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Cardiopulmonary health indices and diabetes risk scores in undergraduate students of a private university in Nigeria

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Abstract

Background: Cardiopulmonary health and its relationship with diabetes mellitus are very important but particularly underexplored in young undergraduate students of private Universities in Nigeria. This observational study investigated the effect of diabetic risk on cardiopulmonary health indices among healthy, consenting undergraduate students of a private university in Nigeria by a convenient sampling method. Cardiopulmonary health indices were assessed by anthropometry; cardiorespiratory fitness was determined by maximum oxygen uptake levels (VO_2 max), blood pressure and heart rates were measured using the Bruce treadmill protocol; oxygen saturation was determined by pulse oximetry, pulmonary function was assessed by spirometry; diabetes mellitus was risk determined by fasting blood glucose levels and the FINDRISC (Finish Diabetes Risk Score questionnaire which is a validated tool, for determining Diabetes risk; heart health awareness was determined by a modification of the healthy heart questionnaire (HHQ-GP-1) which is a standardized tool for heart health awareness and practices.

Results: Results showed that the prevalence of diabetes risk was 38.8% in the sample population. The healthy heart questionnaire revealed that participants had poor diet (76%) or did little or no exercise (60%) and were also ignorant of what a normal blood pressure should be (72%). There was no significant difference between blood pressure (systolic and diastolic) and heart rates after physical exercise of those at diabetes risk and those not at risk ($p > 0.05$). Fasting blood glucose levels between those at diabetes risk and those not at risk was significantly different ($p < 0.01$). The cardiorespiratory fitness (VO_2 max) of those not at diabetic risk was not significantly higher than of those at risk ($p > 0.385$). Respiratory functions (vital capacity, forced vital capacity, and forced expiratory volume) of those not at diabetic risk were higher than those at risk, showing that diabetes may impair lung function. Though this was not statistically significant ($p > 0.05$), the result obtained cannot be disregarded.

Conclusion: Universities and higher institutions of learning should incorporate regular health promotion and education programs that focus more on healthy lifestyles, physical exercise, and proper diet.

Keywords: Cardiopulmonary health indices, Cardiorespiratory fitness, Heart health awareness, Diabetes risk scores, Lung function, Undergraduate students

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1 Background

Diabetes mellitus (DM), commonly referred to as diabetes, is a group of metabolic disorders in which there are high blood sugar levels over a prolonged period [1]. Diabetes is due to either the pancreas not producing enough insulin or the cells of the body not responding properly to the insulin produced [2]. Over time, diabetes mellitus (DM) has emerged as a global healthcare problem that has reached epidemic proportions [3]. In 2019, approximately 463 million adults (20–79 years) are living with diabetes; by 2045 this will rise to 700 million. The proportion of people with type 2 diabetes is increasing in most countries, while 79% of adults with diabetes live in low- and middle-income countries. One (1) in two (2) (232 million) people with diabetes remain undiagnosed [4]. Type 2 diabetes is the most common type of diabetes, accounting for approximately 90% of all diabetes cases [5]. Diabetes is one (1) of four (4) priority non-communicable diseases (NCDs) targeted by world leaders [6].

In Africa, where infectious diseases have traditionally been the focus of healthcare systems, diabetic cases are expected to increase by 90% in 2030 [7]. At least 78% of people in Africa are undiagnosed and do not know they are living with diabetes and the number of people living with diabetes is expected to rise from 366 million in 2011 to 552 million by 2030, if no urgent action is taken [7, 8].

Beyond the effect of smoking, poor lung functions have been long found to have a relationship with other important health outcomes [9]. One of these important relationships is the complex interaction between diabetes and lung functions. Cross-sectional studies have found that patients with diabetes tend to have poorer lung functions than non-diabetics [10–12]. Lung functions parameters can be used for predicting morbidity and mortality [13]. Reduced pulmonary functions in patients with metabolic syndrome and diabetes have been observed in both cross-sectional and prospective studies [14–16]. Microangiopathy, systemic low-grade inflammation, autonomic neuropathy, and diminished respiratory muscle functions have been proposed as possible causes of decreased pulmonary function in diabetics [17]. Cardiorespiratory fitness, as assessed by measuring peak oxygen consumption (VO2) and other measurements that were obtained through cardiopulmonary exercise testing, is an independent predictor of mortality in patients with cardiovascular disease [18], which also allows for an objective assessment of functional performance and physical exercise capacity [19].

The majority of type 2 DM cases, which is a potentially preventable disease, progress over nearly a decade of asymptomatic phase of pre-diabetes during which clinically identifiable risk factors are apparent [20]. Diabetes risk score tools which are usually cost-effective provide an economical and convenient alternative to mass screening using laboratory-based diagnostic tests. According to the International Diabetes Federation, the Finnish Diabetes Risk Score (FINDRISC) is the most valid and inexpensive tool preferred for resource limited settings [4]. FINDRISC was derived in a 10-year prospective study for identification of people at high risk of future occurrence of type 2 DM among the Finnish population [21].

The current generation of adolescents and young adults, who have been more influenced by information and communication technology, differ greatly from their parents in terms of health awareness, food fads, habits, and other cardiopulmonary modifiable risk factors. No known study has investigated the effect of diabetic risk on cardiopulmonary health indices among healthy undergraduate students of private Universities in Nigeria. Therefore, the present study was undertaken in the young student population of a private University.

2 Methods

2.1 Description of study area

The private University was located in South-West Nigeria.

2.2 Study design

A descriptive study in which one of the private Universities in South-West Nigeria was selected.

2.3 Study participants

A total of 25 apparently healthy male and female consenting students of the Private University, participated in the study. Written informed consent was obtained.

2.4 Exclusion criteria

This includes those who are smokers, alcoholics, asthmatics, and ill.

2.4.1 Anthropometric data

The height and weight measurements were obtained with a measuring tape and a weighing scale respectively. Body mass Index (BMI) was calculated from the values of height and weight using the following formula: weight (kg)/height^2 (m^2).

2.4.2 Healthy heart questionnaire

Participants responded to a modified version of the Healthy heart questionnaire [22]. The purpose of the questionnaire was to investigate healthy heart awareness, diet, and exercise/physical activity of the participants.

2.4.3 Finnish diabetes risk score (FINDRISC)

It is a simple, fast, inexpensive, non-invasive, and reliable tool to identify individuals at high risk for type 2 DM [21, 23]. Participants completed the FINDRISC questionnaire, and their scores were determined along with their fasting blood glucose levels. The items on the FINDRISC questionnaire are as follows:

The current 8-item (0–26 point) FINDRISC scale that was used in this original research consists of the following:

1. Age; minimum point = 0, maximum point = 4
2. Body mass index: minimum point = 0, maximum point = 3
3. Waist circumference in both male and female: minimum point = 0, maximum point = 4
4. Physical activity: minimum point = 0, maximum point = 2
5. Frequency of consumption of fruits/ vegetables: minimum point = 0, maximum point = 1
6. Ever taken medication for high blood pressure on a regular basis: minimum point = 0, maximum point = 2
7. Ever been found to have high blood glucose during a health examination, illness or pregnancy?: minimum point = 0, maximum point = 5
8. Any immediate family members or other relatives been diagnosed with either Type1 or Type 2 Diabetes?: minimum point =0, maximum point = 5 (The FINDRISC questionnaire [24]) is available at https://www.diabetes.fi/files/502/eRiskitestilomake.pdf;

The following FINDRISC values were the benchmark for assessment (Table 1).

2.5 Fasting blood sugar test

The fasting blood glucose of all participants was measured between the periods of 7 A.M.–10 A.M., using a glucometer (Double G sugar monitor glucose meter). Diabetes was diagnosed based on fasting blood glucose in accordance with internationally recognized criteria by the American diabetes association: normal, < 100 mg/dL; pre-diabetes, 100–125 mg/dL; diabetes mellitus, ≥ 126 mg/dL [25].

Table 1 Values of FINDRISC, description and prognosis

FINDRISC values	Description	Prognosis
7	Low	1 in 100 will develop disease
7–11	Slight elevation	1 in 25 will develop disease
12–14	Moderate	1 in 6 will develop disease
15–20	High	1 in 3 will develop disease
> 20	Very High	1 in 2 will develop disease

Summary: Score 7: not at risk
Score > 7–20: people at risk

2.6 Cardiopulmonary fitness

Cardiopulmonary fitness was carried out using a treadmill (Lepow Huikang running HL1360J treadmill home fitness folding multifunction Electric genuine). Participants were subjected to run on the treadmill starting on the lowest speed (1.0mph) and increasing the speed (by 2mph) at intervals of 3 min. This was done until the participants were unable to run anymore at which point the treadmill was stopped and the time through which each individual could withstand; the test was recorded. The VO_2 max was calculated using the formula:

- For men, VO_2 max = 14.8 − (1.379 × T) + (0.451 × T^2) − (0.012 × T^3)
- For women, VO_2 max = 4.38 × T − 3.9, where T = Total time on the treadmill measured as a fraction of a minute

2.7 Blood pressure and heart rate

The blood pressure and heart rate were measured and recorded before and after the fitness exercise using a Digital sphygmomanometer (Omron HEM-7120 Automatic Blood Pressure Monitor; Omron Health care Europe B.V). The digital sphygmomanometer was standardized against the mercury in glass sphygmomanometer (Accousson).

2.8 Oxygen consumption

The Oxygen consumption or saturation for participants was measured and recorded before and after the physical fitness exercise using pulse oximetry (Blue Jay Comfort Finger Tip Pulse Oximeter).

2.9 Spirometry

The vital capacity, forced vital capacity (FVC), and forced expiratory volume (FEV_1) were measured before and after the exercise using a Vitalograph (Vitalograph ALPHA Desktop Spirometer). The subjects were properly trained for the lung functions test. This was achieved by asking the participants to breathe forcefully into the mouth piece three times for the vital capacity and forced vital capacity and three times forcefully (prolonging their breath) to calculate the forced expiratory volume.

3 Results

3.1 Diabetic risk score

The prevalence of those at risk was 28% (7).

Table 2 Anthropometric data of both groups (participants at risk and those not at risk)

Variable	Participants at risk	Participants not at risk
Age (years)	21.1 ± 1.67	22.5 ± 0.80
Weight (Kg)	72.9 ± 4.83	66.1 ± 2.49
Height (M)	1.7 ± 0.03	1.7 ± 0.02
Body mass index (Kg/m^2)	24.5 ± 0.97	20.3 ± 0.28
n	7	18

n number of participants
Values are expressed as mean ± SEM.

3.2 Anthropometric data (Table 2)

A greater proportion of the respondents 18 (72.0%) had their body mass index lower than 25, However, 6 (24.0%) of the respondents had a body mass index of 25–30, while 1 (4.0%) had a body mass index of ≥ 30 (Figs. 1, 2, and 3).

3.3 Cardiorespiratory function (Table 3)

3.4 Diabetes risk score (DRS) and fasting blood sugar (FBS) result (Table 4)

3.5 Spirometry (Table 5)

4 Discussion

In the present study, we sought to investigate the relationship between diabetes risk scores and cardiopulmonary health indices in healthy undergraduate students of a private University in South-western Nigeria.

The results of the study showed that the diabetes risk score had significant effect on only the fasting blood sugar level ($p < 0.01$). The diabetes risk was determined using the Finnish Diabetes Risk Score (FINDRISC) questionnaire. Information supplied by participants, in the healthy heart questionnaire, showed that poor diet and lack of physical exercise were prevalent.

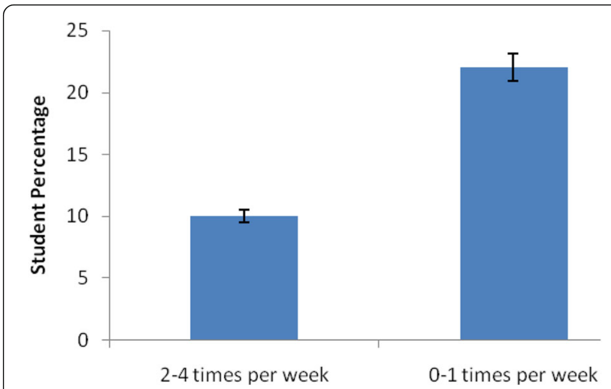

Fig. 1 Frequency of exercise (10 ± 0.5 reported 2–4 times per week, while 22 ± 1.1 reported 0–1 times per week)

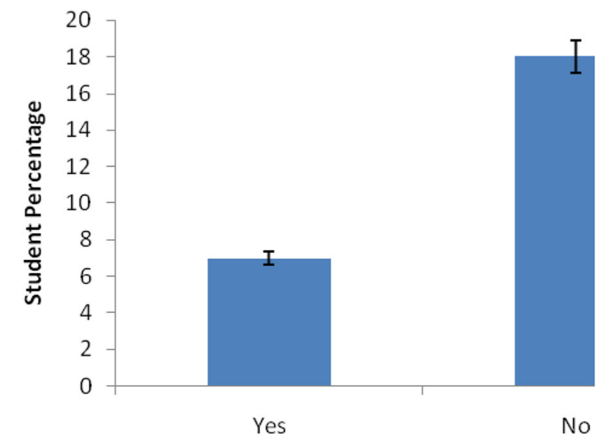

Fig. 2 Is systolic blood pressure of 140 mmHg high? (7 ± 0.35 reported "YES" while 18 ± 0.9 reported "NO")

Students with high risk scores had significantly higher blood glucose levels and higher body mass index (BMI) than those not at risk.

This infers that higher diabetes risk scores are associated with higher body mass index. Similarly, other studies had found that subjects with high risk for type 2 diabetes mellitus had higher BMI, blood glucose, basal insulin, HOMA-IR (insulin resistance), and lower HDL-C (high density lipoprotein), than those with low-moderate risk for type 2 diabetes [26, 27]. They also reported that subjects at high risk according to FINDRISC were 4.8 times more likely to develop metabolic syndrome than those at low risk. Hence, FINDRISC is not only a tool which detects type 2 diabetes mellitus, but also one to identify subjects with elevated global cardio-metabolic risk.

Blood pressure and heart rate were not significantly different between students at diabetic risk and those without or at low risk. The cardiorespiratory fitness (VO_2 max) of those not at risk was higher than of those

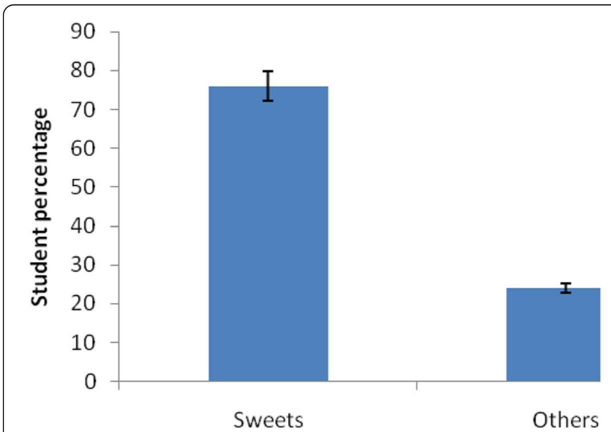

Fig. 3 Types of snacks eaten (sweets: 76 ± 3.8; others: 24 ± 1.2)

Table 3 Cardiorespiratory data of both groups (participants at risk and those not at risk)

Variable	Participants at risk (*n* = 7)	Participants not at risk (*n* = 18)	*P* value
Systolic blood pressure before (mmHg)	120 ± 6.26	119.6 ± 2.22	0.948
Systolic blood pressure after (mmHg)	132.6 ± 3.66	135.9 ± 3.41	0.517
Diastolic blood pressure before (mmHg)	68.9 ± 3.45	74.9 ± 2.55	0.185
Diastolic blood pressure after (mmHg)	68 ± 4.97	73.4 ± 2.61	0.231
Heart rate before (BPM)	82.7 ± 3.80	78.2 ± 2.60	0.349
Heart rate after (BPM)	118.6 ± 3.80	114.3 ± 5.47	0.755
Oxygen consumption before (mmHg)	97.4 ± 0.46	97 ± 0.498	0.963
Oxygen consumption after (mmHg)	97.1 ± 0.55	97.3 ± 0.463	0.854
Cardiorespiratory fitness (VO_2 max)	25.1 ± 4.05	30.5 ± 4.62	0.385

n number of participants
Values are expressed as mean ± SEM. There was no significant difference in Systolic and diastolic blood pressures, heart rates, Oxygen consumption and VO_2 max of both groups of students

at risk. This buttresses the importance of physical fitness via physical exercise, in the prevention of diabetes, and shows that those at risk of diabetes (usually with high BMI) have very low cardiopulmonary fitness. Responses from the healthy heart questionnaire showed that students at diabetic risk were ignorant of importantly specific health information associated with their cardiovascular system (for example normal blood pressure).

Reduced lung function is associated with a diminished capacity of maximum oxygen uptake, which is considered to be the best measure of cardiorespiratory fitness and physical exercise capacity [28]. Despite these diabetes-related reductions in the ability to oxygenate and deliver blood to peripheral tissues, some studies have found that VO_2 max is not different between subjects with type I diabetes and subjects without diabetes when matched for age, sex, body composition, and physical activity [29, 30]. In this current research among University students, respiratory functions (vital capacity, forced vital capacity and forced expiratory volume) of those not at risk was higher than those at risk, showing that diabetes may impair lung functions. Similarly, there are quite a number of studies that have assessed poor lung functions in relation to diabetes or pre-diabetes risk [31–35]. It has also been reported that decreased lung

Table 4 DRS and FBS data of both groups (participants at risk and those not at risk). Values are expressed as mean ± SEM, *n* number of participants

Variable	Participants at risk (*n* = 7)	Participants not at risk (*n* = 18)	*P* value
Diabetes risk score	10.3 ± 1.38	4.1 ± 0.589	< 0.004
Fasting blood sugar (mmHg)	100.5 ± 3.68	89.4 ± 1.42	< 0.001
n	7	18	

There is a significant difference ($p < 0.05$) between the means of DRS and FBS in both groups

Table 5 Spirometry of participants at diabetic risk and those not at risk

Variable	Participants at risk (*n* = 7)	Participants not at risk (*n* = 18)	*P* value
Vital capacity			
Before			
Normal	3.8 ± 0.35	4.1 ± 0.20	0.591
Best	3.4 ± 0.26	3.5 ± 0.21	0.652
After			
Normal	4.6 ± 0.33	4.9 ± 0.20	0.656
Best	4.0 ± 0.30	4.3 ± 0.20	0.712
Forced vital capacity (FVC)			
Before			
Normal	3.8 ± 0.31	4.0 ± 0.17	0.547
Best	3.6 ± 0.29	3.8 ± 0.19	0.763
After			
Normal	4.4 ± 0.24	4.7 ± 0.18	0.602
Best	4.2 ± 0.24	4.4 ± 0.19	0.509
Forced expiratory volume (FEV_1)			
Before			
Normal	3.4 ± 0.18	3.4 ± 0.13	0.796
Best	3.0 ± 0.18	3.1 ± 0.17	0.643
After			
Normal	3.8 ± 0.14	4.0 ± 0.186	0.632
Best	3.6 ± 0.18	3.6 ± 0.02	0.484

n number of participants
Values are expressed as mean ± SEM. Vital capacity forced vital capacity and forced expiratory volume before and after measurements of both groups showed no significant difference

functions observed among diabetics may be explained by collagen accumulation in the lung connective tissue [15]. Respiratory impairment among persons with diabetes might be influenced by increased body mass index (BMI) and result in fat deposits between the muscles and the ribs, which decrease chest wall compliance and weaken the respiratory muscles [36].

5 Conclusion

This study investigated the cardiopulmonary health indices and diabetes risk scores of undergraduate students in a private University in Nigeria. Students at risk of diabetes mellitus (assessed with the FINDRISC) actually had high fasting glycemia levels and lower respiratory functions (assessed by spirometry) than those not at risk.

The influence of western diets and dietary habits in the wake of urbanization has aggravated the morbidity and mortality associated with non-communicable diseases such as diabetes mellitus. Preventive measures should be initiated early from childhood and young adulthood to turn down the trend of the diabetes pandemic. Universities and higher institutions of learning should initiate more in depth health screening at the point of admission as well as yearly. This would ensure proper health interventions and follow up where necessary. Healthy lifestyles, physical exercise, and diet ought to be promoted in more creative ways during regular health education of the students.

Abbreviations

BMI: Body mass index; DM: Diabetes Mellitus; DRS: Diabetes risk score; FBS: Fasting blood sugar; FEV_1: Forced expiratory volume 1; FINDRISC: Finnish Diabetes Risk Score; FVC: Forced vital capacity; NCD: Non-communicable diseases

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Authors' contributions

This research concept, design, and development were by JOY and AAF, as well as supervised by AAF and AOS. ODO was responsible for data collection and analysis. The manuscript was majorly written and edited by both JOY and OIO. All authors read and approved the final manuscript.

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Availability of data and materials

Not applicable.

Ethics approval and consent to participate

This study in a private University among undergraduate students was approved by the Ethical committee of the University's Teaching Hospital in South-West Nigeria. BUTH (Bowen University teaching Hospital) Research committee Registration Number NHREC/12/04/2012 MANUSCRIPT APPROVAL NUMBER: BUTH/REC-032. Informed written consent to participate was obtained from study participants.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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