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Differential Effects of Two Modes of Exercise on Anthropometric Characteristics of Persons with Type-2 Diabetes

Joshua Emeka Umeifekwem (Corresponding author)
Department of Health and Physical Education, University of Nigeria, Nsukka
E-mail: joshua.umeifekwem@unn.edu.ng

Chukwugozie N. Okwuosa
Department of Medical Laboratory Sciences, Faculty of Health Sciences & Technology, College of Medicine, University of Nigeria, Enugu Campus

Abstract
The aim of this study was to determine and compare the separate effects of Aerobic Endurance Exercise (AEE) and Progressive Resistance Exercise(PRE) on some Anthropometric features of Body weight (BW), Body Mass Index (BMI), Percent Body Fat (PBF) and Waist-to-Hip Ratio (WHR) of type 2 diabetics. Type-2 diabetes outpatient volunteers who registered in the University of Nigeria, Nsukka Medical Centre and met the inclusion criteria participated in the study. The randomize Pretest-Posttest Control Group quasi-experimental design was adopted as participants were randomly assigned to each two experimental and one control groups. The study participants in the two experimental groups were exposed to two different exercise modes for 15 weeks while their effects on the anthropometric features were monitored and recorded. Four null hypotheses guided the study, while the descriptive (means, SD and range) and inferential statistics (ANCOVA, eta squared (R^2), and SIDAK pairwise multiple comparisons) were employed for the data analyses. Results revealed that all the hypotheses were not supported indicating that the two exercise protocols had significance effect as seen in the mean values differences of the pretest and posttest anthropometric measures. It was concluded that a twice-weekly session of 15-week supervised circuit type endurance exercise and progressive resistance training protocol at moderate intensity had beneficial reduction effects on physical parameters of body weight body mass index, waist-to-hip ratio and percent body fat. As a result, the two modes of exercise were effective in mediating anthropometric features of person recently diagnosed with type-2 diabetes recommendations were made based on the findings.
Keywords: Type-2 diabetes, Body composition, Obesity, Aerobic Endurance Exercise, Progressive Resistance Exercise.

1. Introduction

The role of physical activity in the prevention and management of predisposing body composition risk factors associated with type-2 diabetes is well known among healthcare givers and practitioners today. Over fat (Obesity) and overweight are both implicated as major risk factors for various metabolic and endocrine syndromes such as impaired glucose metabolism and diabetes particularly type-2 diabetes (Colditz, Willett, Rotnitzky and Manson,1995; Wilmore and Costil, 1999,). Son, et.al. (2005) concluded in their studies of anthropometric characteristics and risks of type 2 diabetes, that high Percent Body Fat (PBF) and Waist-to-Hip Ratio (WHR) were significant factors associated with diabetes even when Body Mass Index (BMI), is normal.

Majority of type-2 diabetic patients are obese (Kahn,1986). World Health Organization’s reports indicated that in 2002, Nigeria had the highest prevalence of the disease in sub-Saharan Africa (1.7 million) and would escalate up to 4.835 million by 2030 (WHO, 2005). Nyenwe et al (2003) found a relatively high prevalence rate with crude prevalence rates of 7.7% and 5.7% for males and females respectively in Port Harcourt, Nigeria. More recently, Ukwuoma and Muanya (2005) reported that the survey of the Nigerian Society for Endocrinology and metabolism (NSEM) showed that 30 percent of Nigerians with Diabetes were unaware that they live with the disease, while 2 out of 3 Nigerians with type 2 diabetes do not have the disease under control and risk early deaths from stroke, heart attack or kidney failure.

Preventing and controlling defective body composition profile as a clinical problem associated with type-2 diabetic patients make regular physical exercise an imperative. Physical exercises have been advocated as important cost effective therapy for the management of type 2 diabetes, because they mediate many other physiological and metabolic factors associated with complications in type 2 diabetes mellitus such as body fat, blood pressure and lipoprotein utilization (Wallberg-Herrickson, et al. 1998; Dela, et al. 1999). According to Tremble and Donaldson (1998), weight loss of up to 10% can be significantly beneficial in terms of not only reducing the risk of developing diabetes mellitus but also in improving metabolic control after the disorder has become established.

Although, researchers e.g. Vignatti and Cunningham,(1986); Eriksson, (1999), have propounded various forms of exercises including Aerobic Endurance and Resistance types in the management of type-2 diabetes, Pierce (1999) expressed concern about the inconsistency of findings resulting from different exercise protocols (frequency, duration, intensity and mode of exercise regimen) usually adopted by researchers working in the area of diabetes management with exercise. Furthermore, Boulé, et al. (2001) observed that clinical trials on the effect of different modes of exercise on certain anthropometric characteristics in individuals with type 2 diabetes have yielded conflicting results. The implication of this is obvious, many Diabetes Educators find it difficult to select, adopt and apply evidence-based and clinically tested exercise regimens that are most efficient in their management of type 2 diabetes patients.

Validation of exercise modes based on dose-response relationship approach especially as they relate to anthropometric characteristics of diabetics has remained a topical issue for researchers. Moreso, experimental research data on exercise and type-2 diabetes for Nigerian type-2 diabetic patients are still scanty. Since obesity is a precursor to the onset of type 2 diabetes this study was therefore an attempt to contribute to the data base in describing the effects of two modes of exercise on anthropometric characteristics of type 2 diabetics and to bridge the gap in knowledge to determine simultaneously the effects of Aerobic Endurance Exercise (AEE) and Progressive Resistance Exercise (PRE) on anthropometric characteristics of persons living with type-2 diabetes. It is anticipated that determining and comparing the different training effects of both Aerobic Endurance and Progressive Resistance Exercises on a number of anthropometric parameters characterizing type-2 diabetes, will facilitate the development of specific exercise models based on a dose-response relationship approach.

The four hypotheses of no significant difference were posited and tested in the study with regards to post exercise Body weight (BW), Body Mass Index (BMI), Percent Body Fat (PBF) and Waist-to-Hip Ratio (WHR) *(anthropometric Characteristics)* of newly diagnosed type 2 diabetics in the two experimental (AEE and PRE) groups and a control group following a 15-week supervised two separate modes of exercise programme. The alpha level for testing each hypothesis was set at 0.01.

2.1 Method

Randomize Pretest-Posttest Control Group quasi-experimental design which permitted randomly assigning of participants to experimental and control groups was adopted for this study. Thirty Three (24 males and 19 female ; Mean Age = 46.69 SD=7.59 years) outpatient volunteers who were recently diagnosed of type-2 diabetes and satisfied the inclusion criteria of the study at the University of Nigeria, Medical Center Nsukka participated in the study. Eligibility criteria included: type-2 diabetes controlled by diet or oral agent; sedentary lifestyle; resting blood pressure values not exceeding 175/100mmHg and certification of fitness to participate in the study by the physician in charge of the diabetes unit of the Medical Centre.

Three stages were involved in the selection processes. The first stage involved writing all the members of population. The second stage involved selecting qualified volunteers. The third stage was the random assignment of the participants into the various groups through the simple random sampling technique of sampling without replacement as follows: AEE group: males =6, females =5; PRE group: males =6, females =4; Control: males =6, females =6. All participants read, understood and signed the consent form to participate in the study. The study was approved by the University of Nigeria Medical Center Ethical committee.

Major instruments used for the collection of data include: A. Questionnaire used to obtain base line demographic data, B. Metric body weighing and height scales, C. Non-elastic measuring tape, D. Harpenden skinfold caliper. The instruments used for this study were standardized instruments and have already been validated by the scientists who designed and manufactured them.

The exercise training was organized in the Exercise Physiology Laboratory and the Multi Gym Centre of the Department of Health and Physical Education, University of Nigeria, Nsukka which served as the venues for the research. The researcher with the trained assistants administered all the training and measurements. The participants in the two treatment groups engaged in the experimental training simultaneously two-sessions per week following the Eriksson, et al. (1997) protocol (Tuesday and Thursday) as from 4.00Pm -6.00Pm local time, while the control group were not engaged but were encouraged to lead their normal routine lives without any form of exercise. Measurements of anthropometric components were taken prior to the commencement of the training programme and at the end of the 15 weeks of the training programme . The Statistical Package for Social Sciences (SPSS 11.0) was used for both the descriptive (mean,SD and range) and inferential statistics (ANCOVA,eta squared and The Sidak Pairwise multiple comparisons).

2.2 Exercise protocol

i. The Circuit model as described by Fox, Bowers and Foss (1989) was modified and adopted for the Aerobic Endurance Exercise while, the circuit design for the Progressive Resistance Exercise followed the protocol as described by Reilly and Thomas (1978). The circuits for both exercise modes included six stations made up of three stations that exercised the lower body segments and the other three stations which exercised the upper body segment.

ii. Exercise stations and Corresponding Aerobic Exercises

STATION	**AEE**	**PRE**
Station one –	Jog-walk	Bench Press
Station two –	Alternate toe touch	Dips
Station three –	Step-ups	Leg press
Station four –	Hip stretch/rotation	Arm Curls
Station five –	Rope skipping	Leg Curls
Station six –	Cycling 1 minute	Bench Push Ups

ii. The training adopted the progressive incremental workload approach. For Aerobic Endurance Exercise group, participants worked at 40 –60% their maximum heart rate, While in the PRE stations, based on each participant's assessed repeated maximum test (1 RM) as described by Dunstan, et al. (2002), the participants worked between 40-60% 1 RM.

iii. Baseline data on all studied anthropometric components collected and duely recorded from all the participants. At the end of the training programme, the same characteristics were measured and recorded for analyses.

iv. A diabetic nurse and the research assistants were present in all the sessions of the training programme.

3. Results

A cursory observation of the mean values of the assessed parameters after 15 weeks of exercise training for each of the experimental groups and control (Table 2.) show a decline compared to the baseline mean values of the respective parameters. The mean score of the participants' BW, BMI, WHR and PBF data in Aerobic Endurance Exercise group decreased from the corresponding baseline values of 84.45kg, 29.40kg/m^2, .91cm, and 24.96% respectively (Table 1), to 79.76kg, 27.70kg/m^2, .88cm and 22.67% (Table 2.) given the respective mean difference values of BW = -4.69kg, BMI = -1.7 kg/m^2 , WHR = -0.03cm and PBF = -2.29% (Table 3).

Similarly, the same parameters of BW, BMI, WHR and PBF in Progressive Resistance Exercise group also declined from the baseline mean values and post exercise mean values of 85.68kg, 29.37kg/m^2, .87cm and 27.12% (Table 1.) to 83.91kg, 28.54kg/m^2 .85cm and 24.67% (Table 2.) respectively. Furthermore the resultant mean difference values BW = -1.77kg, BMI = -0.83 kg/m^2 , WHR = -0.02cm and PBF = -2.45% (Table 3). The non exercising control group showed very slight differences in pre and post study mean values of their respective assessed parameters BW = -0.21kg, BMI = -0.09 kg/m^2 , WHR = -0.00cm and PBF = -0.34% (Table 3).

Analysis of covariance (ANCOVA) performed for changes in respective post exercise mean values of anthropometric parameters between the two exercise groups and the control group (Table 4.) showed that there were significant difference ($P < .01$) of exercise main effects for BW: ($F = 24.71$), BMI : ($F = 15.97$), WHR: ($F = 7.30$) and PBF: (10.98), with the effect size of the treatment, partial eta squared (R^2) of .71 or 71%, .62 or 62%, .43 or 43% and .53 or 53% respectively.

Sidak's multiple pair wise comparisons was applied to determine how the mean values of the two post exercise effects significantly differ from each other and control (Table 5). The result indicated that there were significant post exercise mean differences in body weight and body mass index of the two exercising groups when compared to control. Furthermore, comparisons revealed also significant difference in body weight and body mass index between AEE and PRE post exercise mean values. This suggested that AEE programme might have been more efficacious than PRE in reducing body weight and body mass index. Conversely, there were no significant mean differences between the mean values of both exercise effects on WHR (-.00, 95% Cl = -.02; .02) and PBF (.18, 95% Cl = -.97; 1.34) of the participants. However, both exercises independently demonstrated significant difference in their mean scores when compared with control [WHR = AEE and PRE Vs Control = -

.02, (95% Cl = .04; - .00) and PBF: AEE Vs Control = -1.95, (95% Cl = -3.04; .86), and PRE vs Control = -2.13(95%CI = -3.26;-1.00)].

4. Discussion of Findings

Recent studies have shown that increase in certain aspects of body composition, such as body fat distribution, general body weight, waist-to-hip ratios and body mass index are associated with increased risk for certain metabolic diseases. Son, et al. (2005) concluded that high Percent Body Fat and Waist-to-Hip Ratio were major risk factors associated with type-2 diabetes.

With regards to body weight, the findings of this study revealed that the post exercise training body weight mean measures of the participants in both exercise groups differ significantly from their respective baseline scores. Similarly, when these results were compared with those of control, there was also significant reduction difference ($F = 24.71$, $P < .01$). This finding replicated those of Dunstan, (1997 & 2002) even when exercise protocol differ slightly. This study achieved results similar to those of Dunstan et al. (1997 and 2002) even when the exercise protocols differed slightly. Dunstan and Co-workers reported significant decline in body weights of persons with type-2 diabetes when subjected to aerobic exercise programme (Dunstan et al., 1997), and resistance training programme (Dunstan, et al., 2002). Despite this disparity, the finding support the reports of other studies that demonstrated the prospects of supervised exercises in reducing higher levels of profiles of these physical indices in type-2 diabetic patients (Eriksson, 1999).
However, further analysis (Sidak multiple comparison) indicated significant difference between the mean values of post exercise scores for both aerobic endurance exercises and progressive resistance exercises (-4.35). This suggests that AEE training was more effective than PRE in reducing body weight of those with type-2 diabetes.

This finding of significant weight reduction in this study however contradicts the findings of the studies of Honkola, et al. (1997) and Eriksson et al. (1997) which did not achieve any change in body weight following a 2-session per week circuit resistance exercise for 20 weeks and 13 weeks respectively. The finding in aerobic group also did not support the finding of Mourier, et al. (1997) who reported no change in body weight of persons with type 2 diabetes, after a 2 session per week of moderate to high intensity of aerobic exercise for 8 weeks. One of the reasons for the equivocal findings may not be unconnected with the exercise programmes adopted for the study. While Honkola and Co-workers and Eriksson and associates employed circuit resistance exercise programme the present study adopted progressive resistance exercise programme which probably tasked the physiological system more to create enough energy deficit required to cause weight loss in the participants. Information was unfortunately not available on the specific mode of aerobic exercise used by Mourier, et al. (1997) in their study, however, the duration of the study (8 weeks) may have been relatively short to effect any change in body weight of the participants.

It would appear that most research studies that examined the effects of exercises on certain physical parameters that characterize type-2 diabetes seldom assess exercise effects on Body Mass index. Epidemiological evidence has shown the relationship between BMI and waist circumference and disease risk (Expert Panel, 1998) and Wallace (2002) has demonstrated that there is a strong correlation between body mass index and incidence of type-2 diabetes. In few studies that examined effects of exercise on body mass index of type-2 diabetics, only Balducci et al. (2004) achieved statistical difference in BMI of participants after 52 weeks of 3times/weekly combined aerobic endurance and resistance exercise training at moderate intensity. On the other hand, there was no change in BMI of persons with type-2 diabetes who participated in the study of Ibańez, et al. (2005). More so, in a systematic review and meta-analysis studies, Boule and associates (2001), concluded that there were no change in BMI of those studies reviewed.

This study found a significant difference in body mass of participants, not only between the baseline and post exercise mean scores but also between the post exercise means of individual respective experimental group and control. This result, however disagrees with those of Ibańez, et al. (2005). The result was unexpected and surprising especially when one considers the frequency and duration of the exercise programme. However, the patients tenacity in compliance with the full regimen of the training may have contributed to the observed reduction recorded in the study. Although both exercises produced significant post exercise training reduction in mean values from that of the control, Aerobic endurance had greater reduction effect (AEE – 1.62kg/m^2) than the progressive resistance training (PRE – 0.75kg/m^2). The achieved mean difference was not however sufficient enough to generally place the BMI of the participants in a safer zone of "lower disease risk". When the post exercise training BMI mean measures of the participants in both exercise groups were compared with the norms provided for the categorization of relative risk of BMI to diabetes Milletus (Wallace, 2002) it was found that the post exercise mean BMI measures did not drop from "higher risk" to lower risk category. It was however markedly important in at least stabilizing the BMI of the exercise groups.

The result of this study showed that there were significant reductions in percent body fat (PBF) of participants in both categories of exercise modes after the programme and when compared with the control. This result suggested that both modes of exercise had influence on percent body fat. However, comparatively, PRE elicited greater post exercise mean difference (-2.13%) than AEE (1.95%) suggesting the PRE may be more effective in influencing PBF indices than AEE. These findings were consistent with those of Dunstan, et al. (2002) and Ibanez et al. (2005) that achieved the same reduction effects in PBF using progressive resistance training. In contrast, Ishii, et al. (1998) reported no changes in PBF of type-2 diabetes patients, after 4 – 6 weeks of moderate intensity resistant training. The Ishii and co-workers' study was however limited by the duration of the intervention (4-6 weeks). According to Sigal, et al. (2004), it would ideally require 3-6 months of resistance training to produce a clinically significant effect on body composition and when such effects were seen, loss of fat might have been partially offset by increased body mass.

Unfortunately, most studies on aerobic exercise and type-2 diabetes rarely examined body composition (Sigal, et al. 2004) and so, comparisons of this finding with those of other studies using aerobic endurance exercise mode posed some level of difficulty. However, in a modified version of the protocol, Maiorana, et al. (2002) and Cuff, et al. (2003) combined both aerobic endurance and progressive resistant training of moderate to high intensities, (3 times/week) for 8 and 16 weeks respectively to achieve significant reduction in PBF.

Waist to hip ratios has been adjudged one of the best markers of determining risk and diseases associated with fat and weight distribution around the body such as type-2 diabetes and hypertension (Corbin et al. 2002). Few studies that assessed influence of exercises on WHR among type-2 diabetic patients have essentially used resistance exercise or a combination of Aerobic exercise and Resistance exercise to demonstrate the efficacy of exercise in reducing WHR values among type-2 diabetes patients population.

Ibańez, et al. (2005) adopted progressive resistance training (PRT) in a 2 session/week exercise programme for 16 week to achieve significant reduction in WHR of older male type-2 diabetic patients. Maiorana, et al. (2002) independently used a combination of aerobic endurance and resistance exercise training to produce significant change in WHR of the type 2 diabetes population. The results of these studies especially that of Ibanez et al. (2005) support those of present study (Table 5.) which demonstrated that a 2 session/week progressive resistance exercise training for 15 weeks significantly reduced WHR.

The present study also found significant decrease in WHR among Aerobic endurance groups when compared with the control. Incidentally most of the studies on aerobic exercise and type-2 diabetes have not examined exercise effects on waist-to-hip ratio. However, earlier, conclusion by Boulé, et al. (2001) that aerobic exercise promotes glycaemic control by changing muscle metabolism but not merely by improving body composition might have explained the lack of research interest in evaluating WHR in type-2 diabetes patients.

Further comparisons of AEE and PRE values of WHR between baseline and post exercise data with the classification (Eriksson, et al. 1997), showed that AEE group's WHR reduced from 0.91 baseline (moderately high risk) to 0.88 post exercise (lower risk) a WHR reduction of -0.03, while in PRE group, WHR reduced from 0.87 baseline (lower risk) to 0.85 post exercise (lower risk) a WHR reduction of -0.02. However, the Sidak pairwise comparisons (Table 5) indicate that both exercises would produce similar effect independent of the other.

5. Conclusion

A twice-weekly session of 15-week supervised circuit type endurance exercise training and progressive resistance exercise training protocols at moderate intensity had beneficial reduction effects on anthropometric parameters of body weight body mass index, waist-to-hip ratio and percent body fat. However Aerobic endurance exercise programme more than Progressive resistance exercise was more efficacious in reducing body weight and body mass index of recently diagnosed type-2 patients. Furthermore, both waist-to-hip ratio and percent body fat of the study participant did not differ in the level of effects elicited by both AEE and PRE programmes after 15 weeks.

6. Recommendations

Based on the findings, discussions and conclusions of this work, the following recommendations were made.

1. Professional health care givers and health practitioners in diabetes management in Nigeria should adopt and integrate supervised exercise protocol as used in this study in their treatment/management strategy for people with type of diabetes.

2. Physicians, first health practitioners who usually being diagnose in patients the onset the type-2 diabetes should endeavour to recommend as soon as possible either supervised aerobic endurance exercise or progressive resistance exercises, twice weekly, since these exercise modes and frequency have been found to be effective in glycaemic control and lowering physical anthropometric indices of type-2 diabetes.
3. Hospital managements in Primary Health Care systems should endeavour to employ as core members of their health care delivery team, exercise scientists for the establishment of supervised exercise programme modelled in line with the protocol used in this study for persons with type-2 diabetes.

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Table 1: **Characteristics of the Study Population (N = 33) at Baseline. (**Values are given as means ± SD)

Parameter	Intervention		
	Aerobic Endurance Group	**Progressive Resistance Group**	**Control Group**
Number of participant (men & women)	11 (6/5)	10 (6/4)	12 (6/6)
Height	1.69 ± 0.47	1.73 ± 0.55	1.70 ± 0.48
Age (years)	48.33 ± 6.32	46.69 ± 7.59	47.83 ± 5.65
Body Weight (kg)	84.45 ± 6.59	85.68 ± 9.99	85.75 ± 5.95
Body Mass Index (kg/m^2)	29.40 ± 3.15	29.37 ± 2.40	29.76 ± 2.13
Waist to Hip Ratio (WHR)	.91 ± .06	.87 ± .044	.86 ± .045

Table 2: **Anthropometric Characteristics of the Study Population (N = 33) after 15 weeks**

Parameter	Aerobic Endurance Group	Progressive Resistance Group	Control
Body Weight (kg)	79.76 ± 6.50	83.91 ± 10.14	85.54 ± 6.2
Body Mass Index (kg/m^2)	27.70 ± 3.00	28.54 ± 2.52	29.67 ± 2.12
Waist to Hip Ratio (WHR)	.88 ± .05	.85 ± .04	.86 ± .05
Percent Body Fat (%)	22.67 ± 6.79	24.67 ± 6.25	24.94 ± 4.00

Table 3: **Mean Difference between Baseline and Post exercise values**

	Aerobic	**Resistance**	**Control**
Body Weight(kg)	-4.69	-1.77	-0.21
Body Mass Index (kg/m^2)	-1.7	-0.83	-0.09
Waist to Hip Ratio	-0.03	-0.02	0.00
Percent Body Fat (%)	-2.29	-2.45	-0.34

Table 4: **ANCOVA for Post Exercise Physical Parameter Mean Differences among AEE, PRE and NEC Groups**

Parameter		**Mean Square**	**F-ratio**	**Sig**	**Partial Eta Squared (R^2)**
BW(kg)	Covariate	1724.82	1055.51	.000	.97
	Exercise Main Effect	40.39	24.71	.001	.71
BMI (kg/m^2)	Covariate	187.16	595.75	.000	.95
	Exercise Main Effect	5.02	15.97	.001	.62
WHR	Covariate	.06	193.60	.001	.87
	Exercise Main Effect	.00	7.30	.001	.43
PBF (%)	Covariate	958.40	903.70	.000	.97
	Exercise Main Effect	11.65	10.98	.001	.53

* significant at the .01 level

Table 5: **Comparisons of Post Exercise Effect Mean Differences (1-2) and 95% Cl for Physical Parameters**

(1) Exercise	**(2) Exercise**	**BW (kg) 95%**	**BMI (kg/m^2)**	**WHR**	**PBF (%)**
AEE	PRE	-2.93 (-4.35; -1.51)*	-.87 (-1.49; -.25)*	-.00 (-.02; .02)	.18 (-.97; 1.34)
	Control	-4.49 (-5.84; -3.14)*	-1.62 (-2.22; -1.03)*	-.02 (-.04; -.00)*	-1.95 (-3.04; -.86)*
PRE	AEE	2.93 (1.51; 4.35)*	.87 (.25; 1.49)*	.00 (-.02; .02)	-.18 (-1.34; .97)
	Control	-1.56 (-2.95; -.18)*	-.75 (-1.36; -.14)*	-.02 (-.04; .00)*	-2.13 (-3.26; -1.00)*
Control	AEE	4.49 (3.14; 5.85)*	1.62 (1.03; 2.22)*	.02 (.00; .04)*	1.95 (.86; 3.04)*
	PRE	1.56 (.18; 2.95)*	.75 (.14; 1.36)*	.02 (.00; .04)*	2.12 (1.00; 3.26)*

*The mean difference is significant at the .01 level