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Effects of a 12-Week Resistance Training Program on Glycemic Control and Insulin Sensitivity in Adults With Type 2 Diabetes in Akwa Ibom State

Dr. Esther U. Andrews[1], Ekemini P. Asuquo[2]

Physical and Health Education Department
Akwa Ibom State University of Education, Afaha Nsit

Abstract: The study examined the effects of a 12-week resistance training program on glycemic control and insulin sensitivity among adults with type 2 diabetes in Akwa Ibom State, Nigeria. The purpose of the study was to determine whether structured resistance training could improve fasting blood glucose, glycated hemoglobin (HbA1c), and insulin sensitivity in this population. The study was guided by three research questions and three corresponding null hypotheses. A quasi-experimental pretest–posttest control group design was adopted. Forty adults aged 30–60 years with diagnosed type 2 diabetes were purposively selected and assigned to an intervention group (n = 20) and a control group (n = 20). The intervention group participated in a supervised 12-week resistance training program conducted 2–3 times per week, while the control group received usual medical care without structured exercise. Data were collected using standardized instruments, including a glucometer for fasting blood glucose, laboratory assays for HbA1c, and fasting insulin measurements used to compute insulin sensitivity via the Homeostatic Model Assessment for Insulin Resistance (HOMA-IR). Data were analyzed using descriptive statistics and t-tests at the 0.05 level of significance. The findings revealed significant reductions in fasting blood glucose and HbA1c levels, as well as a significant improvement in insulin sensitivity among participants in the intervention group, while no significant changes were observed in the control group. These results indicate that resistance training is an effective non-pharmacological strategy for improving metabolic control in adults with type 2 diabetes. The findings imply that integrating resistance training into routine diabetes management could enhance treatment outcomes and reduce complication risk. It is recommended that healthcare providers and policymakers promote structured resistance training as part of standard diabetes care in Akwa Ibom State.

Keywords: Resistance training, Type 2 diabetes mellitus, Glycemic control, Insulin sensitivity, Fasting blood glucose, HbA1c, HOMA-IR.

Introduction

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycemia arising from a combination of insulin resistance and relative insulin deficiency. Unlike type 1 diabetes, which is autoimmune in nature, T2DM develops progressively and is strongly associated with modifiable lifestyle factors such as physical inactivity, unhealthy dietary patterns, overweight, and obesity, alongside genetic predisposition. At the physiological level, the condition is marked by impaired insulin action in key metabolic tissues particularly skeletal muscle, adipose tissue, and the liver leading to reduced peripheral glucose uptake and increased hepatic glucose output. These abnormalities collectively sustain elevated blood glucose concentrations and contribute to long-term metabolic dysregulation [1].

Globally, T2DM represents one of the most prevalent non-communicable diseases and accounts

for the majority of diabetes cases worldwide. Its burden continues to rise, with the most rapid increases observed in low- and middle-income countries undergoing urbanization, nutritional transition, and declining physical activity levels. In Nigeria, recent systematic reviews estimate adult prevalence rates of approximately 6–7%, with evidence of higher prevalence in southern regions, including the South-South geopolitical zone where Akwa Ibom State is located. This growing burden has been largely attributed to increasing sedentary lifestyles, dietary shifts toward energy-dense foods, and rising levels of obesity [2].

A central goal in the management of T2DM is the achievement and maintenance of optimal glycemic control. Glycemic control refers to the regulation of blood glucose concentrations within recommended clinical targets over both short- and long-term periods. Clinically, this is commonly assessed using fasting plasma glucose, which reflects baseline glycemic status, and glycated hemoglobin (HbA1c), which provides an index of average blood glucose levels over the preceding 8–12 weeks. Poor glycemic control is strongly associated with the development of diabetes-related complications, including cardiovascular disease, nephropathy, neuropathy, and retinopathy. Conversely, even modest improvements in HbA1c have been shown to substantially reduce the risk of complications and diabetes-related mortality. In many low-resource settings, including Akwa Ibom State, inadequate glycemic control remains common due to limited access to comprehensive diabetes care and insufficient emphasis on lifestyle-based interventions [3].

Closely linked to glycemic control is insulin sensitivity, which describes the responsiveness of body tissues to insulin-mediated glucose uptake. Reduced insulin sensitivity, commonly referred to as insulin resistance, is a fundamental pathophysiological feature of T2DM and a major contributor to chronic hyperglycemia. Improving insulin sensitivity enhances glucose disposal, lowers circulating insulin requirements, and supports more stable glycemic regulation (Su et al., 2024). Skeletal muscle plays a particularly critical role in this process, as it accounts for a large proportion of insulin-stimulated glucose uptake in the postprandial state. Consequently, interventions that target skeletal muscle function are especially relevant for improving metabolic control in individuals with T2DM [4].

The management of T2DM is inherently multifaceted and typically involves a combination of pharmacological therapy, dietary modification, and lifestyle interventions. Among these strategies, regular physical activity is widely recognized as a cornerstone of diabetes management due to its direct effects on glucose metabolism and insulin action. Current clinical guidelines recommend the inclusion of both aerobic and muscle-strengthening activities to improve glycemic outcomes and reduce the risk of diabetes-related complications. Despite these recommendations, physical inactivity remains highly prevalent among adults with T2DM, particularly in low-resource settings, contributing to poor metabolic control and increased complication risk [5].

In recent years, resistance training (RT) has gained increasing attention as a targeted exercise modality with distinct metabolic benefits for individuals with T2DM. Resistance training involves repeated muscle contractions against external resistance, such as free weights, resistance bands, machines, or body weight, and is based on the principle of progressive overload, whereby gradually increasing resistance induces muscular adaptations. These adaptations include increases in muscle mass and strength, improvements in neuromuscular efficiency, and enhanced metabolic capacity. At the cellular level, resistance training promotes glucose uptake through increased expression and translocation of glucose transporter type 4 (GLUT4) and improved insulin signaling pathways, thereby enhancing insulin sensitivity and glycemic regulation.

Evidence from randomized controlled trials and meta-analyses indicates that structured resistance training programs can lead to clinically meaningful reductions in fasting plasma glucose and HbA1c levels among adults with T2DM, with average HbA1c reductions of approximately 0.5%. In addition to glycemic benefits, resistance training has been associated with favorable changes in body composition, lipid profiles, and visceral adiposity, all of which are relevant to the broader

metabolic disturbances accompanying T2DM. However, the magnitude of these benefits varies according to training intensity, frequency, duration, and level of supervision, and empirical evidence from African populations remains limited [6].

In Akwa Ibom State, the rising prevalence of T2DM, combined with widespread physical inactivity and limited access to structured exercise programs, underscores the need for feasible, culturally appropriate, and cost-effective lifestyle interventions. Despite the growing recognition of exercise as a therapeutic tool, diabetes management in many Nigerian settings remains predominantly pharmacological, with insufficient emphasis on resistance-based exercise strategies that directly target insulin resistance. This gap is particularly significant given the central role of skeletal muscle in glucose disposal and metabolic regulation. Against this backdrop, the present study was designed to address the lack of locally generated empirical evidence on the effectiveness of structured resistance training in improving glycemic control and insulin sensitivity among adults with T2DM in Akwa Ibom State. By evaluating the effects of a 12-week resistance training program on fasting blood glucose, glycated hemoglobin, and insulin sensitivity, the study seeks to provide context-specific evidence to inform clinical practice, support the integration of resistance training into routine diabetes management, and guide public health strategies tailored to the sociocultural and resource context of the state [7].

Statement of the Problem

Type 2 diabetes mellitus (T2DM) is a growing public health concern both globally and in Nigeria, characterized by elevated blood glucose levels due to impaired insulin action and relative insulin deficiency. Ideally, effective management of T2DM should achieve sustained glycemic control and improved insulin sensitivity through a combination of pharmacological therapy, proper nutrition, and structured lifestyle interventions, particularly exercise. Resistance training, as a form of muscle-strengthening exercise, has been shown to improve glucose metabolism, enhance insulin responsiveness, and reduce the risk of diabetes-related complications. Under optimal conditions, adults with T2DM would have access to supervised and culturally appropriate resistance training programs that support long-term metabolic health and overall well-being.

In reality, however, glycemic control among adults with T2DM remains largely inadequate, especially in low-resource settings such as Akwa Ibom State. Diabetes management is predominantly pharmacologically oriented, with limited integration of structured exercise programs into routine care. Many adults with T2DM experience persistently high blood glucose and HbA1c levels, reflecting poor metabolic control and an increased risk of complications. Physical inactivity is widespread, and opportunities for guided resistance training are scarce due to insufficient facilities, limited professional support, and low awareness of the benefits of strength-based exercise. As a result, the underlying insulin resistance central to T2DM often remains inadequately addressed, compromising long-term health outcomes [8].

The critical gap lies in the scarcity of locally generated empirical evidence evaluating the effectiveness of structured resistance training programs for adults with T2DM in Akwa Ibom State. Although international studies have demonstrated that resistance training can significantly improve glycemic control and insulin sensitivity, most of this evidence originates from high-income countries and may not be directly transferable to Nigerian populations with different healthcare structures, lifestyle patterns, and resource constraints. This lack of context-specific data has limited the integration of resistance training into routine diabetes management and public health programming within the state. Consequently, there is a need for empirical research that assesses whether a structured resistance training intervention can produce meaningful metabolic improvements among adults with T2DM in Akwa Ibom State. The present study sought to address this gap by evaluating the effects of a 12-week resistance training program on fasting blood glucose, glycated hemoglobin, and insulin sensitivity, thereby providing evidence

to inform clinical practice and guide locally relevant diabetes management strategies [9].

Purpose of the Study

The purpose of this study was to investigate the effects of a 12-week structured resistance training program on glycemic control and insulin sensitivity among adults with type 2 diabetes in Akwa Ibom State. Specifically the study sought:

1. To determine the effect of a 12-week resistance training program on fasting blood glucose levels in adults with type 2 diabetes in Akwa Ibom State by comparing pre- and post-intervention measurements.

2. To evaluate the impact of a 12-week resistance training program on glycated hemoglobin (HbA1c) levels in adults with type 2 diabetes in Akwa Ibom State through systematic pre- and post-intervention assessment.

3. To assess the effect of a 12-week resistance training program on insulin sensitivity in adults with type 2 diabetes in Akwa Ibom State by comparing changes in insulin responsiveness pre-intervention and post-intervention.

Research Questions

The following research questions guided the study:

1. What is the effect of a 12-week resistance training program on fasting blood glucose levels in adults with type 2 diabetes in Akwa Ibom State?

2. How does a 12-week resistance training program affect glycated hemoglobin (HbA1c) levels in adults with type 2 diabetes in Akwa Ibom State?

3. What is the impact of a 12-week resistance training program on insulin sensitivity in adults with type 2 diabetes in Akwa Ibom State?

Hypotheses

The following null hypotheses were generated to guide the study and test at 0.05 level of significant.

1. There is no significant effect of a 12-week resistance training program on fasting blood glucose levels in adults with type 2 diabetes in Akwa Ibom State.

2. A 12-week resistance training program has no significant effect on glycated hemoglobin (HbA1c) levels in adults with type 2 diabetes in Akwa Ibom State.

3. A 12-week resistance training program does not significantly affect insulin sensitivity in adults with type 2 diabetes in Akwa Ibom State.

Methodology

This study adopted a quasi-experimental pretest-posttest design with a control group to investigate the effects of a 12-week resistance training program on glycemic control and insulin sensitivity among adults with type 2 diabetes in Akwa Ibom State. The design allowed for the comparison of metabolic outcomes between participants who underwent the intervention and those who did not, providing evidence on the effectiveness of structured resistance training. The study population comprised adults aged 30–60 years diagnosed with type 2 diabetes mellitus and attending primary healthcare facilities in Akwa Ibom State. Participants were required to be

medically stable and physically able to perform exercise. Individuals with severe diabetes-related complications, uncontrolled hypertension, or other contraindications to physical activity were excluded. A total of forty participants were recruited using purposive sampling, ensuring they met the inclusion criteria and consented to participate in the study. They were evenly divided into two groups: twenty participants in the intervention group, who participated in the 12-week resistance training program, and twenty participants in the control group, who continued their usual medical care without structured exercise.

Data on glycemic control and insulin sensitivity were collected using validated instruments. Fasting blood glucose was measured using a standard glucometer following an overnight fast of 8–10 hours to establish baseline and post-intervention levels. Glycated hemoglobin (HbA1c) was assessed using standardized laboratory assays to evaluate average blood glucose over the preceding 8–12 weeks. Fasting insulin levels were determined through immunoassay techniques, and insulin sensitivity was estimated using the Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) formula. These instruments provided reliable and objective measurements of the primary metabolic outcomes. The intervention consisted of a 12-week structured resistance training program targeting major muscle groups, including the upper and lower body as well as the core. Exercises included squats, lunges, leg press, chest press, seated row, shoulder press, and abdominal exercises. Sessions were held 2–3 times per week, lasting 45–60 minutes, including warm-up and cool-down periods. The program followed the principle of progressive overload: during weeks 1–4, participants exercised at 50–60% of their one-repetition maximum (1RM) for 2 sets of 12–15 repetitions; during weeks 5–8, intensity increased to 60–70% of 1RM for 3 sets of 10–12 repetitions; and during weeks 9–12, intensity was further increased to 70–80% of 1RM for 3–4 sets of 8–10 repetitions. All sessions were supervised by trained personnel to ensure proper technique, safety, and adherence, and attendance was recorded throughout the program. Participants were instructed to maintain their usual diet and medications during the study period.

The control group maintained their routine care without participating in any structured exercise program, serving as a comparison to evaluate the effect of the resistance training intervention. Pre- and post-intervention assessments were conducted for both groups within one week before and after the 12-week period. Data were analyzed using SPSS Version 25. Descriptive statistics, including means and standard deviations, were used to summarize participant characteristics and baseline measurements. Paired sample t-tests were performed to compare pre- and post-intervention values within groups, while independent sample t-tests were used to compare post-intervention outcomes between the intervention and control groups. Statistical significance was set at $p < 0.05$, and effect sizes were calculated to determine the magnitude of changes resulting from the resistance training program. This methodological approach provided a comprehensive framework to evaluate the effectiveness of a 12-week resistance training program on improving glycemic control and insulin sensitivity in adults with type 2 diabetes in Akwa Ibom State, offering evidence to support the integration of resistance exercise into routine diabetes management in the local context.

Results

Research Question 1: What is the effect of a 12-week resistance training program on fasting blood glucose levels in adults with type 2 diabetes in Akwa Ibom State?

Table 1: Mean and Standard Deviation of fasting blood glucose Levels Before and After the 12-Week Resistance Training Program

Group	Pre-Intervention FBG (mmol/L) Mean ± SD	Post-Intervention FBG (mmol/L) Mean ± SD
Intervention (n=20)	9.8 ± 1.2	7.4 ± 1.0

Control (n=20)	9.6 ± 1.1	1.3 ± 1.2

Table 1 presents the mean and standard deviation of fasting blood glucose (FBG) levels for both the intervention and control groups measured before and after the 12-week resistance training program. In the intervention group, the mean FBG declined from 9.8 mmol/L (SD = 1.2) at pre-intervention to 7.4 mmol/L (SD = 1.0) at post-intervention, indicating a notable reduction in fasting blood glucose and suggesting enhanced glycemic control among participants who completed the structured exercise program. The decrease in standard deviation also reflects slightly greater consistency in FBG levels following the intervention. Conversely, the control group showed a smaller change in mean FBG, decreasing from 9.6 mmol/L (SD = 1.1) to 9.3 mmol/L (SD = 1.2), suggesting that participants who did not participate in the resistance training experienced minimal improvement over the 12-week period. The slight increase in standard deviation for the control group indicates more variability in glucose levels among these participants. Overall, these descriptive results suggest that the 12-week resistance training program positively influenced fasting blood glucose levels, whereas the control group maintained relatively stable FBG levels, highlighting the potential effectiveness of resistance training in managing glycemia in adults with type 2 diabetes [10].

Research Question 2: How does a 12-week resistance training program affect glycated hemoglobin (HbA1c) levels in adults with type 2 diabetes in Akwa Ibom State?

Table 2 : Mean and Standard Deviation of HbA1c Levels Before and After the 12-Week Resistance Training Program

Group	Pre-Intervention HbA1c (%) Mean ± SD	Post-Intervention HbA1c (%) Mean ± SD
Intervention (n=20)	8.5 ± 0.9	7.1 ± 0.8
Control (n=20)	8.4 ± 1.0	8.2 ± 1.1

Table 2 presents the mean and standard deviation of glycated hemoglobin (HbA1c) levels for both the intervention and control groups measured before and after the 12-week resistance training program. The intervention group showed a notable reduction in HbA1c, with the mean decreasing from 8.5% (SD = 0.9**)** at pre-intervention to 7.1% (SD = 0.8) at post-intervention. This decline reflects a significant improvement in long-term glycemic control among participants who completed the structured resistance training program. In contrast, the control group experienced only a slight decrease in HbA1c, from 8.4% (SD = 1.0) to 8.2% (SD = 1.1), indicating minimal change in long-term blood glucose regulation among participants who did not participate in the exercise program. Overall, these descriptive statistics suggest that the 12-week resistance training program effectively improved HbA1c levels, highlighting its potential as a strategy to enhance long-term glycemic control in adults with type 2 diabetes in Akwa Ibom State [11].

Research Question 3: What is the impact of a 12-week resistance training program on insulin sensitivity in adults with type 2 diabetes in Akwa Ibom State?

Table 3: Mean and Standard Deviation of Insulin Sensitivity Before and After the 12-Week Resistance Training Program

Group	Pre-Intervention HOMA-IR Mean ± SD	Post-Intervention HOMA-IR Mean ± SD
Intervention (n=20)	3.2 ± 0.5	2.1 ± 0.4

Group	Pre-Intervention HOMA-IR Mean ± SD	Post-Intervention HOMA-IR Mean ± SD
Control (n=20)	3.1 ± 0.6	3.0 ± 0.5

Table 3 presents the mean and standard deviation of insulin sensitivity, assessed using HOMA-IR, for both the intervention and control groups before and after the 12-week resistance training program. The intervention group demonstrated a marked improvement in insulin sensitivity, with the mean HOMA-IR decreasing from 3.2 (SD = 0.5) at baseline to 2.1 (SD = 0.4) following the program. This reduction indicates enhanced insulin responsiveness among participants who engaged in resistance training, reflecting better overall metabolic control. In contrast, the control group exhibited minimal change, with mean HOMA-IR declining slightly from 3.1 (SD = 0.6) to 3.0 (SD = 0.5), suggesting little to no improvement in insulin sensitivity among those who did not participate in structured exercise. Collectively, these descriptive findings indicate that the 12-week resistance training program had a positive effect on insulin sensitivity in adults with type 2 diabetes, underscoring its potential as an effective non-pharmacological strategy for improving metabolic health in this population [12].

Testing of Hypotheses

Hypothesis 1: There is no significant effect of a 12-week resistance training program on fasting blood glucose levels in adults with type 2 diabetes in Akwa Ibom State.

Table 4: **Effect of 12-Week Resistance Training on Fasting Blood Glucose in Adults with Type 2 Diabetes**

Group	Pre-Intervention FBG (mg/dL)	Post-Intervention FBG (mg/dL)	t	p-value	Interpretation
Intervention	147.4 ± 14.4	123.8 ± 15.9	21.87	0.000	Significant decrease in FBG
Control	147.6 ± 12.3	145.8 ± 14.4	1.48	0.155	No significant change in FBG

Note: FBG = Fasting Blood Glucose; SD = Standard Deviation.

Table 4 presents the mean fasting blood glucose (FBG) levels before and after the 12-week resistance training program for both the intervention and control groups. Participants in the intervention group experienced a notable reduction in FBG, with the mean value decreasing from 147.4 ± 14.4 mg/dL at pre-intervention to 123.8 ± 15.9 mg/dL post-intervention. This decline was statistically significant ($t = 21.87$, $p < 0.001$), indicating that the resistance training program effectively improved glycemic control in adults with type 2 diabetes. In contrast, the control group showed only a slight, non-significant decrease in FBG, from 147.6 ± 12.3 mg/dL to 145.8 ± 14.4 mg/dL ($t = 1.48$, $p = 0.155$), suggesting minimal change among participants who did not engage in structured exercise. Overall, these findings indicate that the 12-week resistance training program had a significant positive effect on fasting blood glucose levels, supporting its potential as a non-pharmacological intervention for improving metabolic health in this population [13].

Hypothesis 2: A 12-week resistance training program has no significant effect on glycated hemoglobin (HbA1c) levels in adults with type 2 diabetes in Akwa Ibom State.

Table 5. Effect of 12-Week Resistance Training on Glycated Hemoglobin (HbA1c) Levels in Adults with Type 2 Diabetes

Group	Pre-Intervention HbA1c (%)	Post-Intervention HbA1c (%)	t	p-value	Interpretation
Intervention	8.2 ± 0.7	6.9 ± 0.6	14.56	0.000	Significant decrease in HbA1c
Control	8.1 ± 0.6	8.0 ± 0.7	1.12	0.275	No significant change in HbA1c

Note: HbA1c = Glycated Hemoglobin; SD = Standard Deviation.

Table 5 presents the mean glycated hemoglobin (HbA1c) levels for the intervention and control groups before and after the 12-week resistance training program. The intervention group showed a marked improvement in long-term glycemic control, with mean HbA1c decreasing from 8.2 ± 0.7% at pre-intervention to 6.9 ± 0.6% post-intervention. This reduction was statistically significant ($t = 14.56$, $p < 0.001$), indicating that participation in the resistance training program effectively lowered HbA1c levels in adults with type 2 diabetes. Conversely, the control group exhibited minimal change, with HbA1c decreasing slightly from 8.1 ± 0.6% to 8.0 ± 0.7%, a change that was not statistically significant ($t = 1.12$, $p = 0.275$). These findings suggest that a 12-week resistance training program can significantly improve long-term glycemic control, supporting its use as a non-pharmacological intervention for managing type 2 diabetes in this population.

Hypothesis 3: A 12-week resistance training program does not significantly affect insulin sensitivity in adults with type 2 diabetes in Akwa Ibom State.

Table 6. Effect of 12-Week Resistance Training on Insulin Sensitivity (HOMA-IR) in Adults with Type 2 Diabetes

Group	Pre-Intervention HOMA-IR	Post-Intervention HOMA-IR	t	p-value	Interpretation
Intervention	3.2 ± 0.5	2.1 ± 0.4	12.34	0.000	Significant improvement in insulin sensitivity
Control	3.1 ± 0.6	3.0 ± 0.5	1.27	0.217	No significant change

Note: HOMA-IR = Homeostatic Model Assessment of Insulin Resistance; SD = Standard Deviation.

Table 6 presents the mean insulin sensitivity, assessed using HOMA-IR, for both the intervention and control groups before and after the 12-week resistance training program. Participants in the intervention group demonstrated a significant improvement in insulin sensitivity, with mean HOMA-IR decreasing from 3.2 ± 0.5 at pre-intervention to 2.1 ± 0.4 post-intervention. This reduction was statistically significant ($t = 12.34$, $p < 0.001$), indicating enhanced insulin

responsiveness and improved metabolic control as a result of the resistance training program. In contrast, the control group showed minimal change, with mean HOMA-IR decreasing slightly from 3.1 ± 0.6 to 3.0 ± 0.5, a change that was not statistically significant (t = 1.27, p = 0.217). These findings suggest that a 12-week resistance training program can significantly enhance insulin sensitivity in adults with type 2 diabetes, highlighting its potential as an effective non-pharmacological intervention for improving metabolic health in this population[14].

Major Findings

Based on the analysis of the research questions and hypotheses, the major findings of this study are summarized as follows:

1. The 12-week resistance training program led to a significant reduction in fasting blood glucose levels among adults with type 2 diabetes in Akwa Ibom State. Participants in the intervention group showed a marked decrease in FBG from baseline to post-intervention, while the control group exhibited no significant change. This finding indicates that resistance training is effective in improving short-term glycemic control.

2. The resistance training program resulted in a statistically significant reduction in HbA1c levels in the intervention group, reflecting improved long-term glycemic control. In contrast, the control group recorded only minimal and non-significant changes. This demonstrates that consistent resistance training over 12 weeks can meaningfully lower average blood glucose levels over time.

3. A significant improvement in insulin sensitivity**,** as measured by HOMA-IR, was observed in participants who underwent the resistance training program. The intervention group showed a substantial reduction in insulin resistance, whereas the control group experienced no significant improvement. This finding highlights the role of resistance training in enhancing insulin responsiveness and overall metabolic health.

Collectively, the findings confirm that a 12-week resistance training program is an effective non-pharmacological intervention for improving fasting blood glucose, long-term glycemic control (HbA1c), and insulin sensitivity in adults with type 2 diabetes in Akwa Ibom State. All three null hypotheses were rejected for the intervention group, underscoring the therapeutic value of structured resistance exercise in diabetes management.

Discussion of Findings

Effect of a 12-week resistance training program on fasting blood glucose levels in adults with type 2 diabetes in Akwa Ibom State

The findings of this study demonstrate that a 12-week resistance training program has a meaningful and positive effect on fasting blood glucose (FBG) levels among adults with type 2 diabetes in Akwa Ibom State. The results, as presented in Tables 1 and 4, provide both descriptive and inferential evidence supporting the effectiveness of resistance training as a non-pharmacological strategy for glycemic control. The descriptive results in Table 1 show that participants in the intervention group experienced a marked reduction in fasting blood glucose levels following the 12-week resistance training program. Specifically, mean FBG declined from 9.8 mmol/L at baseline to 7.4 mmol/L post-intervention, indicating a substantial improvement in glycemic regulation. The reduction in standard deviation observed after the intervention further suggests that participants' glucose responses became more consistent, implying a stable physiological adaptation to the training stimulus. In contrast, the control group exhibited only a marginal decrease in fasting blood glucose levels over the same period, with values remaining largely within the hyperglycemic range [15]. This minimal change, coupled with slightly increased variability, indicates that the absence of structured exercise limited improvements in glucose control. The inferential analysis presented in Table 4 further strengthens these observations. Participants in the intervention group showed a statistically significant reduction in

fasting blood glucose levels after the resistance training program, with mean values decreasing from 147.4 mg/dL to 123.8 mg/dL. The large t-value and highly significant p-value ($p < .001$) indicate that this reduction was not due to chance, leading to the rejection of the null hypothesis that resistance training has no significant effect on fasting blood glucose levels. Conversely, the control group demonstrated no statistically significant change in fasting blood glucose over the 12-week period, reinforcing the conclusion that the observed improvements in the intervention group were attributable to the resistance training program rather than external or time-related factors.

The observed reduction in fasting blood glucose among participants who engaged in resistance training can be explained by several physiological mechanisms. Resistance exercise enhances insulin sensitivity by increasing skeletal muscle mass and improving the efficiency of glucose uptake through insulin-dependent and insulin-independent pathways. Repeated muscle contractions stimulate the translocation of glucose transporter type 4 (GLUT4) to the cell membrane, thereby facilitating greater glucose disposal from the bloodstream. Additionally, resistance training improves muscle oxidative capacity and metabolic flexibility, which collectively contribute to better fasting and overall glycemic control [16].

These findings are consistent with recent empirical evidence. Kelley and Kelley (2021) reported that resistance training significantly reduces fasting blood glucose and improves glycemic control in adults with type 2 diabetes, largely due to increased insulin sensitivity and muscle mass adaptations. Similarly, Gordon et al. emphasized that resistance training acts as “medicine” by eliciting favorable metabolic responses, including reductions in fasting glucose levels and insulin resistance. Umpierre et al. also demonstrated that structured exercise interventions, including resistance training, are associated with clinically meaningful improvements in glycemic outcomes compared to usual care. The present findings align well with these studies and extend existing knowledge by providing context-specific evidence from Akwa Ibom State. In this setting, where long-term pharmacological adherence and access to healthcare services may be constrained, resistance training represents a practical, low-cost, and sustainable intervention for improving glycemic control among adults with type 2 diabetes.

The significant improvement observed in the intervention group highlights the importance of incorporating structured resistance exercise into diabetes management programs within similar populations. In conclusion, the results of this study indicate that a 12-week resistance training program significantly lowers fasting blood glucose levels in adults with type 2 diabetes, while no comparable improvement is observed among individuals who do not engage in structured exercise. These findings support the rejection of the null hypothesis and underscore the role of resistance training as an effective adjunct therapy for the management of type 2 diabetes.

Impact of a 12-week resistance training program on glycated hemoglobin (HbA1c) levels in **adults with type 2 diabetes in Akwa Ibom State through systematic pre- and post-intervention assessment.**

The findings presented in Tables 2 and 5 indicate that the 12-week resistance training programme produced a meaningful and statistically significant improvement in long-term glycaemic control among adults with type 2 diabetes in Akwa Ibom State. Descriptively, Table 2 shows that participants in the intervention group experienced a marked reduction in HbA1c levels from 8.5 ± 0.9% at baseline to 7.1 ± 0.8% after the intervention, whereas the control group demonstrated only a slight and clinically negligible decrease from 8.4 ± 1.0% to 8.2 ± 1.1%. These results suggest that engagement in structured resistance training was associated with improved average blood glucose control over time, while the absence of exercise in the control group limited meaningful metabolic improvement. The inferential analysis in Table 5 further confirms this observation, revealing a statistically significant reduction in HbA1c levels in the intervention group ($t = 14.56$, $p < 0.001$), with mean values decreasing from 8.2 ± 0.7% pre-intervention to 6.9 ± 0.6% post-intervention. In contrast, the control group showed no significant change in

HbA1c levels (t = 1.12, p = 0.275). This finding clearly demonstrates that the observed improvement in glycaemic control can be attributed to participation in the resistance training programme rather than to chance or routine care alone.

The significant reduction in HbA1c among participants in the intervention group can be attributed to the physiological adaptations induced by resistance training. Regular resistance exercise increases skeletal muscle mass, enhances insulin sensitivity, and promotes greater glucose uptake through improved GLUT-4 translocation in muscle cells. These adaptations reduce circulating blood glucose levels and contribute to sustained improvements in long-term glycaemic control, as reflected by lower HbA1c values. Additionally, resistance training has been shown to reduce insulin resistance and systemic inflammation, both of which are key contributors to poor glycaemic regulation in individuals with type 2 diabetes. The minimal change observed in the control group may be due to the absence of sufficient physical activity stimulus capable of eliciting these metabolic benefits.

These findings are consistent with recent empirical studies that report significant reductions in HbA1c following structured resistance training interventions among adults with type 2 diabetes. For instance, Deli et al. reported that resistance training significantly improves HbA1c and insulin sensitivity through enhanced muscular glucose disposal. Similarly, Liu et al. found that moderate-to-high intensity resistance exercise leads to clinically meaningful reductions in HbA1c levels. Yardley et al. also concluded that resistance training is an effective non-pharmacological strategy for improving long-term glycaemic control in individuals with type 2 diabetes. Collectively, these findings support the effectiveness of resistance training as a practical and low-cost intervention for managing type 2 diabetes, particularly in resource-limited settings such as Akwa Ibom State.

Impact of a 12-week resistance training program on insulin sensitivity in adults with type 2 diabetes in Akwa Ibom State

The findings presented in Tables 3 and 6 demonstrate that the 12-week resistance training program produced significant improvements in insulin sensitivity among adults with type 2 diabetes in Akwa Ibom State. Table 3 shows that the intervention group experienced a notable reduction in HOMA-IR, from a mean of 3.2 ± 0.5 at pre-intervention to 2.1 ± 0.4 post-intervention, indicating enhanced insulin responsiveness. In comparison, the control group showed minimal change, with HOMA-IR values decreasing slightly from 3.1 ± 0.6 to 3.0 ± 0.5, suggesting little to no improvement in insulin sensitivity without participation in the structured exercise program. These descriptive statistics suggest that engaging in resistance training had a meaningful positive effect on participants' metabolic control. The inferential results presented in Table 6 reinforce this observation. The intervention group demonstrated a statistically significant improvement in insulin sensitivity, with HOMA-IR decreasing from 3.2 ± 0.5 to 2.1 ± 0.4 (t = 12.34, p < 0.001). In contrast, the control group's change was not significant (t = 1.27, p = 0.217), confirming that the improvement in insulin sensitivity was attributable to the resistance training intervention rather than natural variation or routine care. These results indicate that a 12-week resistance training program can effectively enhance insulin sensitivity in adults with type 2 diabetes, reflecting improved glucose utilization by muscle tissue and better overall metabolic regulation.

The significant improvement in insulin sensitivity observed among participants in the intervention group can be attributed to several physiological mechanisms associated with resistance exercise. Resistance training increases skeletal muscle mass and improves muscle quality, which enhances glucose uptake by muscle cells through greater expression and translocation of glucose transporter type 4 (GLUT-4). Additionally, resistance exercise reduces systemic inflammation and decreases visceral adiposity, both of which are key contributors to insulin resistance in type 2 diabetes (. These adaptations collectively improve the efficiency of

insulin signaling pathways, thereby lowering HOMA-IR and promoting better glycaemic control.

These findings are supported by recent empirical studies. For example, Liu et al. (2023) reported that structured resistance training significantly improves insulin sensitivity and glycaemic regulation in adults with type 2 diabetes. Similarly, Deli et al. (2023) demonstrated that resistance exercise effectively reduces HOMA-IR, highlighting its role as a non-pharmacological strategy for enhancing metabolic health. Yardley et al. (2022) also emphasized that resistance training interventions lead to clinically meaningful improvements in insulin responsiveness and glucose homeostasis, reinforcing the importance of exercise in diabetes management. Collectively, these studies corroborate the present findings, indicating that resistance training is a practical, low-cost intervention capable of significantly improving insulin sensitivity and metabolic outcomes in adults with type 2 diabetes.

Conclusion

This study concludes that a 12-week resistance training program significantly improves glycemic control and insulin sensitivity in adults with type 2 diabetes in Akwa Ibom State. Participants who engaged in the program experienced meaningful reductions in fasting blood glucose and HbA1c levels, along with enhanced insulin responsiveness, while those who did not participate showed minimal changes. These findings highlight resistance training as an effective, practical, and low-cost intervention that can complement conventional diabetes management and promote better metabolic health in adults with type 2 diabetes.

Recommendations

Based on the findings of this study, the following recommendations were made:

1. Healthcare providers, including physicians, diabetes educators, and physiotherapists, should integrate structured resistance training programs into the routine management of adults with type 2 diabetes. These programs should target major muscle groups and be conducted 2–3 times per week for at least 12 weeks, following the principle of progressive overload, and include warm-up and cool-down periods. Participants should maintain their usual medical care and diet while engaging in the exercises to ensure safe and effective improvement in glycemic control and insulin sensitivity.

2. Qualified exercise professionals or trained fitness instructors should oversee resistance training sessions to ensure participant safety and adherence. They should monitor technique, adjust resistance progressively, and guide participants through each exercise to maximize metabolic benefits while preventing injuries. Supervision ensures that the intensity and frequency of the program are appropriate for adults with type 2 diabetes and supports consistent engagement.

3. Policy makers, public health authorities, and community health centers should establish accessible and culturally appropriate resistance training programs for adults with type 2 diabetes. These programs should be implemented in local facilities or community centers, equipped with affordable and safe exercise tools, and designed to be feasible for participants with varying fitness levels. This approach will provide a sustainable platform for improving metabolic health in resource-limited settings.

4. Healthcare institutions, public health agencies, and diabetes support groups should educate adults with type 2 diabetes about the benefits of resistance training. They should organize workshops, seminars, and awareness campaigns to inform patients, motivate regular participation, and address barriers such as lack of knowledge, equipment, or supervision. Educating patients will increase adherence to exercise programs and enhance long-term glycemic control.

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