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ORIGINAL ARTICLE

# The Relationship Between Smoking Habits and Cardiorespiratory Fitness ($VO_2max$) in Adult Males

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**Abstract:**
Background: Maximal oxygen uptake ($VO_2max$) is an indicator of cardiorespiratory fitness that reflects the body's ability to consume oxygen during physical activity, expressed in mL/kg/min. A higher $VO_2max$ value is associated with better physical fitness and a lower risk of cardiovascular disease. $VO_2max$ can be measured using the Bleep Test, which is performed through a shuttle run following audio beeps. $VO_2max$ is influenced by various factors such as age, sex, genetics, lifestyle, and smoking habits. Harmful substances in cigarettes can damage the alveoli in the lungs, reducing the effectiveness of oxygen exchange and decreasing oxygen supply to muscles, which leads to reduced cardiorespiratory capacity. Smoking habits can be measured using the Glover–Nilsson Smoking Behavioral Questionnaire (G-NSBQ), which has good validity and reliability. Previous studies have shown a significant relationship between smoking habits and $VO_2max$; however, most were conducted on adolescent or athletic populations with limited sample sizes and without controlling confounding factors. Therefore, this study is important to analyze the relationship between smoking habits and cardiorespiratory capacity ($VO_2max$) in adult males to provide more representative empirical evidence in the general population;
(2) Methods: To analyze the relationship between smoking habits and cardiorespiratory capacity ($VO_2max$) in adult males with research design: An observational analytic study with a cross sectional design. Data analysis was performed using SPSS (Statistical Package for the Social Sciences) version 27; (3) Results: The normality test using the Shapiro-Wilk test showed that the GNSBQ data were normally distributed, while the $VO_2max$ measurement data were not normally distributed. The correlation test results showed a Spearman correlation coefficient of −0.32, indicating a moderate correlation. The negative sign indicates an inverse relationship between the two variables, meaning that the higher the smoking habit score, the lower the cardiorespi ratory capacity. The significance value was $p = 0.027$ ($p < 0.05$), indicating a significant relationship between smoking habits and cardiorespiratory capacity; (4) Conclusion: There is a relationship between smoking habits and cardiorespiratory capacity ($VO_2max$) in adult males.
**Keywords:** Smoking Habits; Cardiorespiratory Capacity; ($VO_2max$); Adult Males.

## 1. Introduction

Maximum oxygen uptake ($VO_2max$) is the maximum amount of oxygen the body consumes during activity. $VO_2max$ is measured in mL/kg/min (milliliters of oxygen consumed per kilogram of body weight per minute of exercise). A higher $VO_2max$ is associated with better physical fitness and a lower risk of cardiovascular disease (Triandini et al., 2025). During breathing, lungs absorb oxygen and transport it to red blood cells, which then carry it to all organs and muscles of the body. Muscle cells require oxygen to produce Adenosine Triphosphate (ATP). ATP provides the primary source of energy needed for muscle function. The more oxygen that is inhaled, the more ATP is produced by the muscles to fuel exercise. A higher $VO_2max$ indicates a greater capacity to utilize oxygen for ATP production (Akhlaqul et al., 2022). $VO_2max$ endurance is also referred to as cardiorespiratory endurance.

These components are essential parts of physical fitness required for various activities (Christanto Sepang et al., 2023). $VO_2$max values are influenced by factors such as age, sex, genetics, lifestyle (smoking, sedentary lifestyle), and body composition. Measurement of $VO_2$max can be performed using various methods such as the Six Minute Walking Test (6MWT), the Balke test, the Cooper test, and the Multistage Fitness Test (Bleep Test) or shuttle run (Ridho Setiawan et al., 2022). In this research, $VO_2$max was measured using the Bleep Test. The Bleep Test is conducted by running back and forth (shuttle run) between two lines marked by cones placed 20 meters apart.

Smoking has been one of the world's major health problems for decades. More than 7 million deaths are caused directly by tobacco use, while approximately 1.6 million additional deaths are due to exposure to secondhand smoke (WHO, 2023). WHO data also show that more than 225,700 people in Indonesia die due to smoking or smoking-related diseases (Walid Waliyudin et al., 2023). Cigarette smoke contains more than 4,000 different chemical substances, many of which are known to be carcinogenic (Kuncoro & Wibowo, 2020)

Substances in cigarettes can damage the alveoli of the lungs. As a result, the exchange of oxygen and carbon dioxide becomes less effective, leading to reduced oxygen intake into the bloodstream. This decreases oxygen supply to the muscles, causing smokers to experience fatigue more quickly during exercise or heavy physical activity. Consequently, $VO_2$max values in smokers tend to be lower compared to non-smokers (Zuhdi and Yuliastrid, 2017). Smoking behavior is a major public health issue within populations. It can be defined as the activity of inhaling tobacco smoke produced by burning tobacco (Halim Putra et al, 2024). This activity is often repeated and can lead to dependence. Each individual has a different level of smoking behavior, influenced by the number of cigarettes consumed per day, frequency, and duration (Umbas et al., 2019). Smoking behavior is also affected by environmental, social and cultural, psychological, and genetic factors (Marín-Jiménez et al., 2023).

Smoking habits increase the risk of cardiovascular disease, lung disease, and reduced aerobic performance (Halim Putra et al, 2024). Smoking behavior can be measured using the Glover–Nilsson Smoking Behaviour Questionnaire, which has good internal reliability ($\alpha = 0.76$) and shows significant correlations with variables such as age, number of cigarettes consumed, and withdrawal symptoms (Carballo et al., 2023).

Previous studies have shown that lungs affected by disease will experience a reduced ability to produce $VO_2$max. Research has also demonstrated a significant relationship between smoking habits and $VO_2$max among students of Physical Education, Health, and Recreation at Universitas Negeri Surabaya (UNESA), Class of 2015, with a moderate correlation level of 20.25% (Zuhdi & Yuliastrid, 2017). However, previous research on the relationship between smoking habits and cardiorespiratory fitness ($VO_2$max) has primarily focused on adolescents or athletes who generally have good levels of physical activity. Physical activity patterns in adult males differ from those of adolescents, so evidence in adult male populations with general characteristics remains limited. Additionally, earlier studies often had small sample sizes and did not control for confounding factors such as physical activity level, body mass index, and other health conditions. Therefore, the relationship between smoking and $VO_2$max cannot yet be strongly generalized. For this reason, this study is important to provide empirical evidence regarding the extent to which smoking habits are associated with cardiorespiratory fitness.

## 2. Materials and Methods

### *Study Design*

Data analysis was performed using IBM SPSS Statistics version 27 for Windows (SPSS, Armonk, New York, USA). Data from the G-NSBQ questionnaire, Bleep Test, and $VO_2$max were analyzed for normality using the Shapiro–Wilk method because the sample size was fewer than 50 participants. The research data were not normally distributed, as the normality test showed a p-value < 0.05. Therefore, since the data were not normally distributed, analysis was conducted using the Spearman correlation test.

### *Subjects*

The subjects of this study consisted of 47 residents of Bulak Banteng, Surabaya, who met the inclusion and exclusion criteria, and their data were then collected as the research subjects. Inclusion Criteria**:** adult males in middle age (45–54 years), have a smoking habit, willing to participate as respondents and have signed informed consent, do not have any ambulation disorders. Exclusion Criteria: have a history of chronic disease, have heart disease, uncontrolled hypertension, or severe anemia, are currently taking medications that affect the respiratory and cardiovascular systems.

### *Research Instruments*

The tools and materials required in this study are as follows: informed consent form, G-NSBQ questionnaire sheet, bleep test assessment form, medical equipment (sphygmomanometer, oximeter), bleep Test audio, cones, whistle, stopwatch, measuring tape, seating, stationery.

### *Procedure*

(1)The research subjects will be selected from the population of adult males in the Bulak Banteng area, Surabaya; (2) Subjects who meet the inclusion criteria will be given an oral explanation and an information sheet regarding the purpose and objectives of the study. If they agree to participate, they will be asked to sign the informed consent form; (3) Respondents will be given the G-NSBQ questionnaire to assess their smoking habits. There are four categories of smoking habits based on the scores from 11 questions, with total scores ranging from 0 to 44. With dependence levels categorized as low (<12), moderate (12–22), high (23–33), and very high (>33). Respondents answer with a score of 0, indicating “not at all,” up to 4, indicating “always,” based on the given questions; (4) The Bleep Test is conducted by running back and forth (shuttle run) between two lines marked by cones placed 20 meters apart. When the “beep” sound is heard from the audio, participants must run from the starting cone to the second cone. When the next “beep” sounds, participants run back from the second cone to the starting cone. This is repeated continuously until the participant stops at a certain level. The test ends when the “beep” sounds but the participant has not yet reached the cone; (5) The researcher collects and processes the data, then performs statistical tests, and finally analyzes the results to draw conclusions.

## Ethics

The study was submitted to the Health Research Ethics Committee of the Faculty of Dental Medicine, Universitas Airlangga. The ethical clearance certificate number is: 1188/HRECC.FODM/XII/2025.

## 3. Results

### General Characteristics of the Study Participants

| Characteristic | Mean | SD | Min | Max |
|---|---|---|---|---|
| **Age (years)** | 49.91 | 2.91 | 45 | 54 |
| 45 | 6 (12.77%) | | | |
| 46 | 4 (8.51%) | | | |
| 47 | 2 (4.26%) | | | |
| 48 | 5 (10.64%) | | | |
| 49 | 8 (17.02%) | | | |
| 50 | 3 (6.38%) | | | |
| 51 | 5 (10.64%) | | | |
| 52 | 5 (10.64%) | | | |
| 53 | 4 (8.51%) | | | |
| 54 | 5 (10.64%) | | | |
| **Smoking Duration (years)** | 33.66 | 2.72 | 28 | 39 |
| **Number of Cigarettes (sticks/day)** | 14.13 | 2.33 | 9 | 18 |
| **$VO_2$max (mL/kg/min)** | 21.87 | 1.56 | 19.15 | 24.57 |

The subjects of this study consisted of 47 participants who met the inclusion and exclusion criteria. General data on the study subjects showed that they were predominantly adult males who had been smoking for a long time and had a relatively high daily cigarette consumption. This condition has the potential to significantly impact health, particularly cardiorespiratory function.

### GNSBQ Questionnaire Results And Cardiorespiratory Capacity Outcomes

| GNSBQ Results | Frequency | Percentage | Mean *Bleep Test* | Mean $VO_2$max |
|---|---|---|---|---|
| 0–11 Low dependence | 9 | 19.1 % | 16.45 | 24.01 |
| 12–22 Moderate dependence | 9 | 19.1 % | 10.44 | 21.85 |
| 23–33 High dependence | 15 | 31.9 % | 9.85 | 21.66 |
| >33 Very high dependence | 14 | 29.8 % | 6.60 | 20.21 |

Based on the results of the Bleep Test (Total Shuttle) and $VO_2$max values, there is a tendency for decreased cardiorespiratory capacity with increasing levels of smoking dependence. In the low-dependence group, the average Bleep Test was 16.45 with a $VO_2$max of 24.01 ml/kgBW/minute. In the moderate-dependence group, the average Bleep Test decreased to 10.44 with a $VO_2$max of 21.85 ml/kgBW/minute. In the high-dependence group, the average Bleep Test was 9.85 and a $VO_2$max of 21.66 ml/kgBW/minute.

**Normality Test**

| Variable | Statistic | df | Significance |
|---|---|---|---|
| GNSBQ | 0.851 | 47 | 0.008 |
| $VO_2max$ | 0.949 | 47 | 0.040 |

Note: p > 0.05 indicates that the data are normally distributed.

The data above shows that the GNSBQ assessment results have a p-value of 0.008, and the VO2max measurement data has a p-value of 0.040. Based on these data, the test results show a significance value of p =<0.05, indicating that the GNSBQ assessment data and VO2max measurement data are not normally distributed.

**Correlation Test**

| | | GNSBQ | $VO_2max$ |
|---|---|---|---|
| **GNSBQ** | Correlation Coefficient | 1.000 | -0.322 |
| | Sig. (2-tailed) | . | 0.027 |
| **$VO_2max$** | Correlation Coefficient | -0.322 | 1.000 |
| | Sig. (2-tailed) | 0.027 | . |

Note: p < 0.05 indicates a statistically significant correlation.

The correlation analysis between smoking habits and cardiorespiratory capacity was conducted after the normality test. The correlation analysis in this study used the Spearman test because the data were not normally distributed. The results of the correlation test showed a Spearman correlation coefficient of -0.32, categorized as moderate. A negative sign indicates an inverse relationship between the two variables, meaning that the higher the smoking habit value, the lower the cardiorespiratory capacity value. From these data, it can be concluded that there is a relationship between smoking habits and cardiorespiratory capacity. The significance value or Sig. (2-tailed) is 0.027 with a p-value <0.05, indicating a significant relationship between smoking habits and cardiorespiratory capacity.

## 4. Discussion

Sit to stand exercise in elderly, can increase the muscle mass and strength of lower limbs, as well as it also affects the neural system which propioceptive function is improved. The information is delivered to the sensory system and it is processed and transferred to the motoric system (Nugraha et al., 2016). The balance control obtained by the synergic function of sensory and motor systems. It stimulates activation of the muscle spindle and golgi tendon organ (GTO) to improve the motor control.

Frequently do this exercise give an impact to the body, as muscle contraction, motor unit recruitment, and coordination improving which be the main factor to increase the muscle mass and strength. Thus, the lower limb muscle strengths improve, the motor control to maintain balance also improve (Swandari, Nurmawan dan Sundari 2016).

Based on this study, sit to stand exercise has large effect to the dynamic balance in elderly, with d value is 1,38 (large effect >0.8). this is in-line with the previous study, that sit to stand exercise give significant effect to lower limb muscles strength, balance, and gait performance (Hyun, Lee Jin & Lee Byoung, 2021).

According to Fujita et.al (2019) sit to stand exercise 3 times a week in 4 weeks period, improves the knee extensor muscles and gets better performance. They measured the muscle strength using Electromyography, in quadriceps femoris, the strength is increased 19,4%. Thus, this exercise has a same effect in the strengthening program with high intensity.

Lower limb muscles, especially quadriceps femoris, has a vital function in maintaining balance. It helps control the stability and the center of gravity (CoG) keep inside the base of support (BoS) (Yılmaz et al., 2023). As its strength is increased, the motor control improved, and the balance is getting better.

### Research Limitations

This research focusing in balance and lower limb muscles, without consider other factors that influence the balance, such as physical activity.

### Directions for Future Research

Future study should concern with some factors that affecting balance in elderly, includes physical activity and comorbidity to get the comprehensive analysis.

## 5. Conclusions

The conclusion that can be drawn from this study is that there is a relationship between smoking habits and cardiorespiratory fitness ($VO_2max$) in adult males.

### Conflict of Interest

The authors declare no conflict of interest.

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