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A comparative study of Vo_2 max among passive smokers and smokeless tobacco users in Northern Gujarat

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Abstract:
Maximal oxygen consumption (VO_2 max) is regarded as the benchmark for muscular and cardiovascular fitness. Therefore, it is of interest to evaluate the effects on VO_2 max among tobacco users and passive smokers. In India, tobacco is used in a wide range of smokeless forms and chewing is done in a variety of ways. Exposure to passive smoking is linked with various health effects in non-smoking individuals. This study comprised two groups with 100 male subjects. Anthropometric measurements and test parameters (VO_2 Max) were done as per the standard procedures. The study found that VO_2 max values were significantly reduced in passive smokers (P value 0.0036). In passive smokers, BMI showed a moderate inverse correlation with VO_2 max ($r = -0.490$). A negative correlation was observed between BSA and VO_2 max ($r = -0.501$), and it was statistically significant ($p < 0.001$) in passive smokers. Thus, data shows that VO_2 max was significantly decreased in passive smokers compared to smokeless tobacco users (SLT).

Keywords: VO_2 max, smokeless tobacco users, passive smokers

Background:
Physical fitness is defined as the ability to do a physical task in a variety of environmental circumstances. Aerobic capability, muscular endurance, flexibility and body composition are its five constituent parts. Maximal oxygen consumption also known as VO_2 max is regarded as the benchmark for muscular and cardiovascular fitness. The highest rate of oxygen intake possible during maximal or exhausting exertion is known as maximal oxygen absorption, or VO_2 max **[1]**. The VO_2 max is basically affected by physical training, gender, genetic factors, gender, body composition and age **[2, 3]**. In a scientific setting, maximum oxygen consumption can be determined by open circuit spirometry. A controlled exercise routine combined with a range of submaximal or maximal indirect tests can be employed when the direct technique is impractical. Moreover, non-exercise techniques like the Queen's College Step Test can be used to determine maximal oxygen utilization (VO_2 max). According to the World Adult Tobacco Survey India report, a significant portion of Indian men and women over the age of 15 use smokeless tobacco. In India, tobacco is used in a wide range of smokeless forms and chewing is done in various ways. Typically, tobacco is chewed in combination with additional components like lime, betel leaf, nut and tobacco. Cooked tobacco flakes combined with hydrated lime make up khaini **[4, 5]**. Studies have shown that the use of smokeless tobacco is linked to the development of peripheral vascular disease, hypertension, gastric ulcers, cardiovascular disease and fetal mortality. Only a few research studies have studied the effects of smokeless tobacco on cardiovascular and respiratory functions. Smoking affects the response to the cardiopulmonary exercise tests. Exposure to passive smoking is linked with various health effects in non-smoking individuals such as COPD, lung cancer, bronchial asthma and heart disease **[6]**. The quantity of tobacco smoke that is breathed by (active) smokers and originates from the burning of tobacco products like cigarettes or cigars. The quantity and concentration of smoke in a closed space varies according to the number of smokers who are actively involved in the habit as well as the kind of smoking, proximity to the smokers, room size and ventilation. When compared to active smoking, passive smoking, or ETS, seems to include the majority of tobacco combustion byproducts, including irritants and chemicals that cause cancer **[7, 8]**. The smoking habit lowers one's VO_2 max. Numerous studies demonstrate the detrimental effects of active and passive smoking on VO_2 max **[9, 10]**. Therefore, it is of interest to investigate the effects of passive (cigarette) smoking and smokeless tobacco chewing among young people.

Materials and Methods:
The present study was a cross-sectional study conducted in the Department of Physiology, Nootan Medical College & Research Centre, Visnagar. This study comprises two groups, which contain 100 male subjects. 50 non-smokers who chew tobacco for at least five grams per day who have never been passive smoker

and who are between the ages of 20 and 40 were included in group A, 50 matched age non-smokers who lived with at least one smoker (cigarette and bidi smokers) or frequently interacted with smokers at work for at least three years before to the study was included in group B. Subjects with acute or chronic diseases like diabetes, cardiac diseases, smoking, alcoholism, Bronchial asthma and Hypertension were excluded. Only male subjects were included in both groups. The experiments followed the amended Helsinki Declaration of 1975, revised in 2013. A convenient non-random sampling method was used to select participants. The study duration was six months. The present study was approved by the institutional ethics committee (Approval No: IEC/NMCRC/APPROVAL/26/2023) and informed consent was taken from all the subjects after explaining the test procedures and the goal of the study in the local language (Gujarati). Anthropometric measurements and test parameters were done as per the standard procedure.

Parameters chosen for this study are:
Anthropometric measurements:
Height, weight, body mass index (BMI), body surface area (BSA)

Test parameters: VO2 max (Maximal oxygen utilization)

Study procedure:
The subject's clinical history was taken, including pertinent historical events, family history, drug history and personal history like smoking, drinking, *etc*. A standardized questionnaire was given to subjects to obtain information about their history of passive smoking, smokeless tobacco consumption, past or present health issues *etc*. Anthropometric measurements were recorded for each subject **[10, 11]**. The weight was recorded on a weighing scale with standard minimum clothing to the nearest 0.5kg. A vertical scale was used to measure height, with the head in the Frankfurt plane and the heel, buttocks and occiput against the wall, all to the nearest 0.5 cm. All individual's body surface area (BSA) and body mass index (BMI) were calculated using the formula below: BSA (m2) = (Body Height in cm) 0.725 × (Body Weight in kg) 0.425 × 0.007184, BMI = Weight (kg) and Height (m^2) **[12].**

VO_2 max:
At the end, maximal oxygen consumption (VO_2 Max) was estimated (after 10 minutes rest) by Queen's College Step Test (QCT) method **[12]**. The step test was performed using a tool of 16.25 inches in height. Stepping was done for 3 minutes at the rate of 24 steps up per minute for males. The carotid pulse rate was recorded from the fifth to the twentieth seconds of the recovery time following the end of the exercise. The following equation determines the maximum oxygen consumption after converting the 15 second pulse rate into beats per minute. Formales: VO_2max=111.33–(0.42×pulse rate beats per min) (ml per kg per min) For females: VO_2 max = 65.81–(0.1847×pulse rate beats per min) (ml per kg per min) **[13].**

Statistical analysis:
Statistical analysis was done using SPSS software version 17 (Chicago, Inc., USA). Results were expressed as mean ± standard deviation (SD) and analyzed using unpaired Student't' test. 'p'-value of <0.05 was considered statistically significant. Karl Pearson's correlation test was used to analyze the correlation between BMI, BSA and VO_2 max among passive smokers.

Results:
A total of 100 male subjects participated in our study. Out of total 100 subjects, 50 were tobacco chewer (Smokeless tobacco) and represented group A, whereas the other 50 subjects were passive smokers and represented group B. Age-matched middle-aged male subjects were included in the present study. The mean age was 35.84 and 34.64 in SLT and passive smokers, respectively (p value 0.0509). The mean height was 172.37 and 172.24 in SLT and passive smokers, respectively (p value 0.8637). **Figure 1** depicts BMI values among SLT and Passive smokers. The mean BMI was 23.68 and 23.89 in SLT and passive smokers, respectively (p value 0.5745). **Figure 2** depicts BSA values among SLT and Passive smokers. The mean BSA was 1.84 and 1.83 in SLT and passive smokers respectively (p value 0.7191). Anthropological measures did not show any significant difference between SLT and passive smoking groups. BMI was slightly decreased in SLT group but it was not statistically significant. The mean VO_2 max was 43.54 and 43.26 in SLT and passive smokers, respectively (P value 0.0036). **Figure 3** depicts VO_2 max values among SLT and Passive smokers. VO_2 max values **(Table 1)** were significantly reduced in passive smokers when compared with SLT users. This difference was statistically significant. Karl Pearson's correlation test was used to analyze the correlation between BMI and VO_2 max in **Figure 4**. In the present analysis, BMI showed a moderate inverse correlation with VO_2 max ($r = -0.52$), indicating that higher BMI was associated with lower cardiorespiratory fitness. The scatter plot demonstrated a downward trend, with VO_2 max tending to decrease as BMI increased. **Figure 5** shows correlation results between BSA and VO_2 max among passive smokers. There is a moderate negative correlation between BSA and VO_2 max ($r = -0.501$). The association is statistically significant ($p < 0.001$).

Table 1: Comparison of vo2 max value among slt and passive smokers

Variable	SLT (Mean ± SD)	Passive smokers (Mean ± SD)	T Value	P Value
VO2 Max (ml/kg/min)	43.544± 0.437	43.269 ± 0.483	2.9854	0.0036 (S)

S – Significant

Discussion:
Passive smoke and tobacco use harm the cardio-pulmonary system. The development and progression of cardiac dysfunctions, such as coronary artery disease and endothelial dysfunction, have been linked to passive smoking as a substantial risk factor **[14, 15]**.

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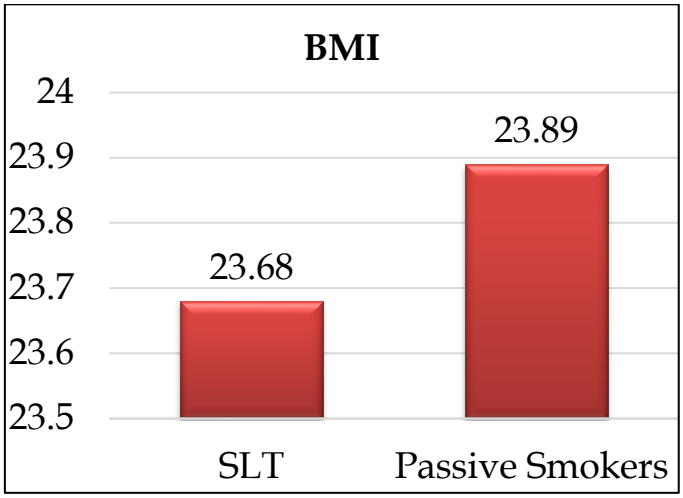


Figure 1: Data regarding body mass index (BMI) in SLT and passive smokers

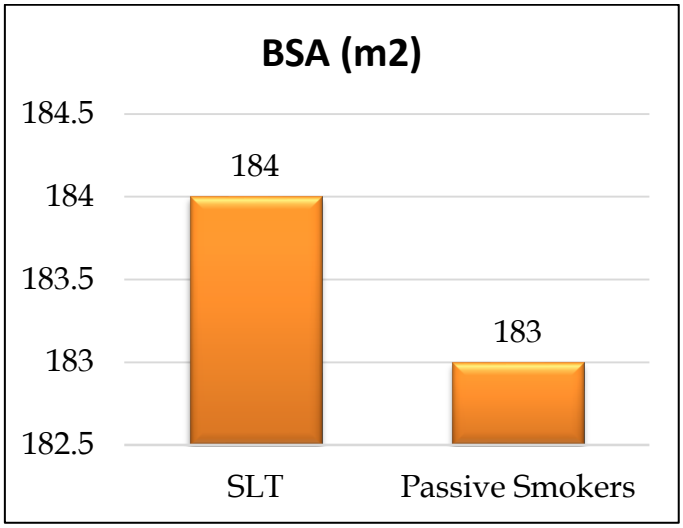


Figure 2: Data regarding body surface area (BSA) in SLT and passive smokers

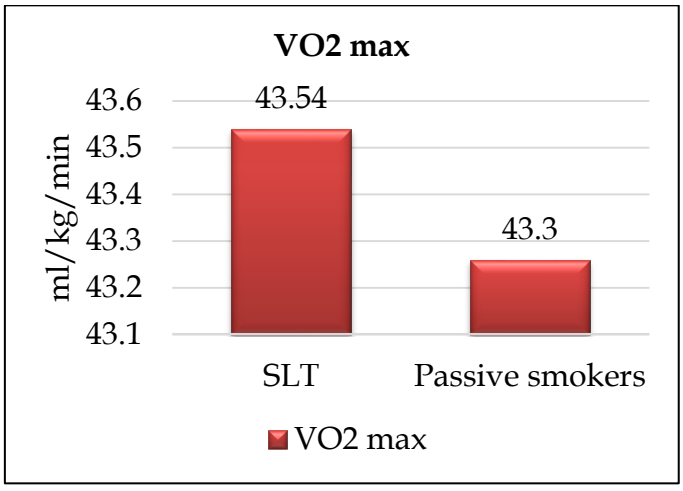


Figure 3: Comparison of VO2 max among SLT and passive smokers

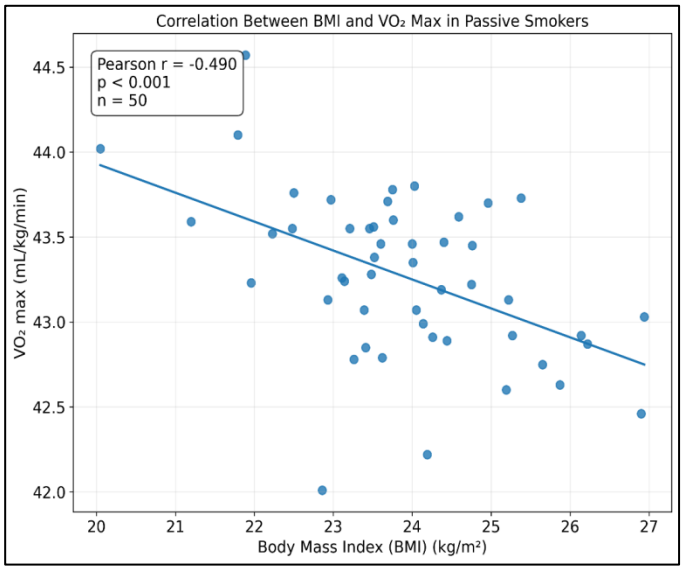


Figure 4: Correlation between BMI and VO2 max among passive smokers

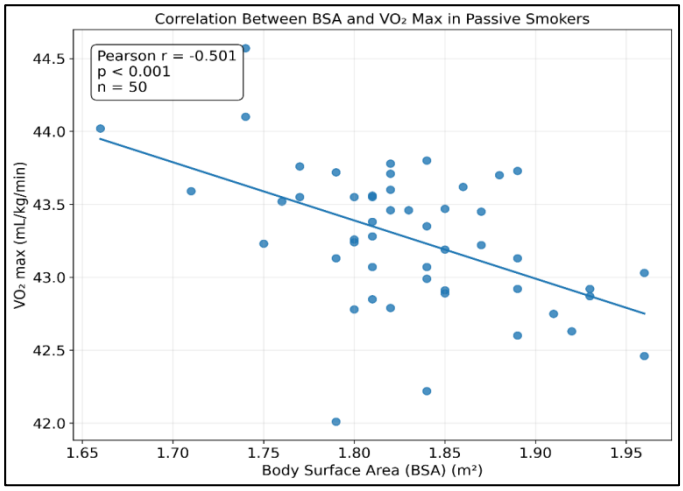


Figure 5: Correlation between BSA and VO2 max among passive smokers

There is a link between pulmonary function decline and passive smoking. However, there is limited information available regarding the impact of passive smoking on cardiorespiratory fitness compared to active smokers. On the other hand, not much is known about how passive smoking affects cardio-respiratory capacity **[16-19]**. Ren *et al.* **[20]** conducted the first study to assess cardiopulmonary hemodynamics and cardiopulmonary capacity in relation to the residual effects of passive smoking and found that passive smoking was linked to systemic arterial hypertension indicating vascular involvement. de Borba *et al.* **[21]** show that VO_2 max was significantly lower in active and passive smokers compared to non-smokers. In the

present study, we have studied VO_2 max among SLT and passive smokers and reported lower values in passive smokers compared to SLT. Passive tobacco smoke contains carbon monoxide (CO), which binds to haemoglobin and forms carboxyhaemoglobin. This reduces the blood's oxygen-carrying capacity and interferes with oxygen delivery to exercising tissues. During exercise, when oxygen demand increases, this impairment can contribute to a reduction in maximal oxygen uptake. The relatively slightly higher VO_2 max observed among SLT users compared with passive smokers may indicate that passive exposure to tobacco smoke has a greater impact on aerobic capacity than smokeless tobacco exposure. Smokeless tobacco users are exposed to nicotine and other tobacco constituents through the oral mucosa. Nicotine can produce sympathetic stimulation, tachycardia and vasoconstriction. However, because SLT does not involve combustion and inhalation of tobacco smoke, exposure to carbon monoxide and smoke-related respiratory irritants is substantially different from passive smoking. It needs detailed clarification in future study with a large number of populations. We could not be able to find articles related to our target group. A detailed study in the future is required on VO_2 max among passive smokers to get clarity. In the present study BMI showed a moderate inverse correlation with VO_2 max. This finding may be attributed to the increased metabolic and mechanical demands associated with greater body mass, which may adversely influence relative aerobic capacity. However, the relationship was not absolute, as considerable individual variation was observed around the regression line. This indicates that other factors, including age, physical activity, body composition and cardiovascular and respiratory fitness, may also contribute to variations in VO_2 max. Present study shows a moderate negative correlation between BSA and VO_2 max. Larger body size may be associated with a lower relative aerobic capacity when absolute oxygen consumption does not increase proportionately with body mass. In our study, passive smoking was taken to compare with SLT and noted significant differences. One study by Zhou *et al.* (2024) shows that Tobacco-dependent participants had significantly lowers cardiopulmonary function than controls. He conducted research among forty-five male tobacco-dependent college students with fort five non-tobacco-dependent college students **[22]**. According to Ernster *et al.* **[23]** smokeless tobacco use has a positive effect on cardiovascular risk factors in young, physically fit Men. It may be due to the quantity of gutkha usage and frequency. Only limited studies have reported the influence of smokeless tobacco (SLT) on VO_2 max. A study from Sweden reported that a higher possibility for cardiovascular mortality was observed among smokeless tobacco customers when compared with non-users **[24].** Shaik *et al.* reported that SLT users are at high cardiovascular risk due to oxidative damage in their research article **[25].** Studies done on gutka chewers show significantly increased heart rate and rapid heart rate variability (HRV) response to acute tobacco exposure, but this study doesn't show long-term exposure of gutka chewing **[26]**. These findings show that gutka chewing (SLT) affects the cardiac autonomic system. It might be due to short-term exposure to tobacco chewing and passive cigarette smoke or the living environment. To make a clear statement about these classifications, a large number of sample studies are necessary in the future.

Conclusion:

VO_2 max was significantly decreased in passive smokers compared to SLT. Consequently, it is determined that VO_2 max is the best measure of physical fitness and a significant factor in determining an individual's capacity to perform prolonged work. Among passive smokers, BSA showed a statistically significant moderate negative correlation with VO_2 max, indicating that higher BSA was associated with lower cardiorespiratory fitness as measured by VO_2 max.

Limitations:

The absence of a tobacco-free control group is an important limitation of the present study. Therefore, it was not possible to determine whether either passive smoking or SLT exposure was associated with reduced VO_2 max compared with an unexposed population. Another limitation of the present study includes a smaller number of male subjects. Female subjects were not included due to the scarcity of getting the expected sample. The present study doesn't contain other cardiac autonomic parameters. Further studies assessing complete cardiac autonomic parameters in a large number of sample sizes can be conducted in the future.

Declaration of conflict of interest: The authors declare that there is no conflict of interest

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