

Research Article

Comparison of Vital Signs and Oxygen Saturation Between Light Smokers and Heavy Smokers Among Engineering Students at Jambi University

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Abstract: Smoking remains a major public health concern, particularly among university students, as it can affect cardiovascular and respiratory physiological responses. This study aimed to compare vital signs and oxygen saturation between light smokers and heavy smokers among engineering students at Jambi University. This research used an analytic observational method with a cross-sectional approach conducted from February to August 2026. The population consisted of 1,713 engineering students, with a total sample of 104 respondents divided equally into light smokers (52) and heavy smokers (52). Data were collected through questionnaires and direct physiological measurements after a 20-meter shuttle run as standardized physical stress. Univariate and bivariate analyses were conducted using the Mann–Whitney test. The results showed that heavy smokers had higher mean systolic blood pressure (149.76 mmHg), diastolic blood pressure (99.07 mmHg), pulse rate (129.90 bpm), respiratory rate (27.13 breaths/min), and body temperature (37.45°C) compared to light smokers, while oxygen saturation was slightly lower (97.50%). Bivariate analysis indicated significant differences in all physiological variables ($p < 0.05$). In conclusion, smoking degree significantly affects vital signs and oxygen saturation after physical activity, with heavy smokers showing greater physiological responses and lower oxygen saturation.

Keywords: Engineering Students; Oxygen Saturation; Physiological Response; Smoking Degree; Vital Signs

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1. Introduction

Smoking has long been a major concern in global public health, as tobacco consumption continues to be one of the leading contributors to mortality worldwide (Organization, 2023). Despite extensive health campaigns and awareness programs regarding the dangers of smoking, the prevalence of smokers in Indonesia remains relatively high, particularly among young people. According to the latest data from the Indonesian Health Survey (Survei Kesehatan Indonesia/SKI) by the Ministry of Health in 2023, the number of active smokers in Indonesia is estimated to reach 70 million people, with 56.5% belonging to the 15–19 age group (Indonesia, 2024). Data from the Global Adult Tobacco Survey (GATS) further indicates that smoking prevalence among individuals aged 15–24 years in Indonesia reaches 27.9% (Wardiah et al., 2023). Previous research conducted in Jambi City also reported that 100% of smokers were aged 18 years and above (Wardiah et al., 2023). These findings demonstrate that smoking remains a significant public health issue among young populations in Indonesia.

This smoking behavior is not only found in the general population but is also prevalent among university students, particularly those studying in academic environments characterized by high academic pressure. In principle, higher levels of education are expected to correlate with lower smoking behavior and better health practices, as education is generally

associated with improved healthy behavior and awareness of health risks. Previous studies have suggested that higher educational attainment should be directly proportional to an individual's health behavior, meaning that individuals with higher education levels are expected to demonstrate healthier lifestyles (Van den Broucke S, Rademakers J, 2014). However, this expectation does not always align with reality, particularly among university students in technical disciplines.

Engineering students, in particular, have been reported to exhibit relatively poor healthy behavior related to smoking. Previous studies indicate that engineering students show a higher smoking prevalence compared to students from other faculties, which may be influenced by the dominance of male students in engineering programs. According to estimates by global health organizations, approximately 50% of men and 8% of women in developing countries are smokers, with tobacco consumption being more widely practiced among men.⁵ A recent systematic mapping study in Asia also revealed that participation and engagement in engineering education and research are predominantly dominated by male students, further reinforcing the demographic pattern associated with higher smoking prevalence in engineering faculties (Programme, 2024).

Poor healthy behavior among university students can lead to a decline in quality of life and an increased risk of health problems at a young age, which may ultimately accelerate the development of chronic diseases and increase the risk of premature mortality. Physiological changes caused by smoking are often reflected early through alterations in vital signs, as smoking directly affects blood pressure, pulse rate, body temperature, and respiratory rate. These vital signs serve as important indicators of an individual's physiological condition and can provide early warning signals of potential health disturbances.

Previous studies have shown that smoking significantly increases blood pressure, heart rate, and sympathetic nerve activity, indicating a substantial impact on the cardiovascular system (Dimitriadis et al., 2022). Continuous smoking behavior has been proven to increase the risk of hypertension and cardiovascular disorders, highlighting the importance of monitoring physiological indicators among smokers. Therefore, the measurement of vital signs plays a crucial role in assessing the basic physiological condition of individuals, particularly among smokers, as changes in these parameters often serve as early indicators of more serious health problems.

Furthermore, previous research has emphasized that the degree of smoking plays a critical role in influencing the physiological condition of smokers. Students who smoke heavily and over a longer duration tend to experience more pronounced cardiovascular and respiratory disorders compared to light smokers (Project, 2018). However, studies specifically comparing vital signs based on the severity of smoking behavior, particularly between light and heavy smokers among engineering students, remain limited. Understanding the differences in vital signs and oxygen saturation between light and heavy smokers is essential to assess the extent to which smoking affects the health condition of engineering students, who often face high academic stress and unhealthy lifestyle patterns. Based on this background, this study aims to analyze the differences in vital signs and oxygen saturation between light and heavy smokers among engineering students at Jambi University to better understand the impact of smoking on the health of young adults in Indonesia.

2. Materials and Method

Research Design

This study employed an observational analytic research design using a cross-sectional approach, in which measurements were conducted only once at a single point in time within a defined population. The cross-sectional design was chosen to compare vital signs and oxygen saturation between light and heavy smokers among engineering students at Jambi University.

Study Location and Period

This research was conducted among engineering students at the Faculty of Science and Technology, Jambi University. The study was carried out from February 2026 to August 2026, covering the preparation, data collection, and analysis stages.

Materials and Samples

The coconut husk used in this study was obtained from mature coconuts of a local tall variety (green coconut) collected from community-owned coconut plantations in Manulai 2

Subdistrict, Alak District, Kupang City, East Nusa Tenggara, Indonesia. The bacterial test strain used was *Escherichia coli* ATCC 25922, obtained from the Center for Health Laboratory (Balai Besar Laboratorium Kesehatan), Surabaya. Chloramphenicol was used as the positive control in the antibacterial assay, while sterile distilled water served as the negative control.

Population and Sample

The population of this study consisted of all engineering students at the Faculty of Science and Technology, Jambi University, totaling 1,713 students. The minimum sample size was determined using the Slovin formula with a 10% error tolerance, resulting in 104 respondents after adding a 10% reserve to anticipate potential dropouts. The sample was divided into two groups, namely light smokers and heavy smokers, with a minimum of 52 students in each group. The sampling technique applied was total sampling, while proportional stratified sampling assisted by statistical software was used to ensure proportional distribution of respondents across seven engineering study programs.

Intervention Procedure

The intervention in this study involved a 20-meter shuttle run to assess differences in cardiorespiratory system adaptation between light and heavy smokers. The shuttle run is an agility exercise that emphasizes rapid and precise directional changes through repeated back-and-forth running movements over a 20-meter distance. Participants were required to run as fast as possible between two points separated by 20 meters and immediately change direction upon reaching each point.

Vital signs and oxygen saturation were measured after participants completed the 20-meter shuttle run as a standardized form of physical stress. The study focused on comparing physiological responses between light and heavy smokers; therefore, the analysis emphasized post-activity vital sign measurements.

Inclusion and Exclusion Criteria

The inclusion criteria of this study were active engineering students at Jambi University aged 18–25 years who were willing to participate as respondents. The exclusion criteria included students who were absent during the measurement session, experienced fever, shortness of breath, or severe cough at the time of measurement, had lower limb injuries, or were professional athletes.

Research Variables

The independent variable in this study was the degree of smoking, classified based on the number of cigarettes consumed per day, while the dependent variables included oxygen saturation and vital signs, namely blood pressure, pulse rate, respiratory rate, and body temperature.

Operational Definition of Variables

The degree of smoking was defined as the number of cigarettes consumed per day and classified according to GATS and WHO criteria into light smokers (1–9 cigarettes per day) and heavy smokers (>20 cigarettes per day) using an ordinal scale. Blood pressure was measured in mmHg using a digital sphygmomanometer in a seated resting position and recorded as systolic and diastolic pressure on a ratio scale. Pulse rate was measured using a digital pulse oximeter and recorded in beats per minute on a ratio scale. Respiratory rate was measured by observing chest movements for one minute after physical activity and recorded in breaths per minute on a ratio scale. Body temperature was measured in degrees Celsius using a digital thermometer on the forehead after activity and recorded on a ratio scale. Oxygen saturation (SpO₂) was measured using a digital pulse oximeter on the finger and recorded as a percentage on a ratio scale.

Research Instruments

The instruments used in this study included an online form and vital sign measurement tools. The online form contained respondent consent and smoking behavior data, including the number of cigarettes consumed per day. The vital sign measurement instruments included a digital thermometer, digital sphygmomanometer, and pulse oximeter.

Data Collection Procedure

Data collection was conducted in two stages: online form completion and direct measurement of vital signs. In the first stage, respondents completed an online form to report the number of cigarettes consumed per day, which was used to classify smoking degree into light and heavy smoker categories.

In the second stage, direct measurements were conducted, including blood pressure measured using a digital sphygmomanometer, pulse rate measured manually or using a digital

device, respiratory rate measured through direct observation for one minute, body temperature measured using a digital thermometer, and oxygen saturation measured using a pulse oximeter. All measurement procedures followed standardized vital sign assessment protocols and adhered to research ethics principles.

Data Processing and Analysis

The collected data were processed through several stages, including editing, coding, data entry, tabulation, and data cleaning to ensure completeness, consistency, and accuracy of the data before analysis. Data analysis was conducted in three stages: univariate analysis to describe the characteristics of each variable using mean, standard deviation, minimum, and maximum values; normality testing using the Kolmogorov–Smirnov test due to the sample size being greater than 50; and bivariate analysis to compare vital signs and oxygen saturation between light and heavy smokers using the Independent T-test for normally distributed data and the Mann–Whitney test for non-normally distributed data.

Research Ethics

This study prioritized ethical considerations by obtaining informed consent from all respondents before data collection. Respondents were provided with clear explanations regarding the research objectives and were given full freedom to participate voluntarily without coercion (autonomy). Respondent identity was kept anonymous by using non-identifiable initials (anonymity). All collected data were kept confidential and used solely for research purposes (confidentiality), ensuring that personal information was not disclosed or used outside the scope of this study.

3. Results and Discussion

Research Results

Univariate Analysis Results

Table 1. Distribution of Respondent Characteristics.

Degree of Smoking	Number of Respondents	%
Lightweight	52	50
Weight	52	50
Total	104	100

Based on Table 1, the total number of respondents in this study was 104, consisting of 52 light smokers (50%) and 52 heavy smokers (50%). The distribution of respondents across the two groups indicates a balanced proportion between light smokers and heavy smokers.

Table 2. Distribution of Respondents' Physiological Variables.

Variabel	Mean Light Smoker	Mean Heavy Smoker
Sistolic (mmHg)	139,69	149,76
Diastolic (mmHg)	85,38	99,07
Pulse Rate (bpm)	107,46	129,90
Breathing Rate (x/min)	23,05	27,13
Temperature (°C)	36,94	37,45
Oxygen Saturation (%)	98,01	97,50

Based on Table 2, the results generally show the mean physiological responses of students after performing the 20-meter shuttle run based on the degree of smoking. Overall, heavy smokers exhibited higher mean values of systolic blood pressure, diastolic blood pressure, pulse rate, respiratory rate, and body temperature compared to light smokers. Meanwhile, the mean oxygen saturation among heavy smokers was slightly lower than that of light smokers. These differences indicate a greater hemodynamic and respiratory response in the heavy smoker group following light physical activity.

Bivariate Analysis Results**Table 3.** Bivariate Analysis Results Using the Mann–Whitney Test.

Variabel	Mean Rank Light Smoker	Mean Rank Heavy Smoker	p- value	Remarks
Sistolik Post	44,94	60,06	0,011	Significant
Diastolic Post	38,27	66,73	<0.001	Significant
Post Pulse	37,65	67,35	<0.001	Significant
Post Breathing Frequency	39,11	65,89	<0.001	Significant
Post Temperature	41,01	63,99	<0.001	Significant
Oxygen Saturation Post	62,00	43,00	<0.001	Significant

Based of Table 3, the results of the bivariate analysis using the Mann–Whitney test showed that post-activity systolic blood pressure demonstrated a significant difference ($p = 0.011$). Meanwhile, post-activity diastolic blood pressure ($p < 0.001$), pulse rate ($p < 0.001$), respiratory rate ($p < 0.001$), body temperature ($p < 0.001$), and oxygen saturation ($p < 0.001$) also showed highly significant differences between the two groups.

Discussion**Comparison of Blood Pressure Between Light Smokers and Heavy Smokers**

The results of this study showed a significant difference in post-activity systolic and diastolic blood pressure after the 20-meter shuttle run between light smokers and heavy smokers. The Mann–Whitney test indicated $p = 0.011$ for systolic blood pressure and $p < 0.001$ for diastolic blood pressure, with higher mean ranks in the heavy smoker group. Descriptively, the average systolic blood pressure in heavy smokers (149.76 mmHg) was higher than in light smokers (139.69 mmHg), as was diastolic blood pressure (99.07 mmHg vs 85.38 mmHg), indicating a greater hemodynamic response in heavy smokers after physical activity.

These findings are consistent with Jareebi MA et al. (2024), who reported that numerous observational studies consistently demonstrate an association between smoking behavior and hypertension risk. Similarly, Rahmawati Mamile et al. (2024) found that smoking increases heart rate and causes vasoconstriction, leading to elevated blood pressure (Mamile et al., 2024). Frequent nicotine exposure in heavy smokers repeatedly stimulates the sympathetic nervous system, increasing norepinephrine release and activating α -adrenergic receptors, which leads to vasoconstriction and increased blood pressure (Menshov et al., 2022). Therefore, a higher degree of smoking is associated with higher systolic and diastolic blood pressure due to repeated nicotine exposure and increased cardiovascular burden (Jareebi, 2024).

Recent research by Khudhur ZO (2025) further supports this mechanism by showing that smoking increases serum interleukin-8 and endothelin-1 levels, which induce inflammation and vasoconstriction, along with elevated neutrophil and oxidative stress markers. These findings indicate systemic inflammation and vascular dysfunction in smokers, contributing to endothelial dysfunction and arterial stiffness that lead to increased blood pressure. Similar evidence was reported by Nusa and Widyastiti (2016) and Gumus et al. (2018), who found higher neutrophil–lymphocyte ratio (NLR) values in smokers, reflecting systemic inflammation (Gumus et al., 2018; Nusa & Widyastiti, 2016).

The relationship between inflammation and blood pressure is strengthened by the meta-analysis conducted by Sarejloo et al. (2023), which demonstrated that individuals with hypertension have significantly higher NLR values than normotensive individuals, indicating the role of systemic inflammation in endothelial dysfunction and arterial stiffness (Sarejloo et al., 2023). In the context of physical activity, individuals with normal vascular function experience controlled physiological increases in blood pressure, whereas heavy smokers tend to experience higher post-activity blood pressure due to impaired vasodilation and increased peripheral vascular resistance.

Overall, this study supports empirical evidence that the degree of smoking contributes to increased blood pressure both at rest and after physical activity. Heavy smokers exhibited higher post-activity blood pressure than light smokers, indicating suboptimal cardiovascular adaptation and a greater potential risk of long-term cardiovascular complications.

Comparison of Pulse Rate Between Light Smokers and Heavy Smokers

The results of this study showed a significant difference in post-activity pulse rate after the 20-meter shuttle run between light smokers and heavy smokers. The Mann–Whitney test indicated $p < 0.001$, with higher mean rank values in the heavy smoker group. Descriptively, the average pulse rate in heavy smokers (129.90 bpm) was higher than in light smokers (107.46 bpm), indicating a greater cardiac response to physical activity among heavy smokers.

These findings are consistent with Rahmawati Mamile et al. (2024), who reported that smoking increases heart rate due to nicotine-induced catecholamine release, leading to myocardial irritability and increased pulse rate (Mamile et al., 2024). Physiologically, nicotine stimulates the sympathetic nervous system by increasing norepinephrine release, which interacts with β -adrenergic receptors in the heart and results in increased heart rate and cardiac contractility (Irfan et al., 2021; Menshov et al., 2022). This mechanism explains the higher pulse rate observed in heavy smokers after physical activity.

In addition, carbon monoxide in cigarette smoke binds to hemoglobin to form carboxyhemoglobin (COHb), reducing the oxygen-carrying capacity of the blood and causing relative tissue hypoxia. This condition triggers compensatory mechanisms, including increased heart rate, to maintain adequate oxygen supply to body tissues (Ina et al., 2024). Such physiological adaptations contribute to the higher pulse rate observed in heavy smokers following shuttle run activity.

Supporting evidence from Son YJ et al. (2020) indicates that smoking is associated with poor health status, ventricular tachycardia, arterial stiffness, and increased supraventricular ectopic activity due to increased sympathetic tone and reduced parasympathetic activity in the cardiac conduction system (Ramakrishnan et al., 2013; Son & Lee, 2020). These conditions further explain the excessive cardiac response observed in heavy smokers under physical stress.

Overall, this study supports empirical evidence that a higher degree of smoking leads to a greater pulse rate response to physical activity. Heavy smokers experience increased cardiovascular workload due to sympathetic overstimulation, relative hypoxia, and reduced cardiorespiratory efficiency, which may increase the risk of long-term cardiovascular disorders.

Comparison of Respiratory Rate Between Light Smokers and Heavy Smokers

The results of this study showed a significant difference in post-activity respiratory rate after the 20-meter shuttle run between light smokers and heavy smokers ($p < 0.001$). The mean rank of respiratory rate in the heavy smoker group was higher than that of light smokers, with the average respiratory rate in heavy smokers (27.13 breaths/min) exceeding that of light smokers (23.05 breaths/min). These findings indicate a greater ventilatory response to physical activity among heavy smokers.

This result is consistent with Mersiana PF et al. (2026), who reported that smoking habits are associated with decreased lung vital capacity, leading to increased respiratory rate as a compensatory mechanism after physical activity (Mersiana et al., 2026). Chronic exposure to cigarette smoke causes airway inflammation, mucus overproduction, ciliary dysfunction, and alveolar damage, which reduce gas exchange efficiency and impair lung function. Such conditions contribute to higher respiratory rates in heavy smokers as the body attempts to maintain adequate oxygenation.

Further evidence shows that cigarette smoke damages lung elastic tissue and mucociliary clearance, reducing lung elasticity and increasing ventilatory resistance, which leads to decreased pulmonary function (Mersiana et al., 2026). Reduced vital capacity reflects impaired ventilation and gas exchange efficiency, requiring higher respiratory rates to meet metabolic demands (Pradana et al., 2024). These findings support the observation that heavy smokers experience greater respiratory impairment compared to light smokers.

In addition, carbon monoxide in cigarette smoke binds to hemoglobin to form carboxyhemoglobin, reducing oxygen transport capacity. Hilyah RA (2021) reported a significant correlation between smoking habits and carbon monoxide levels, with higher cigarette consumption associated with increased CO levels (Hilyah et al., 2021). This condition triggers compensatory increases in respiratory rate, particularly after physical activity, when oxygen demand rises and efficient ventilation is required.

Overall, this study demonstrates that heavy smokers exhibit a greater ventilatory response to physical activity than light smokers. The higher respiratory rate observed in heavy smokers indicates reduced respiratory efficiency and the need for greater ventilatory compensation to maintain oxygen balance under physical stress.

Comparison of Body Temperature Between Light Smokers and Heavy Smokers

The results of this study showed a significant difference in post-activity body temperature after the 20-meter shuttle run between light smokers and heavy smokers ($p < 0.001$). The mean rank of body temperature in the heavy smoker group was higher than in light smokers, with the average body temperature of heavy smokers (37.45°C) exceeding that of light smokers (36.94°C). These findings indicate that the increase in body temperature after physical activity is greater in individuals with a higher degree of smoking.

This finding is consistent with Cahyani KIS et al. (2020), who reported increased serum interleukin-6 (IL-6) levels in active smokers, which are associated with elevated body temperature (Kis et al., 2020). Experimental studies in animal models have also shown that intravenous or intracerebroventricular administration of IL-6 leads to increased body temperature, supporting the role of inflammatory mediators in thermoregulation (Grebenciucova & VanHaerents, 2023).

The higher body temperature observed in heavy smokers can also be explained by the effect of nicotine on the autonomic nervous system. Nicotine stimulates sympathetic activation and catecholamine release, increasing heart rate, blood pressure, and basal metabolic rate, which contributes to thermogenesis. During physical activity such as the 20-meter shuttle run, metabolic demand increases, leading to greater heat production, particularly in heavy smokers with higher sympathetic activity (Bujawati et al., 2024).

Overall, this study demonstrates that heavy smokers experience a greater increase in body temperature than light smokers after physical activity. This finding suggests that smoking degree affects thermoregulatory responses, as heavy smokers tend to show higher heat production and less optimal heat dissipation mechanisms. The results reinforce evidence that smoking influences not only cardiovascular and respiratory systems but also the body's thermoregulatory response to physical stress.

Comparison of Oxygen Saturation Between Light Smokers and Heavy Smokers

The results of this study showed a significant difference in oxygen saturation (SpO_2) after the 20-meter shuttle run between light smokers and heavy smokers ($p < 0.001$). The mean rank of oxygen saturation in light smokers was higher than in heavy smokers, with the average SpO_2 in light smokers (98.01%) exceeding that of heavy smokers (97.50%). These findings indicate that heavy smokers experience a greater decline in oxygen saturation following physical activity compared to light smokers.

Physiologically, oxygen saturation reflects the percentage of hemoglobin bound to oxygen in peripheral circulation. During physical activity such as the 20-meter shuttle run, oxygen demand increases due to elevated muscle metabolism, requiring adaptive responses from the respiratory and cardiovascular systems through increased ventilation and cardiac output to maintain oxygen balance.

This finding is consistent with Tanzila RA (2022), which reported that longer smoking duration and higher cigarette consumption are associated with lower blood oxygen saturation levels in active smokers (Tanzila et al., 2022). Similarly, Hilyah RA (2021) found a significant relationship between smoking habits and carbon monoxide (CO) levels, where higher cigarette consumption and longer smoking duration correlated with increased CO levels (Hilyah et al., 2021). The greater reduction in oxygen saturation among heavy smokers can be explained by long-term exposure to CO, which has a 200–250 times stronger affinity for hemoglobin than oxygen, forming carboxyhemoglobin and reducing oxygen transport capacity.

This study extends previous findings by demonstrating that even within smoking groups, a higher degree of smoking is associated with a greater decline in oxygen saturation after physical activity. During the 20-meter shuttle run, increased oxygen demand combined with impaired ventilation and gas exchange in heavy smokers reduces their ability to maintain optimal oxygenation, although SpO_2 values remain within the normal clinical range.

Overall, the results indicate that the degree of smoking is closely related to the body's oxygenation response to physical activity. Greater smoking exposure is associated with a larger decrease in oxygen saturation, reinforcing evidence that long-term smoking negatively affects respiratory function, oxygen transport, and physiological adaptation to physical stress.

Research Limitations

This study employed a cross-sectional design, which only describes vital signs and oxygen saturation at a single point of measurement. Therefore, the findings cannot establish a causal relationship between the degree of smoking and changes in vital signs and oxygen saturation, but rather reflect associations observed at the time of assessment.

In addition, measurements of vital signs and oxygen saturation were conducted after a single session of physical activity. This approach limits the ability to capture long-term physiological responses or variations that may occur under different exercise intensities or repeated physical activity, which could provide a more comprehensive understanding of smokers' physiological adaptation.

Another limitation lies in the classification of smoking degree based on self-reported data. The categorization of light and heavy smokers relied on respondents' reports of their smoking habits, which may introduce information bias due to inaccuracies or subjectivity in reporting cigarette consumption and smoking duration.

Furthermore, variations in measurement instruments and environmental conditions may have influenced the results. Factors such as room temperature, humidity, and the sensitivity of measurement devices used to assess vital signs and body temperature could affect the accuracy of the recorded data, potentially contributing to measurement variability in the study.

4. Conclusion

Based on the results of this study on the comparison of physiological responses between light smokers and heavy smokers after performing a 20-meter shuttle run, several important conclusions can be drawn. First, there were significant differences in systolic and diastolic blood pressure between light smokers and heavy smokers after the shuttle run, with heavy smokers showing higher increases in blood pressure compared to light smokers. This finding indicates that the degree of smoking is associated with increased hemodynamic response following physical activity.

Second, significant differences were found in pulse rate and respiratory rate between light smokers and heavy smokers after physical activity, with heavy smokers demonstrating greater cardiovascular and respiratory responses. These results suggest that smoking behavior contributes to changes in cardiorespiratory function, particularly under conditions of physical stress induced by the 20-meter shuttle run.

Third, significant differences were also observed in body temperature between light smokers and heavy smokers after the shuttle run, where heavy smokers experienced a higher increase in body temperature. Additionally, oxygen saturation showed a significant difference between the two groups, with heavy smokers tending to experience a greater decrease in oxygen saturation compared to light smokers after physical activity.

Overall, the degree of smoking significantly influences physiological responses after a 20-meter shuttle run. Heavy smokers exhibited greater hemodynamic, respiratory, and thermoregulatory responses, along with a tendency toward decreased oxygen saturation compared to light smokers. These findings indicate that the higher the degree of smoking, the greater the physiological changes that occur after physical activity, highlighting the negative impact of smoking on the health of engineering students.

Therefore, students are encouraged to increase awareness of the harmful effects of smoking by reducing or quitting smoking habits and regularly monitoring their health, particularly vital signs, body temperature, and oxygen saturation as preventive measures against early health problems. Institutions are recommended to strengthen smoke-free campus policies and implement routine health education and screening programs to improve the health and quality of life of the academic community. Future researchers are advised to expand this study by using broader research designs, controlling confounding factors, and incorporating additional physiological parameters to obtain a more comprehensive understanding of the impact of smoking degree on physiological conditions.

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