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Association between Handgrip strength and Insulin Sensitivity and Beta-cell Function in Non-diabetic Young Nigerian Adults

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Abstract

Introduction: Insulin resistance, a condition in which cells do not respond adequately to insulin, plays a crucial role in diabetes and related metabolic disorders. This study investigated the association between handgrip strength (HGS), Insulin sensitivity, and β-cell function in non-diabetic Nigerian young adults.

Materials and Methods: A total of 158 participants were used in this cross-sectional study. They were assessed for HGS, body mass index (BMI), fasting blood glucose (FBG), fasting Insulin, homeostasis model assessment of insulin resistance (HOMA-IR), and homeostatic model assessment of β-cell function (HOMA-β). Assessments of normal distribution, descriptive statistics, subgroup analysis, Pearson's correlation, and regression models were done to analyse relationships and predict insulin and beta cell sensitivity. Multiple regression models were adjusted for confounders, and statistical significance was determined at $p<0.01$ or 0.05.

Results: The individuals exhibited acceptable physical and metabolic well-being, with males having an average Absolute HGS (AHGS) of 59.92 kg and females having an average AHGS of 43.83 kg. The average Relative HGS (RHGS) was 2.87 for males and 2.13 for females, with an overall average BMI of 21.29 kg/m^2. Strong relationships were observed between HGS (both left and right) and insulin sensitivity (measured by HOMA-IR), as well as pancreatic beta cell function (measured by HOMA-β) ($p<0.01$) and across other metabolic parameters ($p<0.01$). The differences in these associations were more evident in males than females. Male participants displayed relatively higher associations between HGS and both HOMA indices. In contrast, female individuals demonstrated weaker and statistically insignificant connections, which could result from physical, lifestyle, or hormonal disparities.

Conclusion: This study is the first to show that HGS substantially indicates insulin sensitivity and beta cell function in a young, non-diabetic Nigerian population. The findings suggest that HGS could be a potential screening tool for managing insulin resistance and a feasible approach to enhancing metabolic health. Additional investigation is necessary to examine the fundamental processes and authenticate these findings in more extensive populations.

Keywords: handgrip strength, insulin resistance, pancreatic β-cell activity, HOMA-IR, HOMA-β, non-diabetic, Nigerian young adults.

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Introduction

Insulin resistance occurs when insulin cannot increase glucose uptake and utilisation (Chandrasekaran & Weiskirchen, 2024), leading to numerous metabolic disorders (Joo *et al.,* 2022; Lebovitz, 2001; Tian *et al.,* 2024), primarily involving the liver, muscle, and adipose tissue. It distorts glucose disposal, with a compensatory increase in beta-cell insulin secretion and hyperinsulinemia (Lee *et al.,* 2022). Moreover, the metabolic consequences can result in hyperglycemia, among other pathologic states (Zyoud, 2024). The most common consequence of insulin resistance is type 2 diabetes (T2DM) (Freeman *et al.,* 2023). Furthermore, the prevalence and incidence of T2DM in Nigeria and sub-Saharan Africa are increasing at an alarming rate, contributing to poor quality of life, morbidity, and mortality (Iheagwam *et al.,* 2022). Insulin resistance also causes muscle protein loss, and studies have shown the association between the loss of muscle strength and diabetes (Merz & Thurmond, 2020). Therefore, early identification of insulin resistance and its prevention is essential from a public health perspective.

However, there are only a few standard tools for measuring insulin resistance. Although HOMA-IR is used to measure insulin resistance, it is not routinely quantified in clinical practice (Joo *et al.,* 2022). Thus, a simple and accessible tool for predicting insulin resistance could be helpful for the early identification of individuals with insulin resistance.

Handgrip strength emerges as a promising, easy-to-measure (Taylor et al., 2024) health indicator suitable for screening insulin resistance (Li *et al.,* 2018) in resource-constrained settings. Unlike expensive and hazardous diagnostic tests, HGS testing avoids health risks associated with chemicals., or bodily fluids. Moreover, as a simple anthropological measurement and an indicator of upper-body muscle strength, it is related to insulin action and the risk of the onset of diabetes (Tajima *et al.,* 2024). Studies have also reported a positive association between HGS and the HOMA-IR (Joo *et al.,* 2022; Jung *et al.,* 2022). Few studies have examined the association between HGS and insulin resistance in a non-diabetic population (Joo *et al.,* 2022). Therefore, this study aimed to examine the associations of HGS with measures of insulin resistance in young adults in Nigeria without diabetes.

Materials and Methods

Study Design and Population

This cross-sectional study was conducted among undergraduate students of the University of Ilorin, Kwara State, Nigeria. A purposive sampling technique was used to select participants. In February 2024, trained laboratory staff measured sociodemographic information, FBG, fasting insulin, BMI, and HGS (both AHGS and RHGS) for both male and female students on the main campus.

Two hundred (200) individuals aged 18-30 years were initially recruited for the study. The inclusion criteria required participants to be within this age range and to provide informed consent. Exclusion criteria were applied as follows: participants who reported any restriction of activity, those with a history of diabetes mellitus, arthritis, renal failure, liver cirrhosis, or cancer, and individuals who had not fasted for 8 hours before blood sampling. Participants with incomplete data for FBG, insulin, BMI, or HGS were excluded. Following these criteria, a final sample size of 158 participants was reached.

All participants provided written informed consent before enrollment. The study protocol was approved by the University Ethical Review Committee of the University of Ilorin, Nigeria (Protocol Identification Code: UERC/BMS/214; Approval Number: UERC/ASN/2024/2736). The study adhered to the ethical principles of the Declaration of Helsinki.

Measurements
Fasting blood sugar levels were measured using Accu-Chek and On-Call glucometers (Roche Diagnostics, Germany, and ACON Laboratories, USA, respectively). Fasting insulin levels were determined using a commercially available enzyme-linked immunosorbent assay (ELISA) kit (BiO Inteco®, Inteco Diagnostics UK Ltd). The test procedures followed the manufacturer's recommendations. BMI was calculated using standard formulas, and HGS was measured using a dynamometer.

Data collection
Participant Recruitment
Two hundred students from the University of Ilorin, Nigeria, were initially recruited for this study through advertisements on social platforms such as Facebook and Instagram. Participants were selected on a "first come" basis, and written informed consent was obtained from all subjects.

Demographic and Medical History Data
Demographic information such as age and sex, along with medical history, including current and past conditions like diabetes mellitus and hypertension, was collected through validated questionnaires. These questionnaires were adopted from a previous study (Ojulari *et al.,* 2024), where their validity and reliability were thoroughly assessed and confirmed. Examples of questions include inquiries about any diagnosis of chronic diseases and current medications.

Physical Activity Data
Athletes were classified as engaging in moderate-intensity physical activity for a minimum of 2.5 hours per week or a mix of moderate- and high-intensity activities for at least 1 hour and 15 minutes per week, together with resistance exercise at least three times per week. Participants who engaged in physical activity were categorised based on their response to the following inquiry: "How frequently do you perform exercises, such as push-ups, sit-ups, dumbbell exercises, weightlifting, or using the horizontal bar?"

Anthropometric Measurements
Trained laboratory staff conducted anthropometric measurements following standardised procedures. Height was measured to the nearest 0.1 cm using a stadiometer, and weight was measured to the nearest 0.1 kg using a calibrated scale. BMI was computed by dividing weight in kilograms by height in square meters.

Handgrip Strength (HGS) Assessment
HGS was measured using a digital grip strength dynamometer (Model TKK 5401; Takei Scientific Instruments Co. Ltd., Tokyo, Japan). Participants stood with feet hip-width apart, arms naturally extended, and wrists in a neutral posture. Measurements were taken with the middle finger at 90° to the handle while exhaling. The maximal hold time was 3 seconds, and each hand was tested thrice with 30-second breaks between measures. AHGS was calculated as the sum of the maximal values from both hands, and RHGS was defined as AHGS divided by BMI (HGS/BMI) to account for body weight.

Biochemical Analysis

Blood samples were collected after participants fasted overnight (8-12 hours). Standardised procedures measured fasting plasma glucose and insulin levels in a central certified laboratory.

Blood Pressure Measurement

Blood pressure was measured twice in the right arm using a conventional sphygmomanometer with a 5-minute gap between measurements. The average of the two readings was used. Proficient experts conducted all measurements.

Variable Definitions

The homeostasis model assessment of insulin resistance (HOMA-IR) is a mathematical model used to evaluate systemic insulin resistance (Qu *et al.,* 2011). It was determined by applying the equation: fasting Insulin (μIU/mL) x fasting glucose (mmol/L)/22.5 (Jiménez-Maldonado *et al.,* 2020). The homeostasis model assessment of β-cell function (HOMA-β) is an index of insulin secretory function derived from fasting plasma glucose and insulin concentrations (Sung *et al.,* 2010) and was assessed by the following formula: 20 x fasting insulin (μIU/mL)/fasting plasma glucose (mmol/L)-3.5 (Dasgupta & Shetty, 2023).

In this investigation, insulin resistance was defined as the highest one-third of the HOMA-IR values, with a cutoff greater than 1.89. Smoking was defined as the act of currently smoking and having consumed over 100 cigarettes in their lives. Alcohol consumption was defined as the act of consuming alcohol for a minimum of two days per week.

Statistical Analysis

The statistical analyses for this study were conducted using IBM SPSS 25.0 for Windows (IBM Corp., Armonk, NY, USA). The variables were assessed for normal distribution and characterised as weighted mean (± standard error of means [SEM]) or median (interquartile range). The study characteristics were summarised using descriptive statistics showing their mean, median, interquartile range and standard error of means. A subgroup analysis was conducted to determine sex differences in metabolic factors such as BMI, fasting blood glucose, fasting Insulin and handgrip strength using boxplot diagrams to describe mean differences.

Pearson's correlation analysis was used to determine the correlations and direction of the relationship between AHGS and RHGS with HOMA indices. Simple linear regression models were used to explain in more detail the relationships between the independent variables (AHGS & RHGS) and dependent variables (HOMA indices [HOMA-IR & HOMA-β]). Furthermore, multiple regression models were used to predict/estimate Insulin and beta cell sensitivity using AHGS & RHGS individually in each group with adjustment for confounding factors such as hand dominance, sex, age group (model 2), BMI, family diabetic history, alcohol intake, athletes (model 3). The associations between these models were depicted in scatter plot diagrams. *P* values less than 5% or less than 1% ($p<0.01$ or 0.05) were considered statistically significant.

Results

Clinical characteristics of the study population

The results demonstrated significant correlations between handgrip strength and insulin sensitivity. Higher AHGS and RHGS were associated with lower HOMA-IR and higher HOMA-β values, indicating better insulin sensitivity and pancreatic β-cell function. The correlations were strong in males, with significant negative relationships between AHGS/RHGS and HOMA-IR and positive correlations with

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HOMA-β. In females, however, the correlations were weaker and mostly insignificant, potentially due to higher fasting blood glucose, fasting Insulin, and BMI levels than males.

Table 1 displays the clinical features and biomarkers of the 158 individuals in the study. It includes the average values, quartiles, interquartile ranges, standard deviations, and standard errors of the mean. The statistics indicate that the participants generally have normal physical and metabolic health, as demonstrated by a mean AHGS of 51.87 kg and a mean BMI of 21.29 kg/m^2. The fasting blood glucose levels and insulin resistance indices were within the normal range, showing a population without diabetes. Moreover, a significant proportion of the individuals (86.8%) exhibited right-handedness, while a minority (7.5%) displayed left-handedness.

Table 1: Sample Clinical characteristics and biomarkers showing Mean, Quartiles, Interquartile Range, and Standard deviation of Continuous variables and Percent (%) of Categorical variables (N=158).

	Mean	Median	Min	Max	25%	75%	Interquartile Range (%)	STD Dev	SEM
AHGS (kg)	51.87	48.87	14.75	100.50	41.50	60.32	18.82	15.06	1.19
RHGS (m^2)	2.47	2.32	0.21	5.16	1.87	2.92	1.05	0.84	0.29
BMI (Kg/m^2)	21.29	20.72	11.54	38.6	18.72	23.0	4.28	3.64	1.44
Fasting Blood Glucose (mmol/L)	4.79	4.70	3.60	8.20	4.3	5.2	0.9	0.68	0.05
Fasting Insulin (µIU/L)	2.70	2.5	0.39	10.14	1.19	4.04	2.85	1.74	0.13
HOMA-IR	0.13	0.08	0.02	0.53	0.05	0.18	0.13	0.10	0.008
HOMA-β	57.18	42.26	5.23	293.21	19.69	79.12	59.43	52.10	4.14
	N	(%)							
Gender									
Male	79	49.7							
Female	79	49.7							
Age Group									
18-21	95	59.7							
22-25	62	39.0							
26-30	1	0.6							
Smokes									
Yes	9	5.7							
No	142	89.3							
Diabetic History									
Yes	27	17.0							
No	123	77.4							
Alcohol Intake									
Yes	6	10.2							
No	53	89.8							
Athlete									
Yes	86	54.1							
No	66	41.5							

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Hand Dominance		
Right	138	86.8
Left	12	7.5

Values are presented as mean± standard error or number (%). AHGS , Absolute Handgrip strength; RHGS, Relative handgrip strength; BMI, body mass index; HOMA-IR, homeostasis model assessment of insulin resistance; HOMA-β, Homeostatic Model Assessment of β-cell function.

Relationship between Handgrip strength and HOMA indices

Figure 1 shows the correlations between mean AHGS and mean RHGS with HOMA indices in the total subjects. A weak positive correlation exists between HOMA-β and mean AHGS/RHGS, while a moderately negative association exists between HOMA- IR and AHGS/RHGS. In this case, 22.1% and 22% of changes in HOMA-IR were linked to AHGS/RHGS, while about 14% of the changes in HOMA-β were linked to AHGS/RHGS.

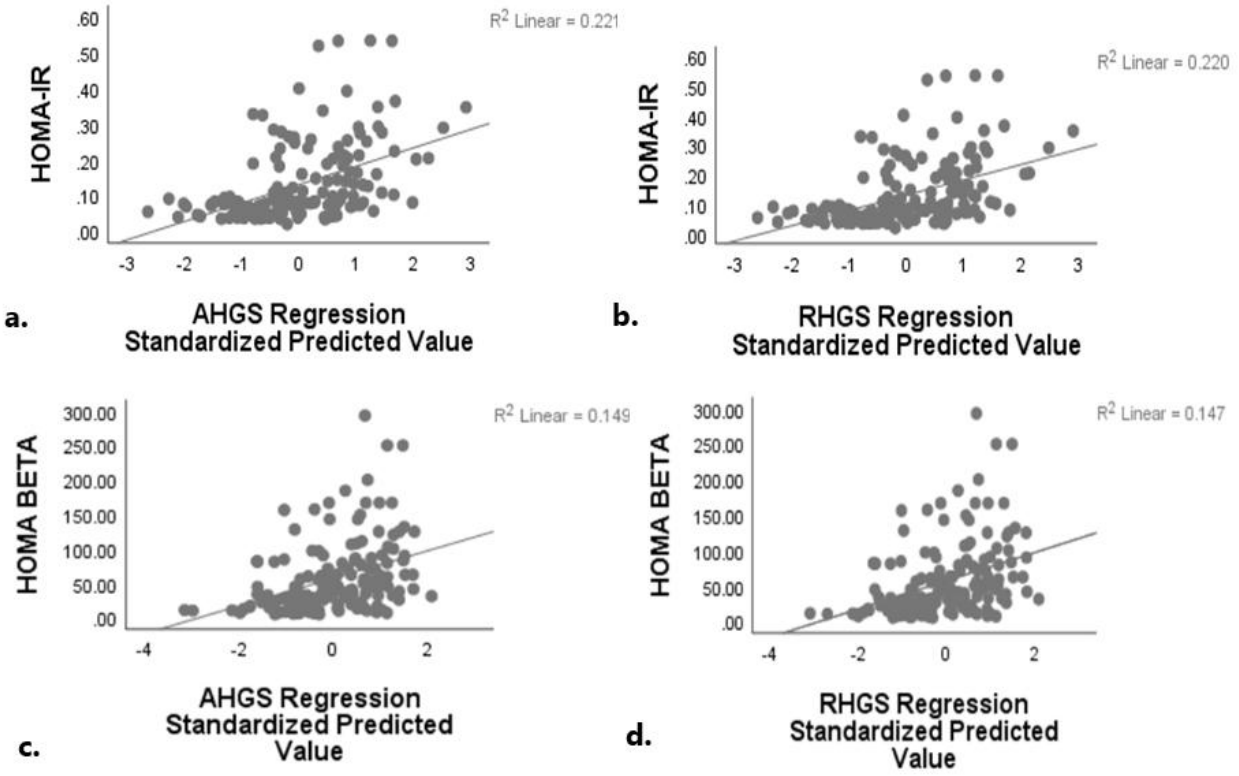

Figure 1: Scatter plot diagrams showing the prediction of HOMA indices by AHGS and RHGS

Table 2 presents a detailed analysis of linear and multiple regression models, illustrating the associations between Relative Handgrip Strength (RHGS) and Absolute Handgrip Strength (AHGS)

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with insulin sensitivity indices (HOMA-IR and HOMA-β). For HOMA-IR, the simple linear regression model for AHGS (Model 1) shows a modest but significant association with a correlation coefficient (R) of 0.203, R^2 of 0.041, and a p-value of 0.011. This association improves significantly in Model 2 (R = 0.443, R^2 = 0.196, p < 0.001) after adjusting for hand dominance, age group, and sex. Further, it improves in Model 3 (R = 0.470, R^2 = 0.221, p < 0.001) with additional adjustments for diabetic history, alcohol intake, and athlete status. Similarly, RHGS shows a stronger initial association with HOMA-IR in Model 1 (R = 0.284, R^2 = 0.081, p < 0.001), which also strengthens significantly in Model 2 (R = 0.443, R^2 = 0.197, p < 0.001) and Model 3 (R = 0.467, R^2 = 0.218, p < 0.001). For HOMA-β, the initial model for AHGS (Model 1) shows no significant relationship (R = 0.087, R^2 = 0.008, p = 0.276) but becomes important in Model 2 (R = 0.356, R^2 = 0.127, p = 0.001) and further improves in Model 3 (R = 0.385, R^2 = 0.149, p = 0.002). In contrast, RHGS shows a significant association with HOMA-β starting from Model 1 (R = 0.201, R^2 = 0.040, p = 0.012), with improved associations in Model 2 (R = 0.325, R^2 = 0.106, p = 0.002) and Model 3 (R = 0.365, R^2 = 0.133, p = 0.003).

Table 2: Linear and Multiple Regression Analysis of RHGS and AHGS with other variables as predictors for Insulin sensitivity indices (HOMA-IR &HOMA-β).

Independent variable	Dependent Variable					
	HOMA-IR					
AHGS Model		R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig
1		.203[a]	.041	.035	.10794	**.011**
2		.443[b]	.196	.169	.10014	**.000**
3		.470[c]	.221	.179	.09957	**.000**
RHGS						
1		.284[a]	.081	.075	.10569	**.000**
2		.443[b]	.197	.176	.09977	**.000**
3		.467[c]	.218	.181	.09941	**.000**
	HOMA-β					
AHGS						
1		.087[a]	.008	.001	52.07508	.276
2		.356[b]	.127	.098	49.48630	**.001**
3		.385[c]	.149	.103	49.35607	**.002**
RHGS						
1		.201[a]	.040	.034	51.21188	**.012**
2		.325[b]	.106	.082	49.91646	**.002**
3		.365[c]	.133	.092	49.64037	**.003**

Note: Boldface indicates statistical significance (p<0.05 or <0.01).

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SE denotes standard error.

[a] Simple Linear regression analysis of AHGS/RHGS and HOMA indices without covariates

[b] Adjusted for covariables in model (a), Hand dominance, Age group, Sex

[c] Adjusted for covariables in model (b), Diabetic History, Alcohol intake, Athletes

RHGS; Relative Handgrip Strength, AHGS; Absolute Handgrip Strength, HOMA-IR; Homeostatic Model Assessment for Insulin Resistance, HOMA-β; Homeostatic Model Assessment for β-cell Function.

Subgroup Analysis

Sex differences in Handgrip strength, FBG, Fasting insulin and BMI

The box plots (**Figure 2**) reveal that males exhibit significantly higher median AHGS and RHGS compared to females. Males have an AHGS median of 60 kg and RHGS median of 3 m^2, while females have medians of 40 kg and 2.5 m^2, respectively. Males also show greater variability in AHGS, with an interquartile range (IQR) of 40-80 kg and whiskers extending beyond 100 kg, whereas females have an IQR of 30-50 kg and whiskers just below 70 kg. For RHGS, males display an IQR of 2.5-4 m^2, with whiskers from 2-5 m^2, whereas females have an IQR of 2-3 m^2 and whiskers slightly over 4 m^2, with notable outliers. This indicates that males generally have stronger HGS with more variability, particularly in AHGS.

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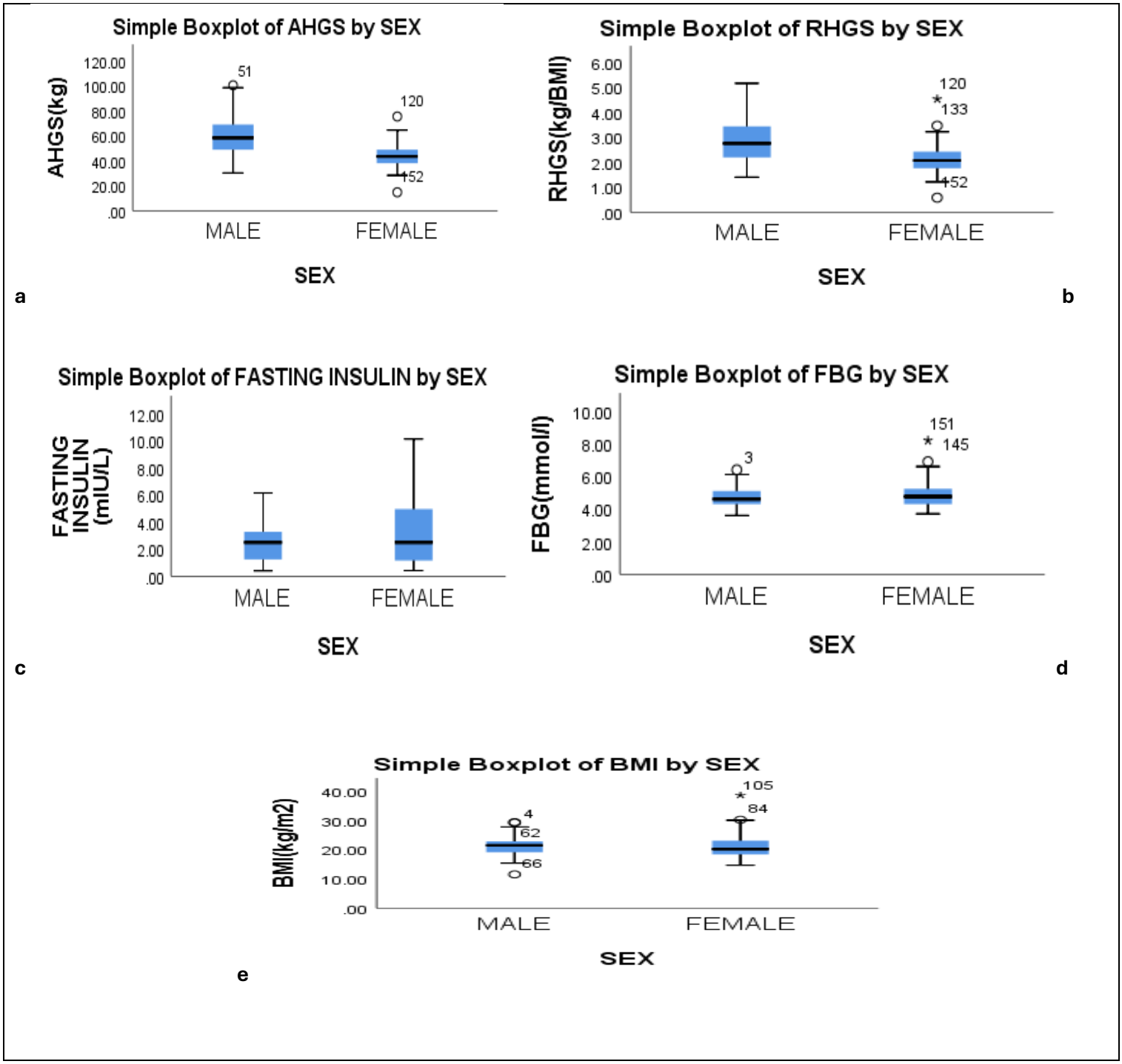

Figure 2: Boxplots showing subgroup analysis comparisons of AHGS, RHGS, Fasting blood glucose, fasting Insulin and BMI by sex, with notable significant differences except for FBG. The t-test shows that AHGS and RHGS were greater in males than females while fasting Insulin and BMI were greater in females than males. AHGS ($P<0.01$), RHGS ($P<0.01$), Fasting Insulin ($p<0.05$), FBG ($P>0.05$).

Contrastingly, the boxplots of fasting Insulin and BMI were significantly higher in females than males, while no significant difference was noted in the FBG between sexes.

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Table 3 shows Pearson's correlation analysis of the relationship between Relative Handgrip Strength

TABLE 3: Pearson's Correlation Analysis of RHGS and AHGS with Insulin Sensitivity Indices by Sex

	Males		Females	
	(R)	Sig.	(R)	Sig.
			HOMA-IR	
AHGS	-0.365	**0.001**	-0.089	0.434
RHGS	-0.403	**0.000**	-0.283	**0.034**
			HOMA-β	
AHGS	0.202	0.075	**0.038**	0.741
RHGS	0.273	**0.015**	0.232	**0.039**

Note: Boldface indicates statistical significance (*p*<0.05 or <0.01).
R denotes Pearson's Correlation Coefficient.
RHGS; Relative Handgrip Strength, AHGS; Absolute Handgrip Strength, HOMA-IR; Homeostatic Model Assessment for Insulin resistance, HOMA-β; Homeostatic Model Assessment for β-cell Function.

(RHGS) and Absolute Handgrip Strength (AHGS) with insulin sensitivity indicators categorised by sex. Among males, there were notable inverse associations between RHGS and HOMA-IR ($r = -0.403$, $p < 0.001$) as well as between AHGS and HOMA-IR ($r = -0.365$, $p = 0.001$). This moderate negative correlation shows that about 40%- and 36%-times greater handgrip strength is linked to reduced insulin resistance in males. In contrast, there were positive associations found between RHGS and HOMA-β ($R = 0.273$, $p = 0.015$) and between AHGS and HOMA-β ($R = 0.202$, $p = 0.075$), indicating that greater handgrip strength is linked to improved beta-cell function. However, this was only significant for RHGS.

The associations exhibited lower strength in the female population and were predominantly not statistically significant. The correlation between RHGS and HOMA-IR ($R = -0.283$, $p = 0.034$) was statistically significant, although it was weaker than in men. Furthermore, the association between RHGS and HOMA-β ($R = 0.232$, $p = 0.039$) was statistically significant but was still comparatively less than in males. The associations between AHGS and HOMA-IR ($R = -0.089$, $p = 0.434$) and HOMA-β ($R = 0.038$, $p = 0.741$) were insignificant.

Discussion

This is the first Nigerian study that sought to determine the relationship between handgrip strength, insulin resistance and pancreatic beta cell function in young, non-diabetic Nigerian adults.

The results indicate that both AHGS and RHGS are significantly associated with insulin sensitivity indices, particularly HOMA-IR, with RHGS generally showing slightly stronger associations. Adjustments for covariates such as hand dominance, age group, sex, diabetic history, alcohol intake, and athlete status significantly improve the model's explanatory power. Model 3 for both AHGS and RHGS emerged as the best-fit model for predicting HOMA-IR and HOMA-β, as it demonstrated the highest R^2 values and the lowest p-values, indicating strong statistical significance and greater explanatory power.

These findings highlight the importance of considering multiple covariates in regression analyses to accurately assess the relationships between handgrip strength and insulin sensitivity indices.

Specifically, AHGS and RHGS were inversely correlated with HOMA-IR and positively correlated with HOMA-β, suggesting that greater muscle strength is linked to improved insulin sensitivity and pancreatic β-cell function.

The subgroup analysis revealed significant sex differences in HGS and its associations with metabolic indices. Males exhibited significantly higher median AHGS and RHGS than females, with more substantial variability in AHGS. This difference is likely due to physiological disparities, such as muscle mass and strength distribution between sexes (Zheng *et al.,* 2021).

In males, both AHGS and RHGS were strongly and inversely associated with HOMA-IR, indicating that increased muscle strength is linked to reduced insulin resistance. Additionally, RHGS showed a significant positive correlation with HOMA-β, suggesting enhanced β-cell function with higher relative strength.

Conversely, in females, the associations were generally weaker and primarily insignificant, except for RHGS, which maintained a statistically significant, albeit weaker, correlation with HOMA-IR and HOMA-β. The sex differences between correlations of AHGS, RHGS, and HOMA indices indicate a possible link between greater muscular strength and insulin sensitivity. This is consistent with other research that suggests a positive correlation between greater muscle mass in males and enhanced insulin sensitivity (Haines *et al*., 2020).

Engaging in physical activity improves muscle strength and boosts insulin sensitivity—nevertheless, the less potent and insignificant associations identified in females prompt inquiries concerning the underlying processes. The hormone variations between genders, such as oestrogen and insulin resistance, may account for these disparities. Furthermore, the elevated levels of fasting blood glucose, fasting Insulin, and BMI reported in females may indicate more significant insulin resistance and obesity. This might weaken the correlation between muscular strength and insulin sensitivity. The mechanism might also be due to the chromosomes and sociocultural differences; men have relatively more substantial muscle mass (Pan *et al.,* 2020), higher inflammatory levels (Visser *et al.,* 2002) and lower insulin sensitivity (Zheng *et al.,* 2021) than women.

The regression models further confirmed the differential impact of HGS on insulin sensitivity between sexes. RHGS consistently showed stronger associations with HOMA indices than AHGS across multiple models, highlighting its potential as a more reliable indicator of metabolic health. The comprehensive models demonstrated that RHGS measures could explain 22% of the variation in HOMA-IR and 14% in HOMA-β, underscoring the significant role of muscle strength in metabolic regulation.

Mechanistically, muscle mass and function influence glucose metabolism by promoting GLUT 4 translocation and improving Insulin signalling pathways (Ritcher, 2021). Moreover, muscle contractions stimulate AMP-activated protein kinase activation, promoting glucose uptake and metabolism and reducing blood glucose levels and insulin resistance (Merz & Thurmond, 2020). Additionally, the skeletal muscles secrete myokines like irisin, which improve sensitivity and regulate glucose metabolism.

Comparable studies have reported similar findings, highlighting the relevance of muscle strength in metabolic regulation. A survey conducted by Kurniawan et al. (2024) in Indonesia on 165 non-diabetic young adults aged 18-40 years found that only RHGS, not AHGS, was significantly associated with insulin resistance measured by HOMA-IR. This study emphasised the importance of adjusting handgrip strength for body weight to reflect skeletal muscle condition accurately. Similarly, a Korean study by Lee *et al.* (2022) found an inverse association between RHGS and the prevalence of diabetes mellitus, with stronger correlations in men and premenopausal women. The proposed mechanisms associated low muscle strength with increased inflammatory markers like

TNF-α, IL-6, and CRP. Another study by Lee *et al*. (2024) on Korean adults highlighted the role of muscle strength in improving insulin activity and glucose consumption, with significant gender differences observed in the relationship between RHGS and DM incidence.

Furthermore, Jung *et al*. (2022) analysed data from the Korea National Health and Nutrition Examination Survey (KNHANES). They found that reduced HGS was significantly associated with adverse cardiometabolic health outcomes, including metabolic syndrome (MetS) and insulin resistance in children and adolescents. This study proposed that HGS is a reliable indicator of metabolic health due to its role in glucose, protein, fatty acid metabolism, myokine secretion, and reducing systemic inflammation and oxidative stress.

Additionally, a study on elderly Korean men by Joo *et al*. (2022) found that lower RHGS was significantly associated with higher insulin resistance, proposing mechanisms such as decreased GLUT4 expression, increased inflammation, and oxidative stress with ageing. Another study by Jang *et al*. (2020) found that low RHGS was significantly associated with increased odds of prediabetes in South Korean men, emphasising the role of muscle strength and central obesity in diabetes risk.

In Saudi children with chronic Type 1 Diabetes Mellitus, Al-Qahtani *et al*. (2023) found no statistically significant difference in HGS between different glycemic control groups. However, a significant positive linear correlation between age and HGS was observed among diabetic children, suggesting mechanisms like protein catabolism, reduced IGF-1 levels, and protein glycation due to chronic hyperglycemia affecting muscle function.

Overall, while our study highlighted the significant role of AHGS and RHGS in insulin sensitivity and β-cell function, other studies emphasised the importance of RHGS as a more accurate predictor of metabolic health and insulin resistance. The variations in findings across different populations underscore the influence of demographic, physiological, and methodological differences in understanding the relationship between HGS and metabolic health.

Limitations/Strengths of the Study

This study represents a significant advancement as it is the first to be conducted in Nigeria using a non-diabetic cohort. The innovative use of HGS to predict insulin sensitivity and potentially diabetes holds promise for enhancing metabolic health in Nigeria. However, there are several limitations to this study. The cross-sectional design only provides a snapshot in time, making it difficult to establish causal relationships between HGS, insulin sensitivity, and pancreatic β-cell function. Additionally, the focus on young, non-diabetic Nigerians limits the generalizability of the results to other age groups and populations.

Longitudinal studies will be necessary to confirm the predictive validity of HGS and establish causality. These would help us understand the temporal relationship between HGS and metabolic health outcomes. Given the documented correlation between higher HGS, improved insulin sensitivity, and beta cell function, this study emphasises further research to explore these relationships and extend the findings to more diverse populations.

Furthermore, several factors could have influenced the results. First, we could only determine an association between handgrip strength, insulin resistance, and pancreatic β-cell function, not causality. Second, residual factors may not be included in this study. Third, health-related characteristics like smoking and drinking status were measured through self-reported questionnaires. Lastly, using data from young Nigerian adults may limit the applicability of our results to other age and ethnic groups.

Conclusion

In conclusion, this study examines the relationship between HGS, insulin sensitivity, and pancreatic β-cell activity in non-diabetic young adults from Nigeria. The findings imply that HGS may serve as a potential indicator of metabolic health. Further investigation is required to determine the processes that confirm the validity of these relationships across different populations and explore the underlying mechanisms driving the sex-specific differences observed.

Acknowledgement

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Conflict of Interest: None declared.

Availability of Data Statement

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request. This study includes data related to handgrip strength, insulin sensitivity, and beta-cell function measurements in non-diabetic young Nigerian adults.

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