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ORIGINAL RESEARCH

Physical Exercise and Glucose Tolerance in Nigerian University Students

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Abstract

Background: Studying post-prandial fluctuations in blood glucose has high physiological and clinical relevance. Physical exercise is known to influence this fluctuation.

Objectives: To determine the gender difference in glucose tolerance following physical exercise in a population of university students.

Methods: A total of 146 students were randomly selected from the Olabisi Onabanjo University, Sagamu, Ogun State, southwest Nigeria. Following overnight fast, Oral Glucose Tolerance Test (OGTT) was carried out. Pre-exercise, fasting blood glucose (FBG) was measured at 0 mins, and after oral glucose load of 75 grams at 30 minutes intervals for 2 hours. The physical exercise involved cycling using a bicycle ergometer for an hour. Thereafter, OGTT was conducted again 1 hour post-exercise.

Results: The ages of the subjects ranged from 20 years to 49 years. There were 73 (50.0%) females. The mean Body Mass Index (BMI) of 23.5±1.1 kg/m² for females was comparable to 22.8±0.3 kg/m² for the males ($p = 0.571$). Seven (9.6%) females were obese compared to 2 (2.7%) males. The mean post-prandial blood glucose increased from 71.6±1.6 mg/dl to 90.8±1.8 mg/dl after oral glucose load and thereafter to 88.0±4.2 mg/dl at 120 minutes among males. The post-exercise blood glucose patterns included a significant reduction in the mean FBS for males compared to females (64.5±1.9 mg/dl vs. 71.7±1.9 mg/dl; $p = 0.001$)

Conclusions: Glucose tolerance with exercise is better in females than males. The clinical importance of physical exercise lies in its effect on glucose tolerance.

Keywords: Bicycle Ergometer, Exercise, Glucose tolerance, Oral Glucose Tolerance Test.

Introduction

In Nigeria, the current prevalence rate of Diabetes mellitus (DM) among adults aged 20–69 years is reported to be 1.7%. [1] It is widely perceived that prevalence figures reported by the International Diabetes Foundation (IDF) grossly under-reported the true burden of DM in Nigeria, given that the figures were derived through the extrapolation of data from other countries. Various researchers have reported prevalence rates ranging from 2% to 12% across the country in recent years. [2] The last time a nationwide population estimate of DM was undertaken in Nigeria was during the 1992 Nigerian National Non-communicable Diseases (NCD) survey, where DM was said to occur in 2.2% of the population. [1]

Poor insulin sensitivity (IS or insulin resistance) is the basic defect resulting in the development of Type 2 Diabetes mellitus (T2D) and it is often associated with a clustering of abnormalities such as hyperinsulinemia, impaired glucose tolerance (IGT), hypertension, and dyslipidaemia. [1] Insulin resistance and IS can be measured directly, [2] or estimated from the glucose and insulin responses to an oral glucose tolerance test (OGTT). [2] Elevated glucose and insulin responses to OGTT reflect a diminution of glucose tolerance and increased insulin resistance, respectively.

It was recently shown that concentric exercise (CE) (muscle shortening contractions) and eccentric exercise (EE) (muscle lengthening contractions) and endurance exercises (walking uphill and downhill) are similarly effective in improving glucose and lipid metabolism in sedentary healthy subjects. [3] Although using different training protocols, Pascalis, *et al.* [4] demonstrated that EE positively modified insulin resistance and glucose tolerance in both sexes. When considering energy expenditure, these adaptations to glucose tolerance seems superior compared to those elicited by CE. [3, 5] Nevertheless, the results remain controversial as other studies failed to show equal or better effects after on glucose metabolism EE compared to CE, [4,6] and physiological explanations are, up till now, missing. Therefore, studying postprandial fluctuations in blood glucose levels has high physiological and clinical relevance. Aerobic exercise is prescribed clinically for the prevention and treatment of T2D because it improves glycaemic control [7] and insulin sensitivity [8] in obese and hyperglycaemic individuals.

There is a paucity of knowledge on the effect of physical exercise using ergometer on glucose tolerance concerning gender difference in Nigeria. Most of the relevant previous studies obtained by literature search were conducted in the western world. There was none from the African continent. Moreover, there has been no accurate determination of the rate of endogenous and exogenous glucose oxidation and the subsequent effect of exercise using a bicycle ergometer. Therefore, this study aimed to determine the gender difference in glucose tolerance following exercise in a population of university students.

Methods

This was a cross-sectional study involving a total of 146 students, aged 20 to 49 years who were randomly selected at the Olabisi Onabanjo University, Sagamu, Ogun State, southwest Nigeria. Students with DM were excluded from the study. The study was conducted between June and November 2019.

Ethical considerations

Ethical clearance for the study was obtained from the Health Research Ethics Committee (HREC) of the Olabisi Onabanjo University Teaching Hospital (OOUTH), Sagamu (HREC/OOU/0020/2019).

Data collection

The bodyweight of each subject was recorded in kilograms (to the nearest 1.0 kg) with only light clothing on, using a calibrated bathroom weighing scale (Soehnle Waagen GmbH and Co. KG, D 71540 Murrhardt/Germany) positioned on a firm horizontal surface. Height in meters was measured (to the nearest 0.1m) using a stadiometer. Subjects stood erect, without shoes and headgears, on a flat surface with the heels and occiput in contact with the stadiometer (Prestige HM0016D; India). The Body Mass Index (BMI) was subsequently calculated using the formula: weight (kg)/ height^2 (metres^2). Using the BMI, the following categorization of participants was adopted:

Underweight – BMI < 18.5kg/m^2
Normal – BMI 18.5-24.9 kg/m^2
Overweight – BMI 25.0-29.9 kg/m^2
Obesity – BMI $\geq$30 kg/m^2

The subjects fasted overnight before the commencement of data collection. Female subjects were subjected to exercise protocol during menstrual period days (3-8 days) to minimize potential gender differences viz the influence of ovarian hormones (oestrogen and progesterone) on glucose tolerance. The fingertip of each participant was cleaned and pricked with a lancet each time blood glucose was measured using Accu-Check® Glucometer. After ingestion of 75g glucose, serial measurement of blood glucose was done immediately and at 30 minutes interval for two hours before physical exercise. All the participants were then subjected to one hour of cycling exercise using Bicycle Ergometer (Lode Corival, Netherland). On the same day, serial measurement of blood glucose was done immediately after the exercise and at 30 minutes intervals for two hours thereafter.

Data analysis

The data were analysed using the Statistical Programme for Social Sciences (SPSS) version 25.0. Categorical variables were described as percentages and continuous variables as means and standard deviations. The Student's t-test was used to compare the mean values of the variables. Probability values less than 0.05 were considered statistically significant.

Results

Demographics (Tables I and II)

A total of 146 students were studied. Their age range was 20 to 49 years. The 20 to 29 years age group constituted the largest (75.3%) in the population of participants. There were 73 (50.0%) males and females respectively.

Physical profile

The mean BMI for females was 23.5±1.14 kg/m^2 compared to 22.8±0.37 kg/m^2 for males but the difference lacked statistical significance (p = 0.571). Table I shows that 9.6% of females were obese compared to 2.7% of males.

The pattern of glucose tolerance

Comparison of pre-exercise blood glucose levels among males and females (Table III)

0 minute: The mean FBS of males was significantly lower than that of females (71.6±1.60 mg/dl vs. 83.3±2.63 mg/dl (p = 0.000).

30 minutes: The mean blood glucose level was significantly lower among males compared to females (90.8±1.8 mg/dl vs. 101.8±3.33 mg/dl (p = 0.001).

60 minutes: The mean blood glucose level of males was significantly lower compared to the mean level for females (91.4±3.3 mg/dl vs. 111.6±3.5 mg/dl (p = 0.000).

90 minutes: The mean blood glucose level of males was comparable to that of females (100.7±3.91 mg/dl vs. 100.2±3.10 mg/dl (p = 0.924).

120 minutes: The mean blood glucose levels of males and females were comparable (88.0±4.22 mg/dl vs. 87.4±3.05 mg/dl (p = 0.920).

Table I: Demographic and clinical characteristics of the study participants

Characteristics	*Categories*	*Total (n=146)*	*Male (n=73)*	*Female (n=73)*
Age Group (Years)	20-29	110 (75.3)	58 (79.5)	52 (71.2)
	30-39	18 (12.3)	6 (8.2)	12 (16.4)
	40-49	18 (12.3)	9 (12.3)	9 (12.3)
BMI Group (kg/m²)	Underweight	20 (13.7)	7 (9.6)	13 (17.8)
	Normal weight	88 (60.3)	53 (72.6)	35 (47.9)
	Overweight	29 (19.9)	11 (15.1)	18 (24.7)
	Obesity	9 (6.2)	2 (2.7)	7 (9.6)

Table II: Comparison of the mean age, weight and BMI among males and females

Parameters	*Male*	*Female*	*t*	*p-value*
Age (years)	26.6±1.4	26.1±1.5	0.209	0.835
Weight (kg)	67.4±1.1	65.6±3.2	0.526	0.599
BMI (kg/m²)	22.8±0.3	23.5±1.1	0.567	0.571

Table III: Comparison of the pre-exercise mean blood glucose levels during Oral Glucose Tolerance Tests among males and females

Time (Minutes)	*Blood Glucose Level (mg/dl)*		*t*	*p-value*
	Male (n = 73)	*Females (n = 73)*		
0	71.6±1.6	83.3±2.6	3.794	0.000*
30	90.8±1.8	101.8±3.3	2.898	0.004*
60	91.4±3.3	111.6±3.5	4.132	0.000*
90	100.7±3.9	100.2±3.1	0.096	0.924
120	88.0±4.2	87.4±3.0	0.099	0.920

Comparison of post-exercise blood glucose levels among males and females (Table IV)

0 minute: The mean FBS of males was significantly lower compared to that of females (64.5±1.9 mg/dl vs. 71.7±1.98 mg/dl (p = 0.001).

30 minutes: The mean blood glucose level of males was significantly lower compared to the value for females (80.5±1.6 mg/dl vs. 90.3±2.5 mg/dl (p = 0.002).

60 minutes: The mean blood glucose level of males was significantly lower than the value for females (84.4±3.02 mg/dl vs. 100.6±2.95 mg/dl (p = 0.000).

90 minutes: The mean blood glucose level of males was comparable to that of females (93.9±3.47 mg/dl vs. 93.3±2.6 mg/dl (p = 0.893).

120 minutes: The mean blood glucose of males was comparable to that of females (83.2±3.92 mg/dl vs. 83.0±2.93 mg/dl (p = 0.972).

Figure 1 shows the graphical representation of glucose tolerance pre-exercise and 120 minutes post-exercise. Glucose uptake was higher in females compared to males, p = 0.000 post-exercise.

Table IV: Comparison of the post-exercise mean blood glucose levels during Oral Glucose Tolerance Tests among males and females

Time (Minutes)	*Blood Glucose Level (mg/dl)*		*T*	*p-value*
	Male (n =73)	*Female (n = 73)*		
0	64.52±0.91	71.77±1.98	3.327	0.001*
30	80.50±1.69	90.32±2.52	3.236	0.002*
60	84.46±3.02	100.60±2.95	3.823	0.000*
90	93.91±3.47	93.33±2.60	0.133	0.893
120	83.24±3.92	83.07±2.93	0.035	0.972

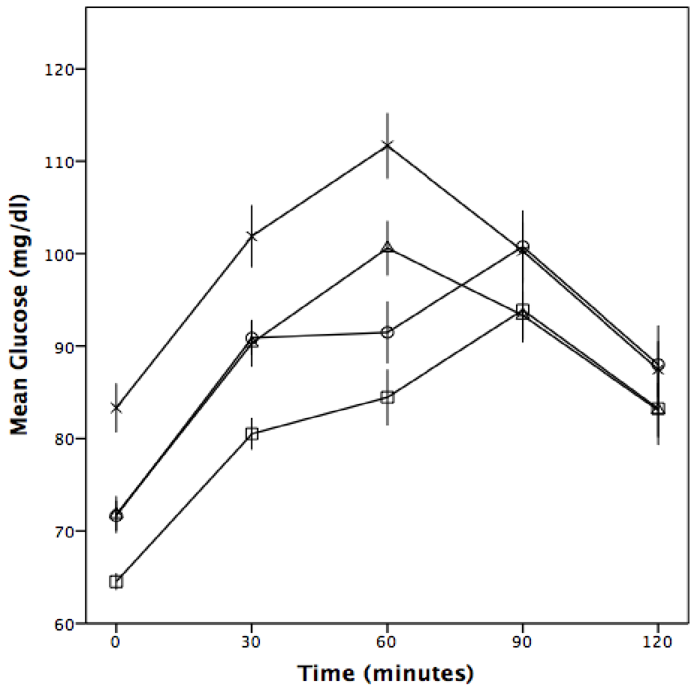

Figure 1: Glucose tolerance with Time and Gender differences of the study groups
○ Male- Before exercise; □ Male- After exercise; X Female- Before exercise; Δ female- After exercise

Discussion

In the present study, it was observed that there were significant differences in glucose tolerance between male and female participants up to 60 minutes. However, there was no significant difference in the mean blood glucose levels for both sexes at 120 minutes after glucose meal, before and after physical exercises. This may be attributed to the biological and genetic make-up of the body of females vis- a- vis increase in both the visceral and total body fats and greater insulin resistance. It may also be hormonal in nature, concerning the females. [5] The significant changes in OGTT following physical exercise agree with the report of the only other single-bout of exercise study in which OGTT was measured. [5]

Although the focus of the present study precluded the identification of specific mechanisms underlying the exercise-induced changes observed, it is reasonable to infer that the reduced mean blood glucose after physical exercise was most likely because of two factors. [9] The primary sources of adenosine triphosphate (ATP) during exercise are derived from high-energy phosphagen breakdown, glycogenolysis, and lipolysis of intramyocellular lipids. Depletion of intramuscular energy substrates has a beneficial effect on glucose uptake. The greater improvements observed after physical exercise suggest greater substrate use. Secondly, the increase in glucose uptake most likely resulted from a protracted post-exercise increase in IS that may persist for approximately 48 hours after exercise. [9] In summary, this is the first study to examine the effects of a single bout of one hour of exercise on OGTT responses relative to a higher volume exercise protocol of like intensity. Glucose tolerance significantly improved only after exercise. Although the data from this study confirmed previous research findings that higher doses of exercise tend to yield greater improvements in glucoregulatory control, this principle may be counterproductive in certain populations who are untrained, obese, and have a low exercise tolerance. However, program adherence is a major obstacle for many individuals who are obese and have never participated in a structured exercise program.

Therefore, it is essential to establish a prescription for appropriate exercise volume that will be sufficient to elicit improvements in glucose regulation while minimizing the attrition rate in these individuals. Based on the findings in the present study, health fitness professionals, to maximize both benefits and compliance, should consider the following with respect to prescribing exercise volume. Performing higher volumes of exercise will typically maximize improvements in glucose tolerance and IS. Therefore, practitioners should typically seek to progressively increase physical exercise for most individuals seeking to improve glucoregulatory control. Conversely, although a systematic increase in total volume may tend to improve glucose tolerance and IS in many individuals, an alternative strategy may need to be considered for individuals who are obese and have been previously inactive. [9]

The improvement in glucose tolerance post-exercise in the present study is similar to the finding reported by Adeleke and Ayendegbara, [10] where the effect of physical exercise, appropriate diet and lifestyle modification was reviewed. The findings in the present study with regards to sex differences corroborated the report of Prasanna, *et al.* [11] where it was stated that the 1-hour plasma glucose value during OGTT is a good predictor of future dysglycaemia among subjects with normal glucose tolerance. [11]

The inability to conduct the OGTT over a longer period and the possibility of other underlying health challenges in the subjects which were not identified at the time of study may be limitations to the study. These are interesting issues to be put into consideration for future investigations. Indeed, prospective studies to be conducted over years are desirable.

Conclusion

Regardless of the characteristics of the sample size and type of exercise deployed, glucose tolerance reduced in the hour following an exercise session. However, the reduction was beneficial if the exercise was performed as a preventive strategy and in physically active individuals who were not yet on medications. The study has reinforced the possibility that exercise improves and has a beneficial role in metabolic health. Based on the outcome of this study, people with metabolic syndrome should engage in exercise daily as it has been proven to improve metabolic health. The clinical importance of physical exercise may be a useful intervention.

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