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Original Article

Assessing Impact of Smoking on Skeletal Muscle Strength among Walter Sisulu University Students, Eastern Cape Province in South Africa

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Abstract

Background: Cigarette smoking is a risk factor which causes death in the whole world. Previous studies have focused more attention on the deleterious effects of smoking for high mortality diseases such as cancer and diseases of the cardiovascular and respiratory systems, with less research attention on other body systems such as the musculoskeletal system.

Aim of the study: Aim of this study was to investigate the effects of cigarette smoking on muscle strength among Walter Sisulu University students.

Methodology*:* Smoking and non-smoking male participants aged between 18 to 24 years were recruited, 30 smokers and 33 non-smokers in the study. Participants were asked to complete a questionnaire. Body composition was assessed using Omron BF 511 and muscle strength by hand Grip strength was measured using PowerLab 26T, connected to computer.

Results*:* Muscle strength as assessed by Endurance and dynamic time were significantly higher in non-smokers than smokers [28.4±9.3 vs 20.9±10.2; p=0.000963] and [26.8±9.5 vs 18.2±9.5, p=0.000301] respectively. Also, muscle percentage was significantly higher in non-smokers than smokers, [42.0[3.5] vs 37.5 [8.0]; p= 0.025].

Conclusion*:* muscle strength of the smokers group was lower than that of non-smokers among Walter Sisulu University students as assessed by hand grip dynamometer PowerLab 26T.

Keywords: Tobacco Smoking; Muscle Strength; Endurance Time; Dynamic time; Grip Strength.

INTRODUCTION

Smoking results to damage of most organs of the body and directly causes a number of diseases. Cigarette smoke is composed of more than 5000 chemicals or substances, evidence clearly demonstrates that most of these substances result in cardiovascular diseases such as coronary heart disease, respiratory diseases such as chronic obstructive pulmonary diseases [COPD], cancer and tobacco smoke could also lead to premature death [1]. The substances in cigarette smoke damage muscles directly and this could result in limited ability of people to exercise hence smoking leads to muscle weakness. Muscular strength and endurance are two important parts of the ability of the body to move. Muscular strength is how much force a person can put out or how much load a person can lift while muscular endurance is how long a person can put force without getting exhausted. Muscular strength and endurance are most important for many reasons; they make it possible for people to do activities like opening doors, they reduce the risk of injury, they help to keep a healthy body weight. Muscle strength can be assessed using hand grip dynamometer [2].

Globally, tobacco smoking was estimated at 22.1% and in Africa at 12.8% [3]. Recent surveys place tobacco smoking at 17.6% with men affected four-fold compared to woman [4]. Previous studies have focused more attention on the deleterious effects of smoking for high mortality diseases such as cancer and diseases of cardiovascular and respiratory systems, with less research attention on other body systems such as the musculoskeletal system [5].

Tobacco smoking is said to be the main cause of chronic obstructive pulmonary diseases [COPD], relatively little attention has been paid to its potential damage to muscles. Previous studies examined skeletal muscles of smokers in comparison with muscles of non-smokers and found structural and metabolic damage in skeletal muscles [6]. However, it is known that muscle weakness, declining muscle strength is associated with mortality, independent of physical activity and muscle mass [7]. Cigarette smoking is a risk factor which causes death in the whole world [8]. There is scarce information about effects of smoking on endurance or strength of the muscle. Therefore, the study seeks to assess effects of cigarette smoking on muscle strength and endurance.

METHODOLOGY

1. Study design

This work is a case-control study of 63 [30 smokers and 33 non-smokers] adults [≥18 years] male students at Walter Sisulu University during the period February 2019 to November 2019. Purposive sampling was used to recruit study participants, and selection was therefore based on population characteristics. Smoking participants who were exercising and those suffering from respiratory disorders and not smoking were excluded from the study. Questionnaire contained information such as age, number of cigarettes smoked per day, duration of smoking, diet and medication was used to obtain demographic data.

2. Anthropometric measurements

Height was measured using a stadiometer TCS-200-RT. Participants were instructed to remove shoes and bulky clothing. The back of the head, shoulder blades, buttocks, and heels had to touch the stadiometer. Small gap between legs, feet straight ahead and the ear canal had to be in the level with the cheek bone. Horizontal arm on the stadiometer was adjusted so that it rests on top of the head. The height was recorded to the nearest centimeter. Weight, body fat % and muscle % were measured using a digital scale, Orman [BF511]. Participants were asked to remove heavy outer garments, to take off the shoes and empty pockets. Participants were instructed to stand still in the center of the platform, 10 cm gap between the heels so for weight to be equally distributed on both legs. Weight was recorded in kilograms. Body Mass Index [BMI] was calculated using height and weight. BMI=weight/height^2.

3. Grip strength measurements

Grip strength was measured on hand by use of PowerLab 26T, which was connected to a computer. Grip force transducer was connected to input 1 of the power-lab and to the computer. Participants were instructed to sit upright with feet on the floor, hips as far back in the chair as possible and the hips and knees positioned at 90 degrees. The shoulder of the gripping arm was maintained in adduction, the elbow was flexed between 90 and 120 degrees. Then, the dynamometer was held with the index finger positioned at the top of the handle and the other fingers positioned at the handle band.

Participants were instructed to loosely grip the hand dynamometer in the fist. Start was clicked, participants were instructed to squeeze the dynamometer as hard as possible for a second or two and then relax. Stop was clicked. To calibrate for the strength of participant, trace at the time when the force was zero was clicked then point 1 button in the calibration panel was clicked so to set 0% grip force. Trace at peak force was clicked then point 2 buttons in the calibration panel was also clicked representing 100% of each participant's grip force. Calibration was done to measure 100% of maximally voluntary contraction for each participant.

Participants were instructed to perform dynamic or pump and endurance at 60% of their maximal voluntary contraction at a rate of metronome set at 70 b/ min until fatigue sets in, this was done using hand grip dynamometer. Participants were instructed to use hand grip dynamometer to produce gripping force without any movement at 60 % of their maximal voluntary contraction. Participants were allowed to perform the pumping while holding hand grip dynamometer till the time where they reach fatigue was recorded in seconds, secondly, they were instructed to hold dynamometer without pumping till they reach fatigue then time was recorded, in seconds.

4. Ethical consideration: Ethical approval was obtained from Walter Sisulu University ethics committee. The protocol No. is 058/2019. Participants were given information sheet and consent form to sign if they agreed to be part of the study.

5. Statistical analysis: Descriptive statistical analysis was performed using Statistica [TIBCO Software Inc.]. Normality of the distribution of the data was examined with the Shapiro-Wick W test. Data was expressed as mean ± SD for normally distributed data and as median [interquartile range] for non-normally distributed data. Students T-test was used when comparing means between smokers and non-smokers group. For non-normal distribution Kolmogorov-Smirnov test was used to compare case [smokers] and control [non-smokers]. The Spearman correlation was used to determine the relationship between variables in the groups. Differences were considered statistically significant at $p \leq 0.05$.

RESULTS

The study involved sixty-three male participants from Walter Sisulu University with age range of 18–24 years and they were divided into two groups: smoker [n=30] and non-smoker [n=33] groups. [See figure 1]. Table [1] shows the demographic data of the two study groups. Body mass index [BMI] for non-smokers was significantly higher than smokers [21.0[4.0] vs 18.5 [2.2]; p= 0.001]. As in Table [2], endurance and dynamic time were significantly higher in non-smokers than smokers [28.4±9.3 vs 20.9±10.2; p=0.000963] and [26.8±9.5 vs 18.2±9.5, p=0.000301] respectively. Also, muscle percentage was significantly higher in non-smokers than smokers, [42.0[3.5] vs 37.5 [8.0]; p= 0.025] but resting metabolic rate was significantly higher in smokers than non-smokers [1482.0[165] vs 1578.5[138]; p=0.01].

In non-smokers, there was significant positive correlation between age and each of dynamic and endurance. Similar correlation was reported between BI and dynamic in non-smokers [Table 3].

There was a significant and positive correlation [r=0.523; p= 0.003] between dynamic and endurance time of smokers as well as in non-smokers [r=0.573; p=0.00]. This is shown in Figure [2] below.

As shown in scatter diagram, figure [3] [A&B] below, there was a significant positive relationship [r=0.405; p=0.019] between resting metabolic rate and endurance of non-smokers but insignificant among smokers.

As shown in scatter diagram, figure 4 [A&B] below, there was a significant positive relationship [r=0.405; p=0.019] between age and dynamic of non-smokers but insignificant among smokers.

As shown in scatter diagram, figure 5 [A&B] below, there was a significant positive relationship [r=0.469; p=0.006] between age and endurance of non-smokers but insignificant negative relationship [r=-0.099; p=0.604] between age and endurance of smokers.

As shown in scatter diagram, figure 6 [A&B] below, there was insignificant positive relationship [r=0.253; p=0.156] between muscle percentage and endurance of non-smokers but there was insignificant negative relationship [r=-0.038; p=0.840] between muscle percentage and endurance of smokers group.

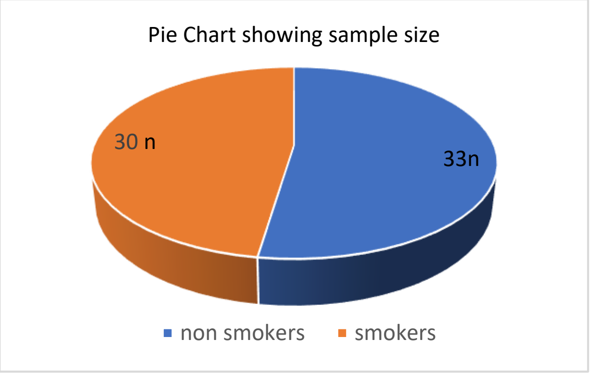


Figure [1]: Pie chart showing sample size, 30 smokers and 33 non-smokers

Table [1]: Demographic data of smokers and non-smokers.

Variables	Non-smokers	Smokers	P-value
Age [years]	23[2.0]	23[2.0]	0.100
Weight [kg]	167.0 [6.0]	57.9[10.0]	0.100
Height [cm]	167.7±4.4	167.7± 4.2	0.693
BMI [kg/h^2]	21.0 [4.0]	18.5 [2.2]	0.001*

Values of normal distribution are represented as mean± SD of mean and median [inter quartile range] for non-normal range, p≤0.05 is considered statistical significance. Statistical significance*. BMI- body mass index.

Table [2]: Body composition parameters, dynamic and endurance time of smokers and non-smokers.

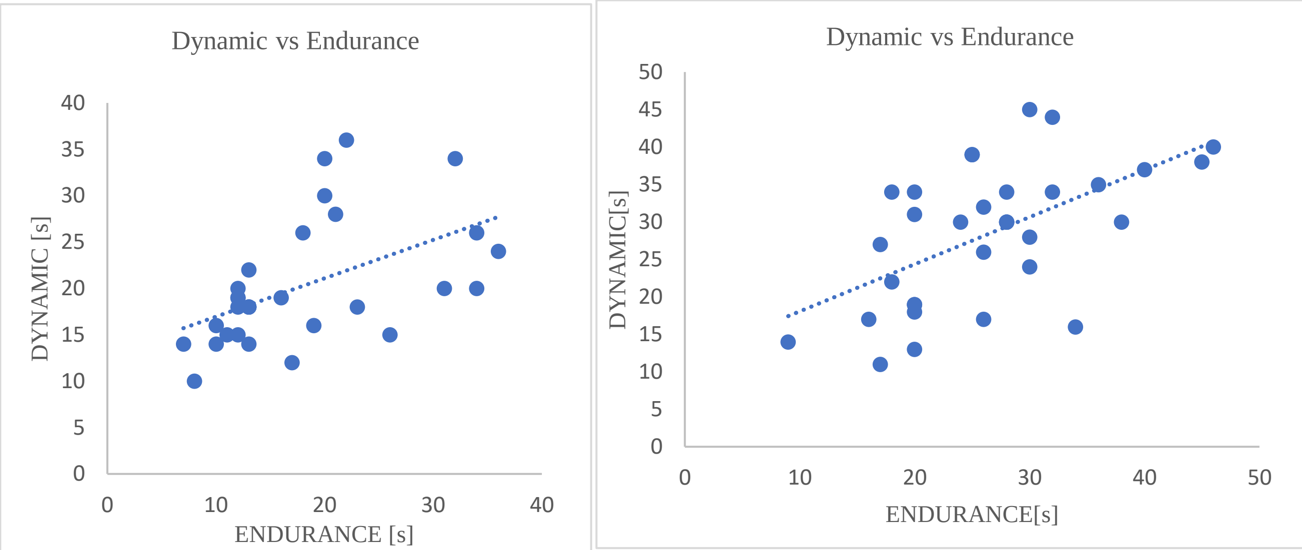
Variables of interest	Non-smokers	Smokers	P value
Body fat %	18.0 [8.6]	20.0 [4.3]	0.10
Muscle %	42.0 [3.5]	37.5 [8.0]	0.025*
RMR [Cal]	1482.0 [165]	1578.5 [138]	0.01*
Dynamic time [s]	26.8±9.5	18.2±9.5	0.000301*
Endurance time[s]	28.4±9.3	20.9±10.2	0.000963*

Values of normal distribution are represented as mean± SD of mean and median [inter quartile range] for non-normal range, p≤0.05 is considered statistical significance. Statistical significance*, RMR is resting metabolic rate, muscle%- percentage body muscle mass, body fat %-body fat percentage.

Table [3]: Correlation between body composition parameters with dynamic and endurance of smokers and non-smokers.

	NON-SMOKERS				SMOKERS			
	Dynamic		Endurance		Dynamic		Endurance	
Variables	R	P value	r	P value	r	P value	r	P value
Age [years]	**0.405**	**0.019***	**0.469**	**0.006***	0.012	0.950	-0.099	0.604
Weight [kg]	0.016	0.928	-0.024	0.895	0.110	0.564	0.194	0.305
Height [cm]	-0.271	0.127	-0.101	0.575	0.344	0.063	0.157	0.409
BMI [kg/h2]	0.444	0.010*	0.133	0.460	0.000	0.999	0.221	0.240
Body fat %	0.313	0.077	0.011	0.953	-0.078	0.681	0.255	0.175
Muscle %	0.41	0.821	0.253	0.156	0.065	0.733	-0.038	0.840
RMR[Cal/day]	0.530	0.002*	0.405	0.019*	0.096	0.614	0.140	0.462

Value r is Pearson correlation coefficient, value r=1 means a perfect positive correlation and value r=-1 means a perfect negative correlation. p≤0.05 is considered statistical significance. BMI is body mass index, RMR is resting metabolic rate. Muscle %- percentage body muscle mass, body fat %-body fat percentage.



A. Smokers B. Non-smokers

Figure [2]: Correlation of dynamic time [s] and endurance time [s] of smokers and non-smokers.

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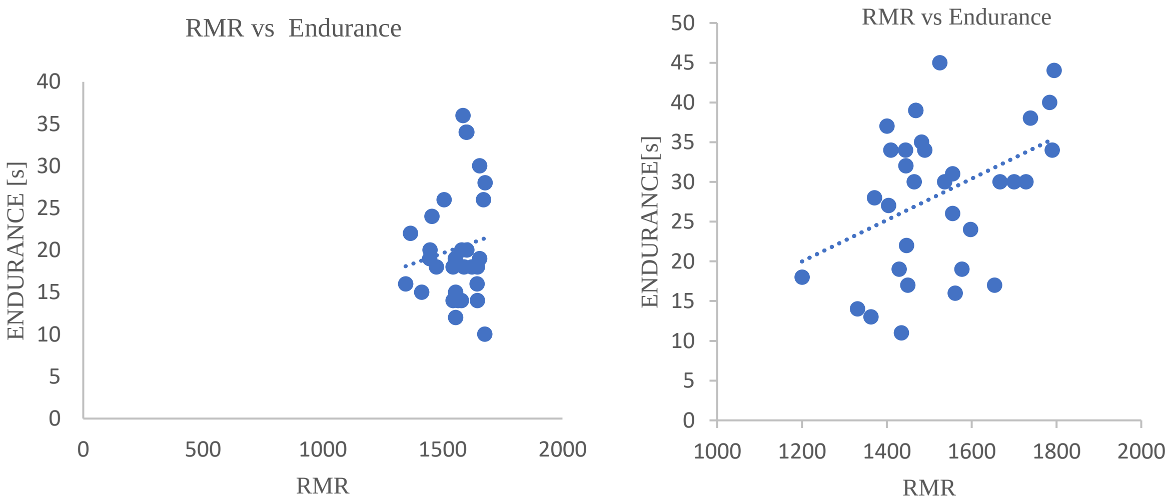
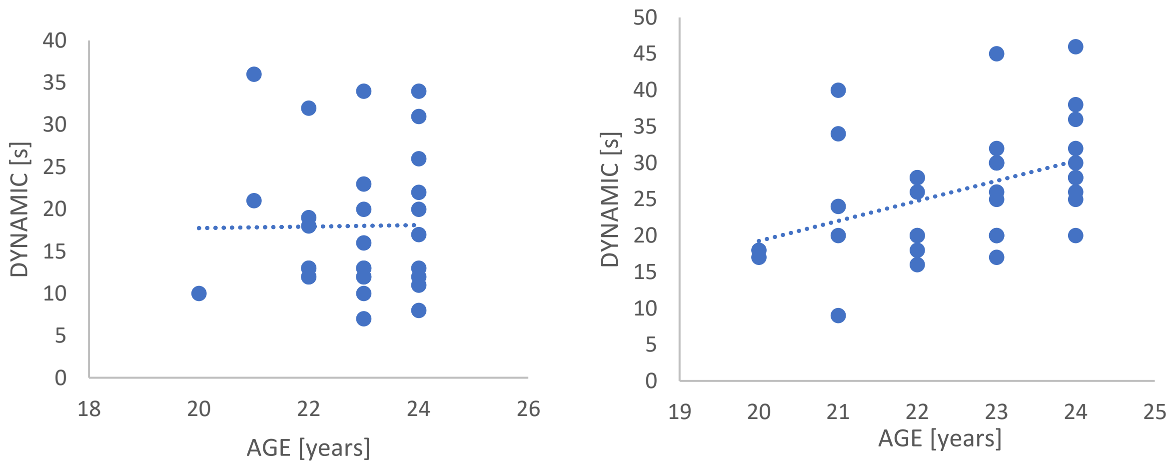


A. Smokers B. Non-smokers

Figure [3]: Resting metabolic rate [kcal/day] and endurance [s] correlation in non-smokers and smokers group.



A. Smokers B. Non-smokers

Figure [4]: Age [years] and dynamic [s] correlation in two groups.

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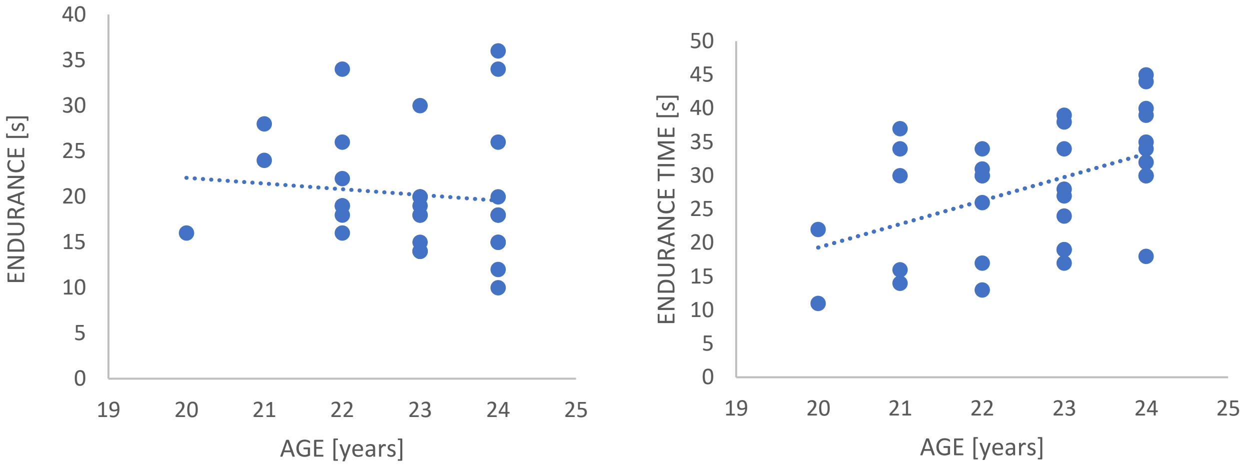
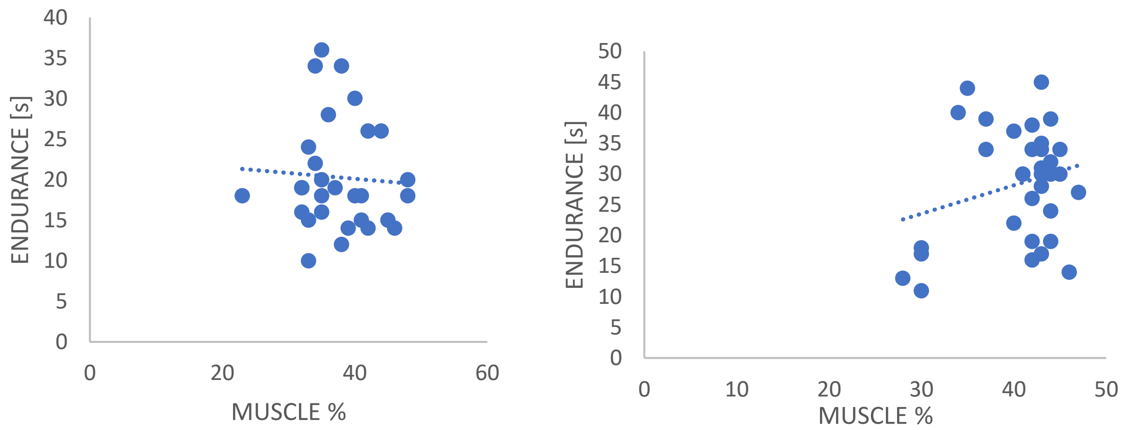


A. Smokers B. Non-smokers

Figure [5]: Age [years] and endurance[s] correlation in non-smokers and smokers group.



A. Smokers B. Non-smokers

Figure [6]: Muscle percentage and endurance[s] correlation of two groups

DISCUSSION

This study was to assess the impact of smoking on skeletal muscle strength among Walter Sisulu University male students. The findings of this study showed that smokers have less muscle strength as compared to non-smokers, since both dynamic and endurance time was higher in non-smokers than smokers. Other similar studies on physical endurance have shown that smokers reach exhaustion before non-smokers do and cannot run as fast as non-smokers [9]. Researchers reported that smokers had a lower proportion of type I fibres in the vastus laterals muscle than non-smokers [6]. It has also been reported that muscle strength, as measured by the Kraus-Weber physical fitness test, showed a significant decrease in cigarette-smoking athletes ages 19 to 30 years compared to non-smoking athletes [10].

The decrease in muscle strength among smokers may be due to several reasons, for example, body mass index and percentage body muscle mass among smokers in this current study was less than that of non-smokers, which could be a contributing fact. Previous studies suggest that cigarette smoke directly damages muscles by reducing the number of blood vessels in the skeletal muscles and this reduces the amount of oxygen and nutrients they can receive [11-13]. Furthermore, the literature indicated that smokers group tend to have a lower lung capacity compared to non-smokers, this leads to less oxygen that enters the lung and this means less oxygen to the brain, muscles and other body parts and this can easily lead to fatigue [5,14], and do experience disturbed sleep patterns, shortness of breath [9].

Moreover, the presence of nicotine and carbon monoxide in cigarettes makes blood to be sticky and arteries may become narrow, reducing blood flow to muscles and other body organs which makes exercising harder [15]. This may be the reason why there was a correlation between age and muscle strength among non-smokers in this current study, but not among smokers.

In our study, it was also indicated that resting metabolic rate was increased in smokers compared to non-smokers. This may be supported by previous studies which associated this with increased heart rate among smokers [16]. Smoking effects on body weight are said to decrease the body weight by increasing metabolic rate, decreasing or reducing appetite and this is associated with tobacco use [6,9].

Our study also demonstrated that the mean BMI of smokers group was lower compared to non-smokers group which was similar to a study conducted by [8]. This is probably due to higher energy expenditure in smokers than non-smokers as suggested by other studies [14, 17]. Furthermore, a study conducted by Kok et al. suggested that lower BMI in smokers was associated with involvement of plasma lectin, which has an important role in energy intake and expenditure regulation [18].

Most cross-sectional studies show that body weight [kg] or body mass index [BMI] is higher in non-smokers group than smokers' group [19]**.** Lower BMI in smokers could mean low muscle mass and hence less strength.

Conclusion: This study has shown that smoking has an impact on skeletal muscle, it decreases muscle strength in WSU male students aged between 18 and 24. Compared to non-smokers, smokers indicated lower muscle percentage, higher resting metabolism rate due to lower endurance time[s]. The findings of the study indicated that BMI, muscle percentage, dynamic and endurance time was significantly higher in non-smokers compared to smokers, while the RMR was significantly higher in smokers compared to non-smokers. The findings of the study indicated that muscle strength of smokers was lower than that of non-smokers. Less smoking participants who have been advised by a health professional to stop smoking, this means that there should be more awareness about smoking effects.

Limitations and recommendations: Potential limitations remain in the study. First, females were not evaluated in the study. Lastly, the relatively small sample size may have contributed to a type-2 error, highlighting that significant differences may in fact be present but not observed because of the small sample size. As recommendations, an increase in sample size might give more reliable results and longitudinal studies may be conducted.

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