15%) par rapport à MNF dans tous les stages de l'exercice. Dans la récupération aussi la PAD que la FC ont été plus grande dans MF quand comparées à MNF. Ces résultats démontrent que des jeunes femmes fumeuses présentent préjudice dans des paramètres cardiovasculaire dans repos et dans réponse à l'exercice submaximum.

**MOTS CLÉ :** fumée, l'essai ergométrique, femmes.

**EFECTO DEL FUMO EN LAS RESPUESTAS CARDIOVASCULARES AL EJERCICIO SUBMAXIMO EN MUJERES JOVENES.**

**RESUMEN**

Según la Organización Mundial del Salud (OMS) el tabagerismo es la principal causa de muerte evitable en todo el mundo. El fumo afecta la función cardiorespiratoria y puede reducir la capacidad del ejercicio físico. El objetivo del presente estudio fue verificar el efecto del fumo en las respuestas cardiovasculares al ejercicio físico progresivo submaximo en mujeres sedentarias fumantes. La presión arterial sistólica (PAS) y la diastólica (PAD y la frecuencia cardiaca (FC) fueron medidas de forma no evasiva en mujeres jóvenes no fumantes (MNF, n=7) y fumantes (MF, n=7) en reposo, durante la realización del prueba submaximo en bicicleta ergometrica así como en la recuperación. En reposo, la PAD y la FC fueron mayores en las MF (75 ± 2 mmHg e 85 ± 12 bpm) cuando comparadas con las MNF (67 ± 5 mmHg e 73 ± 5 bpm). Durante el ejercicio, la PAS y la FC aumentaron en los grupos estudiados. La PAD fue mayor en las MF (~15%) en relación a las MNF en todos los estajos del ejercicio. En la recuperación tanto la PAD cuanto la FC fueron mayores en las MF. Estos resultados demuestran que mujeres jovenes fumantes presentan prejuicios en parámetros hemodinámicas en reposo y en respuesta al ejercicio submaximo.

**Palabras-clave:** fumo, test ergometrico, mujeres.

**EFEITO DO FUMO NAS RESPOSTAS CARDIOVASCULARES AO EXERCÍCIO SUBMÁXIMO EM MULHERES JOVENS**

**RESUMO**

Segundo a Organização Mundial da Saúde (OMS) o tabagismo é a principal causa de morte evitável em todo o mundo. O fumo afeta a função cardio-respiratória podendo reduzir a capacidade de exercício físico. O objetivo do presente estudo foi verificar o efeito do fumo nas respostas cardiovasculares ao exercício físico progressivo submáximo em mulheres sedentárias fumantes. A pressão arterial sistólica (PAS) e diastólica (PAD) e a freqüência cardíaca (FC) foram medidas de forma não invasiva em mulheres jovens não fumantes (MNF, n=7) e fumantes (MF, n=7) em repouso, durante a realização do teste submáximo em bicicleta ergométrica e na recuperação. Em repouso, a PAD e a FC foram maiores nas MF (75 ± 2 mmHg e 85 ± 12 bpm) quando comparadas com as MNF (67 ± 5 mmHg e 73 ± 5 bpm). Durante o exercício, a PAS e a FC aumentaram nos grupos estudados. A PAD foi maior nas MF (~15%) em relação as MNF em todos os estágios do exercício. Na recuperação tanto a PAD quanto a FC foram maiores nas MF, quando comparadas as MNF. Estes resultados demonstram que mulheres jovens fumantes apresentam prejuízo em parâmetros hemodinâmicos em repouso e em resposta ao exercício submáximo.

**PALAVRAS CHAVE:** Fumo, teste ergométrico, mulheres.

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