Wiatrak Adrian, Mosiejczuk Hanna, Szylińska Aleksandra, Ryl Aleksandra, Turoń-Skrzypińska Agnieszka, Maziarz Agata, Rotter Iwona. The effect of smoking and physical activity level on exercise capacity in older adults. Journal of Education, Health and Sport. 2018;8(11):240-252. eISNN 2391-8306. DOI http://dx.doi.org/10.5281/zenodo.1482851
http://ojs.ukw.edu.pl/index.phpohs/article/view/6288

The journal has had 7 points in Ministry of Science and Higher Education parametric evaluation. Part B item 1223 (26/01/2017).
1223 Journal of Education, Health and Sport eISSN 2391-8306 7

Received: 25.10.2018. Revised: 25.10.2018. Accepted: 11.11.2018.

The effect of smoking and physical activity level on exercise capacity in older adults

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Summary

Introduction: Exercise capacity is highly age-dependent and influenced by factors such as physical activity level and smoking.
Aim: The aim of the study was to analyze the relationship between physical activity level, smoking and exercise capacity in people over 60 years of age.
Materials and methods: The study involved 100 participants (50 female and 50 male) over 60 years of age (mean age 68.2 years). Based on the answers provided to a questionnaire about smoking and physical activity level, participants were divided into four groups: exercising non-smokers, exercising smokers, non-exercising non-smokers, and non-exercising smokers. Each group consisted of 25 subjects. Exercise capacity was measured using the 6-minute walk test and the Borg scale.
Results: Intergroup comparison showed statistically significant differences between the average results of each group, both in the 6-minute walk test ($p=0.010$) and on the Borg scale ($p<0.001$). There was a positive correlation between the number of cigarettes smoked and the

Borg score in the exercising smokers group ($p<0.001$). In both exercising groups there was a correlation between amount of physical activity per week and the results of the 6-minute walk test ($p<0.001$). In the same test, the mean results differed between the two sexes ($p<0.001$).
Conclusions: In the studied population (aged over 60), non-active individuals and smokers had significantly lower exercise capacity than those who exercised regularly or did not smoke.

Key words:

Introduction

Exercise capacity can be defined as the body's ability, specifically the ability of the cardiovascular system, to tolerate disturbances in intracorporeal homeostasis induced by physical effort [1]. This capacity can be consciously modified by factors such as physical activity and tobacco smoking [2].

Physical activity significantly reduces cardiac contractions at rest and increases stroke volume (SV) [3-5], resulting in reduced strain on the heart muscle and a decrease in its oxygen intake. Reduced blood vessel stiffness [6] additionally improves the efficiency of the cardiovascular system, translating into increased muscle efficiency and endurance during effort.

Exercise capacity can be significantly reduced by smoking, mainly due to the effect of nicotine leading to increased heart rate and oxygen demand [7]. Smokers also exhibit a higher blood concentration of fibrinogen, a protein responsible for platelet aggregation, which may result in embolism [8,9]. Furthermore, carbon monoxide present in tobacco smoke binds to hemoglobin and reduces oxygen transport by erythrocytes to target organs. In the case of physical activity, this lowers the anaerobic threshold of muscles and elevates the feeling of fatigue [10].

Elderly people are the most at risk for cardiovascular disease and decreased exercise capacity. After 60 years of age, people experience a gradual decrease in muscle strength, with mid-sexagenarians exhibiting muscle strength only 75% of its level in vicenarians [1]. This results in increased tissue oxygen demand during submaximal efforts. In addition, in comparison to the second decade of life, cardiac output (CO) decreases by as much as 2 L/min and stroke volume (SV) decreases to 80% of its peak value [11]. These reasons, coupled with the known detrimental effects of smoking and inactivity, strongly indicate a vital importance for older adults to exercise regularly and avoid tobacco consumption.

The aim of the study was to assess the effects of physical activity and tobacco consumption on exercise capacity in people over 60 years of age.

Material and methods

The study was conducted between November 2015 to April 2016 in the clinic "Medika" sp. z o.o. in Police, Poland. The study involved 100 participants over 60 years of age (mean age 68.2 years), 50 women and 50 men. People with cardiac and circulatory insufficiency, neurological or orthopaedic dysfunctions restricing the ability to walk, respiratory diseases, current or recent infections, or showing symptoms of general exhaustion were excluded from the study.

Participants were asked to fill out a questionnaire inquiring about physical activity level and use of tobacco products. On the basis of the answers given, participants were divided into the following groups: exercising non-smokers, exercising smokers, non-exercising non-smokers and non-exercising smokers. Each group consisted of 25 subjects.

Participants assigned to the exercising group were those who exercised regularly at medium intensity level as outlined by WHO (i.e. 3 training sessions per week of at least 30 minutes each). The non-exercising group was comprised of individuals who were not engaged in any regular physical activity.

Additional information was collected on the number of years that smokers had been smoking and the average number of cigarettes smoked per day throughout that period. These data were used to calculate pack-years, the conventional parameter used to assess risk for development of tobacco consumption-related diseases, according to the following formula:

$$\text{pack-years} = (\text{packs smoked per day}) \times (\text{years as a smoker})$$

Exercise capacity in each group was measured once using a 6-minute walk test conducted according to the guidelines of the American Thoracic Society [12]. Tolerance to induced effort was evaluated immediately after the walk test by means of the 15-degree Borg Scale of Perceived Exertion.

Participants gave written voluntary and informed consent to take part in this study. They were informed about their right to abandon the study at any stage and discontinue the exercise test in the event of any worrying symptoms.

Statistical analysis

Statistical analysis was performed using Statistica 12 software (StatSoft, USA). In the case of quantitative variables, the distribution of the variable is illustrated by histograms. Central tendency and dispersion are presented in a table. Differences in group means were calculated using the Student's t-test (2 independent means) and ANOVA with Bonferroni correction (>2 independent means). Correlation was evaluated using Spearman's rank correlation coefficient. Percentages of individual responses variants are presented in bar charts. The level of significance was $p \leq 0.05$.

Results

Of all groups in the study, the best average score – both in the 6-minute walk test and in the Borg scale – was achieved by exercising non-smokers (559.92 meters and 9.12 points on the Borg scale). Their score was 38.56 m and 4.04 points better than the worst group (non-exercising smokers) who achieved an average score of 521.36 m and 13.16 points.

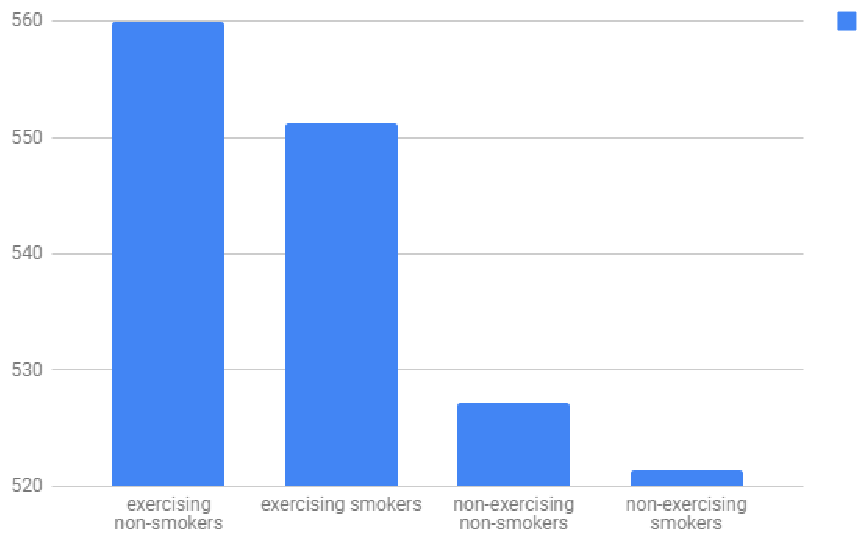
A full analysis of the data from both the 6-minute walk test and Borg scale was carried out for each of the surveyed groups. The results of one-way ANOVA indicate significant differences in average Borg scale score ($p<0.001$) and 6-minute walk test distance ($p=0.010$) between individual groups. The results are presented in Table 1 and illustrated in Diagrams 1 and 2.

Table 1: Evaluation of results of 6-minute walk test and Borg scale in subsequent groups

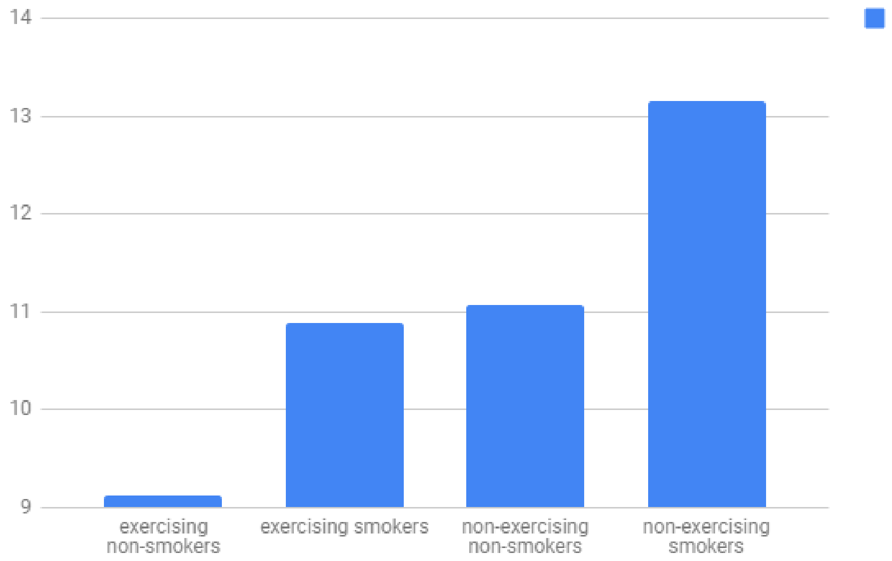
Group	walk test (meters)	Borg scale
exercising non-smokers	559.92 ± 50.07	9.12 ± 2.20

exercising smokers	551.16 ± 46.18	10.88 ± 1.96
non-exercising non-smokers	527.24 ± 40.28	11.08 ± 3.13
non-exercising smokers	521.36 ± 47.82	13.16 ± 2.90
ANOVA test	**p=0.010**	**p<0.001**

Figure 1: Average results of the 6-minute walk test in all groups. AXIS X - group, AXIS Y - meters travelled.



Graph 2: Average results of the Borg scale in all study groups. AXIS X - group, AXIS Y - points on Borg scale.



Additionally, after Bonferroni's correction, analysis of the 6-minute walk test showed statistically significant differences between the two extreme groups, exercising non-smokers and non-exercising smokers (p=0.024). On the Borg scale, statistically significant differences were found between the exercising non-smokers and all other groups: exercising smokers (p=0.015), non-exercising smokers (p<0.001), and non-exercising non-smokers (p=0.034).

Calculation of mean pack-years in both smoking groups showed exercising smokers at 19.58 pack-years and the non-exercising smokers at 18.17 pack-years.

Analysis of the relationship between pack-years and smokers' average scores in the 6-minute walk test and Borg scale of perceived exertion are presented in Table 2.

Table 2. Correlation between pack years and walk test and Borg scale scores.

			Meters in a 6-minute walk test	**Borg scale**
exercising smokers		Spearman's	r=0.031 p=0.884	**r=0.782 p<0.001**

non-exercising smokers	pack-years	rho / level of significance	r=0.164 p=0.444	r=0.065 p=0.761

Correlation analysis in exercising smokers showed dependence between pack-years and score on the Borg scale (p<0.001), indicating that the higher the number of pack-years, the greater the fatigue felt during exercise.

Similarly, the two exercising groups were analysed for correlations between weekly time spent on physical activity and 6-minute walk test and Borg scale scores (Table 3). The exercising non-smokers averaged 148 minutes per week and the exercising smokers averaged 158.40 minutes per week.

Table 3. Correlation between weekly physical activity and walk test and Borg scale scores.

			Meters in a 6-minute walk test	**Borg scale points**
exercising non-smokers	Physical activity - minutes per week	Spearman's rho level of significance	**r=0.717 p<0.001**	r=0.133 p=0.525
exercising smokers			**r=0.683 p<0.001**	r=0.274 p=0.184

Spearman's correlation coefficient showed a significant positive correlation between time spent on physical activity and the results of the 6-minute walk test in both smokers (p<0.001) and non-smokers (p<0.001). However, no significant correlation was demonstrated between time spent exercising and Borg scale results in either group.

The relationship between sex of participants and score in the 6-minute walk test was also analysed. The data are shown in Table 4.

Table 4: 6-minute walk test and Borg scale scores by sex.

Group	Sex	Meters in the walk test	Borg scale points
exercising non-smokers	Women	524.00 ± 39.32	9.64 ± 2.29
	Men	588,14±38,60	8.71 ± 2. 13
exercising smokers	Women	536.54 ±38.61	10.92±2.10
	Men	567.00 ± 49. 99	10.83 ± 1. 90
non-exercising non-smokers	Women	516.00 ± 32.23	11.27 ± 3.13
	Men	536.07 ± 44.79	10.93 ± 3. 25
non-exercising smokers	Women	504.67 ± 47.62	12.80 ± 2.78
	Men	546.40 ± 37.53	13.70 ± 3.13
average for all groups	Women	519.70 ± 41.14	11.28 ± 2.78
	Men	560.14 ± 46. 76	10.84 ± 3. 09
Student t-test		**p<0.001**	p = 0.456

There was a significant correlation between the sex of subjects and the results of the walk test ($p<0.001$). The average score for male participants was 560.14 m, while the average score for females was a significantly lower 519.7 m. The Borg scale showed no statistically significant correlation with sex.

Discussion

The 6-minute walk test and Borg scale are common tools used in the assessment of exercise capacity, especially in cardiac patients. However, studies indicate that they can also be used for the assessment of effort tolerance in healthy subjects [13-15]. The high popularity of these evaluation methods results primarily from their low cost and ease of implementation.

In a study by Mesquita et al. of 154 healthy subjects over 60 years of age, smoking exhibited a significant impact on exercise capacity. The smokers surveyed, including those who had quit smoking, achieved a lower average score in the 6-minute walk test than those who never smoked. [16]. This is consistent with the results obtained in this study, wherein each group of smokers achieved worse results than non-smokers at the same level of weekly physical activity. Conversely, a study by Rocci et al. demonstrated a different result, finding a lack of correlation between history of smoking and exercise capacity, and suggesting that quitting smoking is highly beneficial, even among the elderly [17]. A slightly different study, using a 6-minute treadmill test according to Bruce Heffernan's protocol in place of the walk test, showed a similar relationship to that observed in this study. Smokers achieved an average score of 425 s while non-smokers achieved an average of 522 s, showing a significant difference in exercise capacity [18].

Sumiński et al. showed a significant reduction in VO2(max) in spirometry tests between heavy smokers and those who smoked less, as measured in pack-years [19]. As VO2(max) is a good indicator of exercise capacity, this decrease may also be noticeable in smoking patients on the Borg scale.

The significant impact of smoking on performance in exercise tests can be explained by the results of the Deveci study, which investigated 322 smokers and non-smokers for carbon monoxide levels in exhaled air. It was found that the level of exhaled carbon monoxide in smokers was on average 17.13 ± 8.50 ppm, while in non-smokers it was only 3.61 ± 2.15 ppm [20]. There was also a significant correlation between the number of cigarettes smoked per day, the duration of smoking, and the concentration of carbon monoxide. Szczeremeta previously demonstrated that carbon monoxide reduces oxygen transport by erythrocytes to target tissues [10]. During physical activity, when demand for oxygen in muscle tissue rapidly increases, changes caused by the presence of large amounts of carbon monoxide will result in a decrease in muscle efficiency. This also supports the results showing a statistically significant influence of the number of packs of cigarettes on the fatigue felt by the participants as measured on the Borg Scale.

This study also found a significant correlation between results from the 6-minute walk test and physical activity level. Exercising participants achieved better scores in the walk test than those who did not exercise. However, this is not consistent with the results obtained by some previous studies. In a study by Cress et al. conducted on 49 healthy men and women aged 76 years, there was no significant correlation between physical exercise level and walk test results. However, a significant increase in maximum oxygen consumption (+11%) and muscle strength (+33%) was observed in the exercising group [21]. In a study by Zenith et al. cirrhosis patients aged on average 57.6 years were divided into two groups, one of which was subjected to an 8-week exercise programme, and the other did not exercise at all. At the end of the experiment, it was observed that VO2(max) was 5.3 ml/kg/min higher in exercising participants [22]. This indicates that physical activity has a significant impact on exercise capacity and fatigue during exercise. The results of this study further support this thesis, as effort tolerance among members of the exercising group was greater in participants declaring higher weekly activity (min per week).

The observed sex-related differences in walk test results were consistent with those described in another study, in which a group of healthy adults aged between 20 and 80 years achieved average scores in the walk test of 735 ± 98 m for men and 659 ± 56 m for women [23]. In another study, an examination of 290 people further showed the advantage of male subjects over females in the 6-minute walk test. In this case, the results were 576 meters and 494 meters, respectively [24]. In yet another walk test study, on 2281 patients, healthy men over 68 years of age reached about 400 meters and healthy women 367 meters [25]. These differences in exercise capacity between men and women result from sex-specific biological predispositions such as muscle strength, which are known to affect walking speed, as shown in a study by Inouye et al. [26].

Conclusions

This study showed that physical activity level and tobacco consumption influence exercise capacity in people over 60 years of age. Exercising non-smokers achieved the best average scores, while non-exercising smokers achieved the worst scores both in the 6-minute walk test and on the Borg scale.

Across groups, men achieved better average scores than women; however, this is most likely due to preexisting biological conditions, such as muscle strength which is higher in men.

Older adults who smoke and avoid physical activity showed poorer exercise capacity compared to other participants tested, and thus, are at higher risk of developing cardiovascular disease. The results support the importance of pro-health prophylaxis, including education, assistance in coping with nicotine addiction, and encouraging physical activity.

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