Artículo original

Rating of perceived exertion and sustainability of repetition during resistance exercise in cigarette smoker and non-smoker men

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Summary

Introduction: Regarding lack of clear information about the effects of smoking on rating of difficulty sensation during resistance exercise and to clarify the influence of cigarette use on exercise performance, the aim of this study was to compare the rating of perceived exertion (RPE) and sustainability of repetition in different intensities of resistance exercises between cigarette smoker and non-smoker men.
Methods: Ten untrained cigarette smoker and ten untrained cigarette non-smoker men performed bench press and leg press exercises with 50, 70 and 90% of one repetition maximum (1RM) for four consecutive sets. After completing each set, the number of repetitions and the RPE were measured.
Results: There were no significant differences between smoker and non-smoker in number of repetitions during bench press and leg press exercises; however, both the experimental groups indicated decrements in number of repetitions with increases in exercise intensity and number of sets. Moreover, these decrements were greater for the cigarette smokers. The cigarette smoker men showed greater RPE during bench press exercise at set 3 and 4 with 50% of 1RM and set 4 with 70% of 1RM ($P\leq0.05$). In leg press, there were significant differences between cigarette smoker and non-smoker at set 4 with 70% of 1RM and set 2, 3 and 4 with 90% of 1RM ($P\leq0.05$).
Conclusion: According to the different RPE between cigarette smoker and non-smoker men, it seems that cigarette smoker men exhibit greater discomfort during same resistance exercise protocol.

Key words:
Resistance exercise. Smoking. Sustainability. Perceived exertion.

Escala de esfuerzo percibido y sostenibilidad de repetición en entrenamiento de fuerza en hombres fumadores y no fumadores

Resumen

Introducción: Con respecto a la falta de información clara sobre los efectos del tabaquismo en la escala de sensación de dificultad durante el entrenamiento de fuerza y para aclarar la influencia del tabaquismo en el ejercicio, el objetivo de este estudio fue comparar la escala de esfuerzo percibido (RPE) y la sostenibilidad de repetición de diferentes intensidades en ejercicios de fuerza entre hombres fumadores no fumadores.
Método: Diez hombres fumadores no entrenados y diez no fumadores no entrenados realizaron ejercicios de press de banca y press de piernas al 50, 70 y 90% de su repetición máxima (1RM) durante cuatro series consecutivas. Después de completar cada serie, se midieron el número de repeticiones y el RPE.
Resultados: No hubo diferencias significativas entre fumadores y no fumadores en el número de repeticiones durante los ejercicios de press de banca y press de piernas; Sin embargo, ambos grupos experimentales mostraron disminuciones en el número de repeticiones con incrementos en la intensidad del ejercicio y el número de series. Además, estas disminuciones fueron mayores para los fumadores. Los hombres fumadores mostraron mayor RPE durante el ejercicio de press de banca en las series 3 y 4 al 50% del 1RM y en la serie 4 al 70% de 1RM ($P\leq0.05$). En la prensa de piernas, hubo diferencias significativas entre el grupo fumador y el no fumador en la serie 4 al 70% de 1RM y en las series 2, 3 y 4 al 90% de 1RM ($P\leq0.05$).
Conclusión: En relación a los diferentes valores en RPE entre hombres fumadores y no fumadores, parece que los fumadores muestran una mayor incomodidad durante el mismo protocolo de ejercicios de fuerza.

Palabras clave:
Ejercicio de fuerza. Tabaquismo. Sostenibilidad. Esfuerzo percibido.

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Introduction

It has been well documented that rating of perceived exertion (RPE) is a good tool to monitor the intensity of exercise, stress or magnitude of discomfort during training[1]. Different sensation of fatigue for the various parts of the body are caused by anatomical status and body movements[2,3], resulting in different RPE during upper- and lower-body exercises[1,4].

There were two man pathways for perceived exertion during exercise including peripheral physiological mediators and metabolic respiratory. Metabolic-respiratory signals act with cardiovascular system and the elevation of that pathway is in relation to metabolic demands[5]. However, peripheral physiological mediators rise induced by recruitment and stimulation of muscles (e.g. legs, trunk, shoulders, or neck) during exercise[1]. The metabolic-respiratory mediators are respiratory stimulants[1,3,6,7], CO_2 release[1,7], O_2 consumption[3,4,8], heart rate[1,6], and blood pressure[6,8]. In addition, physiological procedures and the mediators related to peripheral stimulation are metabolic acidosis (pH and lactic acid), elasticity specificity of slow and fast twitch muscle fibers, muscle blood flow and muscle's energy substrates (e.g. glucose, fatty acids and glycerol)[1].

Regarding increases number of cigarette smokers in the world, it is necessary to assess the effects of cigarette smoking on human health. Smoking is in relation to several cardiovascular diseases such as hypertension, atherosclerosis and cardiac disease[9], and also affects the quality of physical activity and sport performance. It has been well documented that exercise training could promote health related variables; however, American Department of Health indicated that smokers have fewer propensities to exercise than non-smokers[10]. It is believed that smokers experienced higher RPE than non-smokers, and this situation induced restriction in sport activities[10].

Cigarette smoking has effects on metabolic-respiratory and peripheral mediators. Elevation of heart rate during and after the exercise and also at rest could be a sign of weakness in cardiovascular system[11,12]. The stimulation of sympathetic nervous system induced by smoking could generally affect elevation in heart rate[12], and greater resting oxygen consumption[12]. Other negative effects of smoking are elevation of systolic and diastolic blood pressure and pulmonary ventilation[10,12]. Regarding, the effects of the smoking on peripheral mediators of perceived exertion[13] it is well known that smoking accelerated the metabolic acidosis process, increases resting blood glucose level and reduced the percentage of slow twitch muscle fibers, muscle blood flow and insulin response[13,14]. Thus, it appears that elevation of RPE is in line with metabolic-respiratory increment and peripheral mediators in smokers[13]; however, this report was not established clearly.

Although, the possible adverse effects of smoking on RPE have been shown by literature, very few studies investigated the effect of smoking on RPE and consistency of performance during physical activity. Rotstein *et al.*[12] found that cigarette smokers were able to carry out exercise (10-minutes aerobic exercise, 60% of VO_2max) and their perceived exertion were not higher than non-smokers. Gardner *et al.*[15] examined the effect of vascular occlusion in leg muscles of cigarette smokers and non-smokers within walking. They observed that peripheral blood flow restriction led to superior performance of non-smokers compared to smokers. Moreover, they also completed more distances; however, there was no difference between male and female smokers in RPE[16].

Although previous studies have only investigated the effects of smoking on RPE during aerobic exercises, less attention has been provided on resistance exercises and there is no previous information regarding the effects of smoking on the ability to sustain of resistance exercises and RPE. Regarding the prevalence of resistance exercise among adults, the influence of cigarette use on exercise performance during resistance exercise is unclear. Therefore, the present research aimed to compare the RPE and ability to sustain of repetitions at different intensities of upper- and lower-body resistance exercises between cigarette smoker and non-smoker men. We hypothesized that the ability to sustain of repetitions during resistance exercise are greater in non-smoker men with lower RPE in comparison to smoker men.

Material and method

Participants

Twenty healthy men volunteered to participate in this study. The subjects had not any experience in resistance exercise and training. Before inclusion to study, the subjects were screened by physician and were free from cardiorespiratory and blood diseases or allergies and had not any physical problem or discomfort for performing resistance exercises. Inclusion criteria for smokers were smoking at least 15 cigarettes a day for at least one year. The subjects did not use drugs and supplements that could influence the results (vitamin supplements) and had not any oral infection and acute disease in the past 6 months (which requires the use of antibiotics). All subjects were carefully informed about the experimental procedures and about the possible risks and benefits associated with participation in the study. The study was conducted in accordance with the Declaration of Helsinki II and the study was approved by an institutional ethics committee from the University (Table 1).

Study design

Subjects in both groups recruited to the laboratory on seven occasions with 48 h apart at 4-7 PM, respectively. On the first visit,

Table 1. Baseline values of non-smokers and smokers (M ± SD).

Variables	Non-Smokers (n = 10)	Smokers (n = 10)
Age, y	24.9 ± 2.8	22 ± 2.3
Height, cm	174.1 ± 5.2	175.3 ± 5.6
Weight, kg	72.9 ± 6.8	75.5 ± 8.2
Body fat, %	15.4 ± 3.5	17.7 ± 5.7
1RM (bench press), kg	49 ± 11.1	47 ± 12.9
1RM (leg press), kg	127.5 ± 20	110 ± 29.9
Resting heart rate, bpm	76.3 ± 4.4	79.2 ± 8.1
Systolic blood pressure, mm Hg	126 ± 10.6	128.7 ± 17.3
Diastolic blood pressure, mm Hg	83.8 ± 7.1	85.9 ± 10.1

subjects were familiarized with exercise and testing procedures. During this session subject characteristics such as; age, height (Seca 222, Terre Haute, IN), weight (Tanita, BC-418MA, Tokyo, Japan), percent body fat[17] and cardiovascular variables such as systolic and diastolic blood pressure (sphygmomanometer [Missouri®] and stethoscope [Rappaport® GF Health Products, Northeast Parkway Atlanta]) and resting heart rate (Polar S610i heart rate Monitor, FIN, 90440, FINLAND) were measured. The subjects were instructed to maintain their usual diet, have adequate rest the night before the test, drink enough water, and avoid intense physical activity at least 24 hours prior to the test. Smokers were asked not to smoke just before the test. On other days, the subjects participated 4 set to failure for bench press, and leg press with volitional lifting velocity. The subjects performed the selected percentages of 1RM for 2 exercises (i.e., leg and bench presses) on different days. Each subject attempted 2 different exercises at 50, 70, and 90% of 1RM, which was balanced, matched, and randomized. After completing each set, the RPE was measured for each subject. To standardize the exercise procedures, a one-week orientation took place consisting of three sessions in which the methods and techniques of the exercise programs were demonstrated.

One repetition maximum testing

A bilateral leg press test was selected to provide data on maximal strength through the full range of motion of the muscles involved. Maximal strength of the lower extremity muscles was assessed using concentric 1RM leg press action. Bilateral leg press tests were completed using standard leg press equipment (Nebula Fitness, Inc., Versailles, OH), with the subjects assuming a sitting position and the weight sliding obliquely at 45°. On command, the subjects performed a concentric leg extension (as fast as possible) starting from the flexed position to reach the full extension against the resistance determined by the weight. Warm-up consisted of a set of 10 repetitions at loads of 40-60% of the perceived maximum. For the bench press, each subject lowered the bar until contact with the chest was achieved and subsequently lifted the bar back to the fully extended elbow position. Any trials failing to meet the standardized technique criteria were discarded. A warm-up consisting of 5-10 repetitions with approximately 40-60% of perceived maximum was performed. The rest period between the actions was always 2 minutes. Subjects were allowed to perform maximum 8 repetitions during bench press and leg press, and were used equation of Brzycki[18] for the determine of 1RM;1RM = Weight / 1.0278 – (repetitions × 0.0278). The reliability coefficient (ICC) for 1RM was 0.93.

Exercise program

The subjects took part in 6 testing sessions (except the familiarization session). The sequence of the exercises were performed during 6 days of testing, during which the subjects performed 4 set to failure for the bench press, and leg press with volitional lifting velocity. The subjects performed the selected percentages of 1RM for 2 different exercises on different days. Each subject attempted 2 exercises at 50, 70, and 90% of 1RM, which was balanced, matched, and randomized. For example, in one testing sessions the subjects performed 50% of 1RM for the bench press and, 70% of 1RM for the leg press. Before the testing, the subjects performed a 10-min general warm-up consisting of ballistic movements and flexibility exercises to increase blood circulation and temperature of the involved muscle groups. A specific warm-up consisted of 1 set of 5 repetitions at 50-60% of 1RM. The rest between the exercises was 20-30 minutes and the subjects could rest at least 48 hours between each testing session. Also, the subjects had 2-min rest among sets to ensure recovery. Repetitions performed with poor technique or which were not performed properly was not taken into account. The rating of the perceived exertion was obtained by the Borg 15-category scale after each set of exercises[19].

Statistical analysis

All of the values presented as mean ± SD. A two-way analysis of variance was used to analyze the data. In the event of a significant F ratio, the Tukey post hoc test was used for pair-wise comparisons. The level was set at $P \leq 0.05$ for statistical significance. All statistical analyses were performed through the use of a statistical software package (SPSS®, Version 16.0, SPSS, Chicago, IL).

Results

There were no significant differences ($P \leq 0.05$) between cigarette smokers and non-smokers in the number of repetitions of the bench press and leg press. When the number of sets increased, both groups showed decrements in the number of repetitions at 50, 70 and 90% of 1RM bench press and leg press ($P \leq 0.05$). In addition, there was significant difference between intensities of resistance exercises in smoker and non-smoker men ($P > 0.05$). Likewise, no significant differences were observed in the number of repetitions in both exercises for the experimental groups (Table 2).

Progressive increases in RPE according to increases in exercise intensity and the number of set were observed for both groups. The RPE on the 3rd (P=0.037) and 4th (P=0.011) sets of the bench press and leg press at 50% of 1RM was higher for the cigarette smokers compared to non-smokers. In addition, significant difference was found on the 4th set of bench press at 70% of 1RM (P=0.05). Significant differences were found between cigarette smokers and non-smokers in leg press at 4th set of 70% of 1RM, and 2nd, 3rd and 4th sets at 90% of 1RM (Figure 1).

Discussion

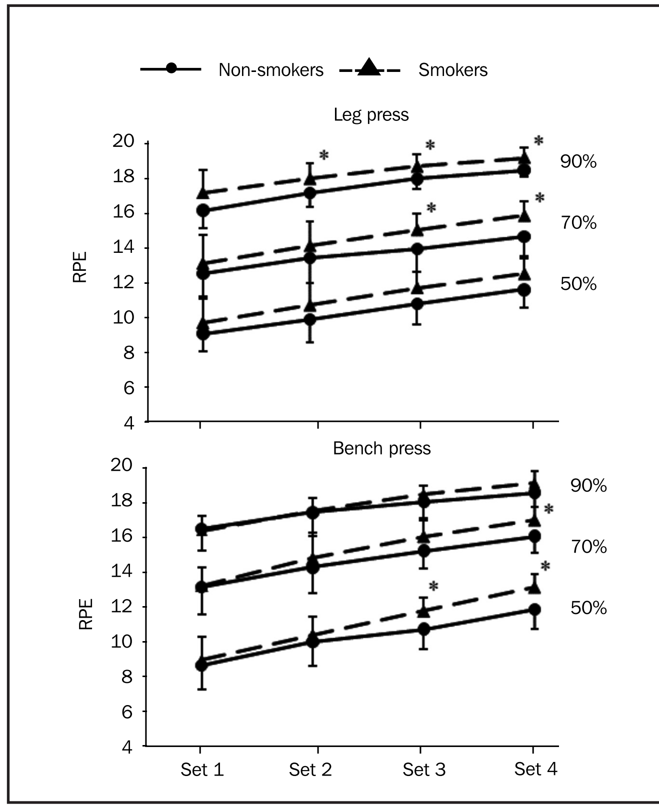
The aim of this study was to compare the ability to sustain of repetitions and rate of perceived exertion during bench press and leg press exercises at 50, 70 and 90% of the 1RM in cigarette smoker and non-smoker men. The results showed decrements in number of repetitions after increases in exercise intensity. Although, smoker and non-smoker groups showed a drop in the number of repetitions, the smokers performed fewer repetitions, no significant difference, when compared with non-smoker group. Regarding perceived exertion, greater RPE scores were observed with elevation of exercise intensity. On the other hand, progressive increases in RPE was found with increases in intensity (90>70>50) and number of sets (4>3>2>1). The RPE scores in set 3 and 4 of bench press at 50% of 1RM were higher for the smokers compared

Table 2. The number of repetitions performed by two groups (M ± SD).

Variables	Non-Smokers (n = 10)	Smokers (n = 10)
Bench press (50% of 1RM)		
1st set	18 ± 1.8	16.3 ± 1.8
2nd set	14.2 ± 1.7ª	13.1 ± 1.7ª
3rd set	11.3 ± 1.7ᵇ	10.2 ± 1.6ᵇ
4th set	8.6 ± 1.8ᶜ	7.8 ± 1.1ᶜ
Bench press (70% of 1RM)*		
1st set	10.6 ± 1.2	10.6 ± 1.5
2nd set	7.6 ± 0.9ª	7.6 ± 1.7ª
3rd set	5 ± 1ᵇ	4.8 ± 1.6ᵇ
4th set	2.6 ± 0.9ᶜ	2.3 ± 1ᶜ
Bench press (90% of 1RM)*†		
1st set	3.6 ± 0.9	3.3 ± 0.8
2nd set	2.1 ± 0.8ª	1.9 ± 0.5ª
3rd set	1.2 ± 0.4ᵇ	1.1 ± 0.4ᵇ
4th set	0.85 ± 0.2ᶜ	0.8 ± 02ᶜ
Leg press (50% of 1RM)		
1st set	20 ± 2.2	19.5 ± 2.8
2nd set	16.6 ± 2.1ª	14.5 ± 2.5ª
3rd set	13.2 ± 2.6ᵇ	11.1 ± 2.4ᵇ
4th set	9.6 ± 2.1ᶜ	8.2 ± 2.4ᶜ
Leg press (70% of 1RM)*		
1st set	11.4 ± 1.6	10.9 ± 1.8
2nd set	8 ± 1.3ª	7.4 ± 1.5ª
3rd set	5.3 ± 1.1ᵇ	4.4 ± 0.8ᵇ
4th set	2.9 ± 0.9ᶜ	2.3 ± 0.6ᶜ
Leg press (90% of 1RM)*†		
1st set	3.9 ± 0.9	3.7 ± 1.1
2nd set	2.3 ± 0.6ª	2.1 ± 0.5ª
3rd set	1.3 ± 0.4ᵇ	1.3 ± 0.4ᵇ
4th set	0.85 ± 0.2ᶜ	0.8 ± 0.2ᶜ

*Significant difference with 50% of 1RM $P \leq 0.05$. †Significant difference with 70% of 1RM $P \leq 0.05$. ªSignificant difference with set 1 $P \leq 0.05$. ᵇSignificant difference with set 1 and 2 $P \leq 0.05$. ᶜSignificant difference with set 1, 2 and 3 $P \leq 0.05$.

Figure 1. Comparison of RPE between two groups.



*Significant difference between groups at $P \leq 0.05$.

to non-smokers. In addition, significant difference was found on the 4th set of bench press at 70% of 1RM. Significant differences were found between cigarette smokers and non-smokers in leg press at 4th set of 70% of 1RM, and 2nd, 3rd and 4th sets at 90% of 1RM.

We found decreases in number of repetitions during resistance exercise when the exercise sets increased. These findings are in line with previous studies[20-27] who found decrements in repetitions following resistance exercise sets.

An important mechanism for reducing number of repetitions could be due to metabolite production following exercise. Lactate is an exercise-induced metabolic product and elevation of lactate production is depending on exercise intensity, and utilize of glycolysis and glycogenolysis pathways during resistance exercise is in relation to exercise intensity resulting in H^+ increases and muscle cells acidity[28].

The ability of muscles to produce powerful contraction will be decreased when blood H^+ increases and the level of pH decreases. In this situation the ability of muscle to continue number of repetitions during resistance exercise will be dropped[29]. The sustainability of repetitions may be attributed to the ability of maintain muscular power output. With regard to type and duration of resistance exercises, of the ATP-PCr system plays an important role. Increment in lactate and other metabolites could lead to decreases in muscular power output and limitation of several enzymes activity which made the ATP production. On the other hand, enhancement in blood metabolites is in line with reduction of muscle ability to sustain energy production resulting in number of repetition decreases[30]. Although in this study we did not measure lactate and H^+, the influence of these metabolites on muscle performance during resistance exercise and also decrements in number of repetitions were confirmed by previous documents[22,23].

Regarding cigarette use previous studies reported acceleration of metabolic acidosis[13,14] resulting in greater decrements in anaerobic performance; however, the present study showed no significant difference between smoker and non-smoker men in the number of repetitions during resistance exercise sets. It seems that short duration of cigarette use (because of young subjects) and few numbers of subjects could be a reason for these findings and more studies are necessary for this subject.

Regarding RPE scores, the present study that RPE scores for cigarette smokers in sets 3 and 4 of bench press at 50% of 1RM was greater than non-smokers. This finding occurred for set 4 of bench press at 70% of 1RM. Furthermore, significant difference was found between cigarette smokers and non-smokers for leg press in the set 4 at 70% of 1RM, and set 2, 3 and 4 at 90% of 1RM. These results are in agreement with the study of

Gardner *et al.* (1999) who found higher RPE scores for cigarette smokers compared to non-smokers[15]. Conversely, some researchers found that RPE did not significantly differ between smokers and non-smokers[12, 16]. Different findings from various studies may be due to the dissimilarities within exercise protocol, exercise intensity and subject's fitness status.

Both groups reported progressive increment in RPE scores with elevation of exercise intensity. Consistent with these findings, previous studies[20-26] found that increases in RPE with increases in exercise intensity. Legally *et al*[4] observed that during resistance exercise, active muscle(s) signals play overriding role in RPE scores[4]. Other evidence recorded muscle activity during resistance exercise by electromyography[31]. When exercise intensity increased, activation of muscle fibers increased and resulted RPE rises because of great stimulation and response of the sensors within activated muscles occurrd[4,22,26].

Cigarette use accelerated metabolic acidosis process, stimulated metabolic and peripheral mediators and sympathic nervous system resulting in RPE elevation in smokers. Additionally, elevation of RPE have been confirmed with increased muscle activation, greater muscle fiber recruitment and firing rate[32]. The positive and incremental gradient of RPE with increasing exercise intensity and the number of sets is in line with increases in sensory signals within activated muscles which can be accompanied by fatigue due to the accumulation of metabolites. Furthermore, fatigue and greater RPE scores could be due to reduction of plasma creatinine, blood pH, and increases in muscle lactate and decreases in muscle carbohydrate[1,22-32,33]; however, in this study these variables did not measure and could be guess and speculation.

Conclusion

It could be concluded that the ability to sustain repetitions during resistance exercise will be decreased when number of sets increased. This finding could be affect by cigarette smoking. In addition, amount of perceived exertion increased by enhancing exercise intensity and number of sets. It seems that metabolic and peripheral mediators affect perceptual mechanisms and muscle fiber ability to sustain number of repetition and also perceived exertion. Since the information about the effects of cigarette use on the quality and quantity of training are scarce, more research is necessary to clarify whether cigarette use affects sport performance, especially resistance trainings.

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