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INTENSITY, DURATION AND FREQUENCY OF EXERCISE NEEDED TO ACHIEVE CHANGE IN METABOLIC PROFILES IN PREDIABETES AT MOI TEACHING AND REFERRAL HOSPITAL IN UASIN GISHU COUNTY IN KENYA
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INTENSITY, DURATION AND FREQUENCY OF EXERCISE NEEDED TO ACHIEVE CHANGE IN METABOLIC PROFILES IN PREDIABETES AT MOI TEACHING AND REFERRAL HOSPITAL IN UASIN GISHU COUNTY IN KENYA

H. M. Muroki, N. G. Magak, M. G. Owiti and K. Onyango

ABSTRACT

Objective: **To establish the intensity, duration and frequency of exercise needed to achieve change in metabolic profiles of pre-diabetes at Moi Teaching and Referral Hospital, Eldoret, Kenya.**
Design: **A randomized controlled experimental study**
Setting: **Moi Teaching and Referral Hospital, Eldoret, Kenya**
Subjects: **Two comparison groups Experimental Group (EG) and Control Group (CG) with both groups having the same size of subjects, 17 patients each**
Results: **The results showed that training reduces FBG by 5% and 13%, in 6 and 12 weeks, respectively. HDL were significantly higher in the experimental than in the control group during post-training (z= -3.20.17, p=0.001). On the other hand the level of LDL decreased in the experimental group during both mid-training and post-training period relative to pre-training (z= -2.908.18, p=0.001). There was a significant reduction of Hemoglobin A1c (HbA1c) (of 3%) after six weeks and an even more marked drop (8%) after 12 weeks in EG compared to CG in which there was no drop in HbA1c levels. High correlation was found between FBG and HbA1c (r=0.95)**
Conclusion: **The knowledge of how much exercise is required to impact change in disease progression would inform the prescription of exercise by physiotherapists to their clients**

INTRODUCTION

In Kenya the prevalence of diabetes is estimated at3.3%, which is a threat to social and economic development (1). This condition gradually drains the strength and resources of an individual rendering them unproductive and poor. Undetected and untreated complications from diabetes may lead to premature morbidity and mortality. Apart from diabetes being the leading cause of blindness, they also lead to renal failure and triggers cardio-vascular disease, which is the leading cause of deaths in diabetes patients (2)

People with pre-diabetes have an increased risk of Type 2 diabetes (3). Around 5% to 10% of people with pre-diabetes become diabetic every year (4). An estimated 34% of adults have pre-diabetes and the lifestyle risk factors for this condition include overweight and physical inactivity (5). The International Diabetes Federation (IDF) Diabetes Atlas has now recognized pre-diabetes as a reversible condition that increases an individual's risk for development of diabetes.

Apart from impairments in glucose metabolism, type 2 diabetes is associated with dyslipidemia which increases the risk of cardiovascular diseases in this population. Almost 30% of people with diabetes go undiagnosed and nearly 25% of them have micro-vascular complications by the time their diabetes is diagnosed (4,6). Effort must be made to diagnose diabetes and other forms of glucose metabolism impairments including glucose intolerance and impaired fasting glucose as early as possible. Up to now diabetes has been diagnosed by measuring fasting Blood glucose (FBG) of more than 7mmol/L and/or with the oral glucose tolerance test (OGTT) more than 11 mmol/L. In agreement with International Expert Committee suggestions, the latest ADA Standards of Medical Care in Diabetes 2010 state that "HbA1c is appropriate for diabetes screening, a confirmed HbA1c > 6.5% is diagnostic for diabetes," and that "mixing different methods to diagnose diabetes should be avoided".

In Kenya, diabetic epidemic is particularly serious just like other developing countries because of dramatic change in living standards, urbanization and demographic changes (7). The assessment of drug prescription standards and quality of care is an essential component of evaluating and improving diabetic therapy. People living with diabetes are at a higher risk of numerous medications and are more vulnerable to irrational prescription (8-10). A research conducted in the Kenyan Coast (Mombasa region) has shown that overweight/obesity, physical inactivity and hypertension are the most common registered causes for Common Non-communicable Diseases (CNCDs) among the Kenyan population (11).

In general, physical activity and even exercises at moderate intensities such as walking significantly reduces the risk of the developing type 2 diabetes (12). However, it is still a matter of debate about the exercise prescription in terms of the exercises mode, intensity and frequency.

MATERIALS AND METHODS

Design: Randomized controlled trial study
Study Setting: The Moi Teaching and Referral Hospital in Uasin Gishu County. All testing sessions were conducted in the physiotherapy department of Moi University School of Medicine.

Sample Size: Zhong (2009) provides a formula for calculating sample size in a randomized controlled trial having two comparison groups with both groups having the same size of subjects as:

$$N = 2 \times \left[\frac{z_{1-\alpha} + z_{1-\beta}}{\delta - \delta_0}\right]^2 \times s^2$$

Where

N is the size per group

Z_x is the standard normal deviate for a one sided

δ is the hypothesized mean difference between the two groups

δ_0 is the clinically admissible margin of superiority

s^2 is the pooled variance of both comparison groups

Power standard to set this at 80% requiring a greater sample size

For this study HbA1c was used to compute the sample size. We have

$= 0.05$, $= 0.20$, $= 0.3$, $= 0.1$, $= 0.2$. Hence

$$N = 2 \times \left[\frac{1.645 + 0.845}{\delta - \delta_0}\right]^2 \times 0.2 = 17$$

Each arm was having 17 participants

Inclusion criteria: All overweight patients attending outpatient clinic at MTRH aged 18 to 60 years during study period, Secondly Participants with HbA1c of between 5.7% to 6.7% and Fasting Plasma Glucose of between 5.6mmol/L to 6.9mmol/L.

Exclusion criteria: Patient already on treatment for dyslipidemia

Diabetic patients and Persons with disabilities

Data collection: Data were collected using a laboratory-based experiment whereby blood samples were taken by a medical laboratory scientist at the end of every six weeks after administration of prescribed physical therapy exercise regimen. During the day of the laboratory tests, the identified participants were instructed to fast for 8 – 12 hours prior to the tests.

Data Analysis: All experimental results were evaluated and analysis of variance (ANOVA) was used to investigate associations between variables (relationship between physical therapy exercises and metabolic components). Presentation was done by use of charts, tables and Figures.

Exercise prescription: Exercise prescription was guided by the FITT (Frequency, Intensity, Time and Type) principle.

Stretchings: The participants started the prescribed exercises with a 5-minute stretching of major muscle groups (legs, hips, chest, back, abdomen, shoulders, and arms).

Warm up: This was a 5 minute drill of several multiplanar movements such as forward an backward leg swings that incorporate some rotation, as well as donkey kicks, squat jumping, prone alternate arm and leg extension.

Intensity: Intensity of training is defined by either the physiologic response of the individual, or the intensity of the exercise performed. For example, in this program of prescribed exercises intensity were aimed at a Heart Rate Reserve (HRR) and Borg's Scales for Ratings of Perceived Exertion (RPE).

Aerobics were performed in form of cycling at a moderate intensity of 12-13 (Fairly Light To Somewhat Hard) on (RPE) and HRR of 70%. This was used to measure the level of effort the participant was applying.

Vigorous exercises was a prescription of 25-minutes of treadmill Walking on aerobic Zone of 70%--80% HRR at 14-16 RPE and resistance exercises of 70 – 80% HRR using thera Band on major muscle groups of the legs, hips, chest, back, abdomen, shoulders, and arms for a duration of 10 minutes.

There was a cool down of 5-minutes whereby participants were guided to gradually reduce the exercise intensity whilst gently stretching the major muscle groups.

Frequency: Frequency of training is defined as how often exercise is performed over a fixed period, and is usually expressed in sessions per week. It is a fine balance between providing enough stress for the body to adapt and allowing time for healing and adaptations to occur. At a minimum, training programs should be three times per week. The prescribed physical therapy exercise was spread out to 3 days a week with no more than two consecutive days between the bouts of exercises.

Ethical Considerations:

Approval was sought from Institutional Research and Ethics Committee (IREC) at Moi Teaching and Referral hospital, there after permission was given by the Moi University administration. A Written informed consent was received from the study participant before the commencement of the study and data collected from the participant were treated with outmost confidentiality.

RESULTS

The study collected data from 34 respondents (17 each for the experimental and control groups). Data were collected from the participants at three time-periods: pre-training, mid-training (at end of 6 weeks), and post-training (at end of 12 weeks).

Table 1

Biographic information of respondents

Bio-graphic information	Overall (n=34)	Experimental group (n=17)	Control group (n=17)
Respondents' gender			
Male (%)	19 (55.9)	9 (52.9)	10 (58.8)
Female (%)	15 (44.1)	8 (47.1)	7 (41.2)
Total (%)	34 (100.0)	17 (100.0)	17 (100.0)
Highest education level			
1. Primary (%)	6 (17.6)	3 (17.6)	3 (17.6)
2. Secondary (%)	18 (52.9)	8 (47.1)	10 (58.8)
3. Tertiary (%)	10 (29.4)	6 (35.3)	4 (23.5)
4. Total (%)	34 (100.0)	17 (100.0)	17 (100.0)
Respondents' age Mean years + SD	35.94±9.35	34.59±9.53	37.29±9.25

Key: SD = standard deviation; n = number of respondents

Descriptive results (Table 1) showed that the study sampled slightly more males (56%) compared with female (44%) participants. Gender distribution among the experimental and control groups generally reflected the overall proportion, with 53% male and 47% female in the experimental group.

Exercise Regimen required to change Pre-diabetes Metabolic Profiles

Table 2

Metabolic profiles of pre-diabetes recorded at pre-training, mid-training and post-training

Variable	Treat.	Pre-training	Mid-training	Post-training	Main effects (F values)		Interaction (F value)
		Mean±SD	Mean±SD	Mean±SD	Group	Time	Group*Time
BMI (Kg/m²)	Exp.	$28.47 \pm 2.37^{a, k}$	$27.85 \pm 2.17^{a, k}$	$26.51 \pm 2.26^{b, k}$			
	Cont.	$28.77 \pm 2.66^{a, k}$	$28.80 \pm 2.77^{a, k}$	$28.04 \pm 2.74^{b, l}$	1.28^{ns}	18.27^{**}	3.49^{*}
FBG	Exp.	$6.11 \pm 0.47^{a, k}$	$5.81 \pm 0.53^{b, k}$	$5.30 \pm 0.46^{c, k}$			
(mmol/L)	Cont.	$6.19 \pm 0.55^{a, k}$	$6.28 \pm 0.48^{a, l}$	$5.99 \pm 0.76^{a, l}$	7.22^{*}	15.20^{**}	5.05^{*}
	Exp.	$206.29 \pm 27.56^{a, k}$	$203.41 \pm 26.06^{a, k}$	$194.35 \pm 32.77^{b, k}$			
TC (mg/dL)	Cont.	$216.41 \pm 20.17^{a, k}$	$208.65 \pm 21.80^{b, k}$	$209.88 \pm 20.32^{a, k}$	0.22^{ns}	7.27^{**}	2.24^{ns}
	Exp.	$48.00 \pm 9.68^{a, k}$	$49.53 \pm 7.69^{a, k}$	$51.47 \pm 6.77^{b, k}$			
HDL	Cont.	$43.06 \pm 7.73^{a, k}$	$43.18 \pm 7.73^{a, k}$	$43.53 \pm 4.06^{a, l}$	8.17^{**}	2.32^{**}	1.33^{ns}
(mg/dL)	Exp.	$138.47 \pm 34.72^{a, k}$	$134.29 \pm 34.61^{a, k}$	$123.24 \pm 25.03^{b, k}$			
	Cont.	$144.18 \pm 31.21^{a, k}$	$146.47 \pm 30.59^{a, k}$	$139.59 \pm 25.03^{a, k}$	1.38^{ns}	5.41^{*}	1.30^{ns}
TRI (mg/dL)	Exp.	$131.12 \pm 29.30^{a, k}$	$128.26 \pm 25.59^{a, k}$	$118.15 \pm 33.91^{b, k}$			
	Cont.	$145.00 \pm 20.59^{a, k}$	$136.04 \pm 24.20^{a, k}$	$138.44 \pm 22.10^{a, l}$	2.71^{ns}	6.91^{**}	2.79^{*}
LDL (mg/dL)	Exp.	$5.93 \pm 0.23^{a, k}$	$5.78 \pm 0.30^{b, k}$	$5.46 \pm 0.25^{c, k}$			
	Cont.	$5.97 \pm 0.28^{a, k}$	$6.00 \pm 0.28^{a, k}$	$5.80 \pm 0.41^{b, l}$	6.18^{**}	21.00^{**}	4.02^{*}
HbA1c (%)							

Key.BMI: body mass index, FBG: fasting blood glucose, TC: total cholesterol, HDL: high-density lipoprotein, TRI: triglycerides, LDL: low-density lipoprotein, HbA1c: glycosylated haemoglobin,
*SD: standard deviation, Treat: Treatment, Exp.: experimental, Cont.: Control. For every group, means with similar letters in a row (a, b, and c) and for every variable, means with similar letters in a column (k and l) are not significantly different by Tukey HSD test.**, * : significant at 99% and 95% significance levels, respectively.*

The levels of BMI decreased in the experimental group during both the mid-training and post-training period. There were no outliers in the data, as assessed by inspection of a box plot. BMI scores for each level of treatment was normally distributed, as assessed by Shapiro-Wilks test ($p > 0.05$) whereas the Levene's Test indicated error variance to be equal across the groups (all $p > 0.05$). Over time, BMI levels, significantly reduced in both groups. However, the most substantial decrease was recorded in the experimental group relative to the control group (Figure 1).

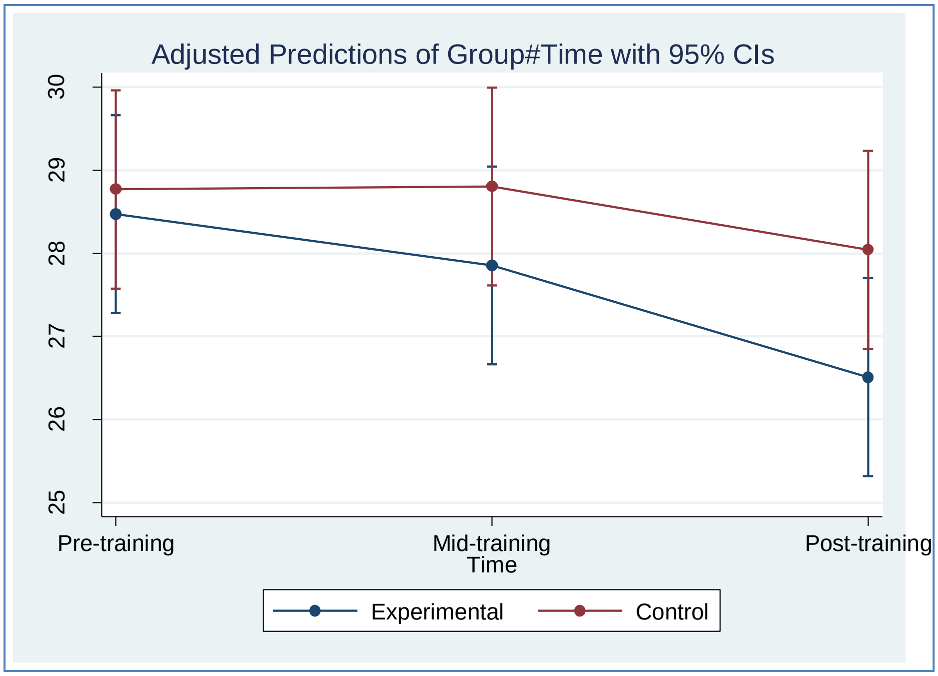

Figure 1: Predicted BMI interactions between group and time

The levels of FBG generally decreased in the experimental group during both mid-training and post-training period. A mixed ANOVA was done to determine the effect of time and group on FBG levels. Inspection of a box plot revealed no outliers, while the parameter was normally distributed (Shapiro-Wilks test had $p > 0.05$). Levene's Test indicated error variance to be equal across the groups (all $p > 0.05$).

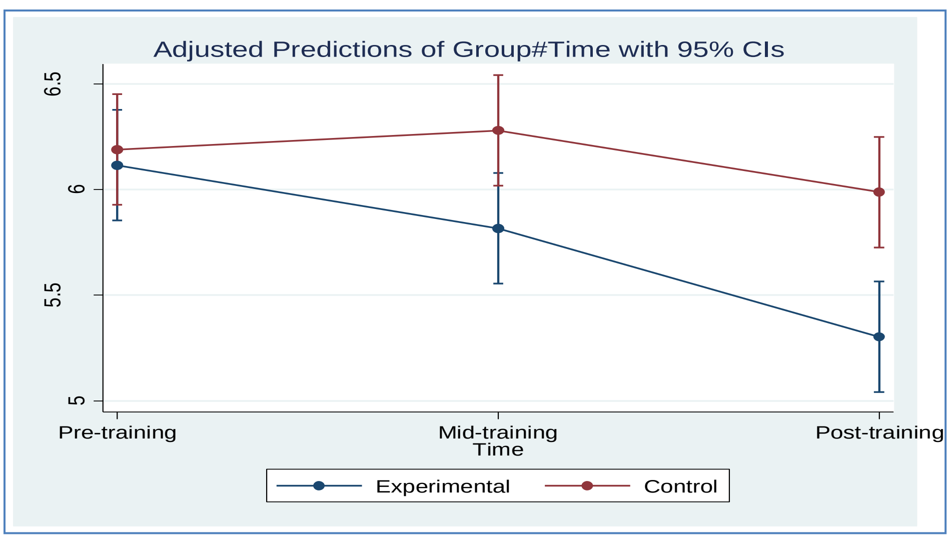

Figure 2: Predicted FBG interactions between group and time

Pair wise comparisons showed that in the experimental group, training significantly lowered the level of FBG in six weeks compared to pre-training period.

The levels of TC generally decreased in the experimental group during both mid-training and post-training period relative to pre-training. There was no need to adjust the degrees of freedom for the averaged tests of significance. A significant main effect of time, F (2, 64) = 7.27, p=0.001 was found on the level of TC. However, group, F (1, 64) = 71.27, p = 0.22 and the interaction between group and time, F (2, 64) = 2.24, p = 0.11, were found to have no significant effect on the level of TC.

For the experimental group, TC level at mid-training was not significantly different from the level at pre-training (Table 3). However, TC level at post-training was significantly lower compared to both mid- and pre-training, suggesting that a longer exercise regime (12 weeks) is required to reduce the level of TC in the body (Figure 3).

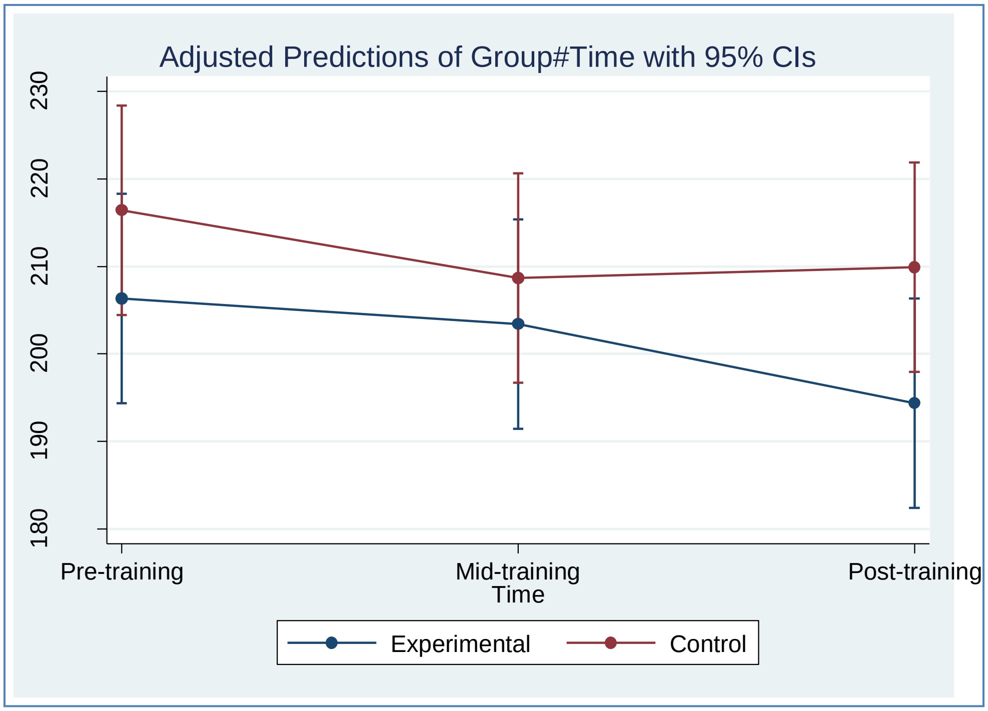

Figure 3: Predicted TC interactions between group and time

The level of HDL generally increased in the experimental group during both mid-training and post-training period compared to pre-training.

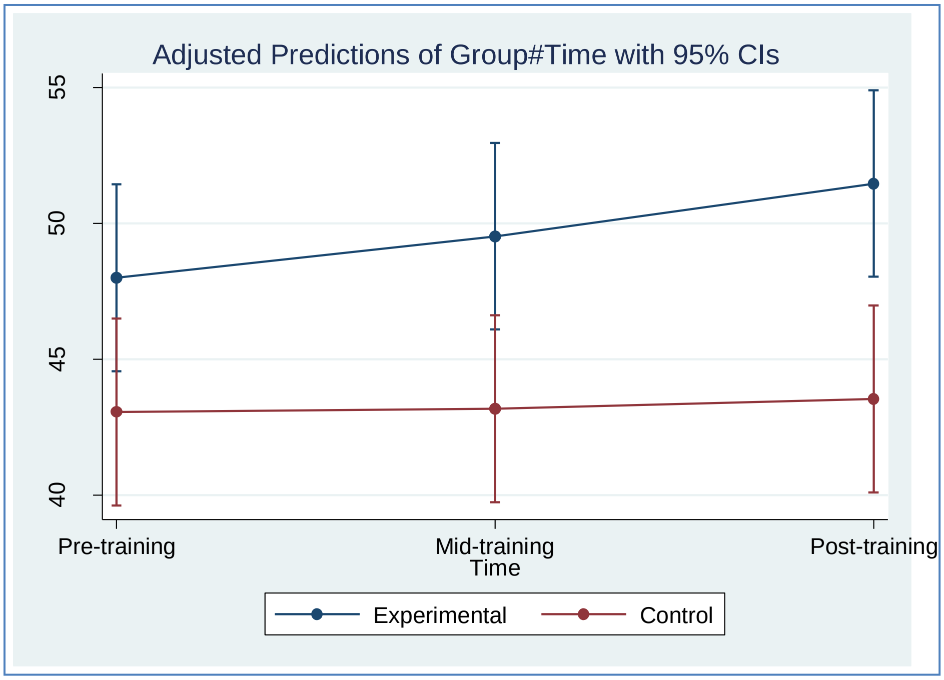

Figure 4: Predicted HDL interactions between group and time

The level of TRI generally decreased in the experimental group, from pre-training to post-training period (Table 3).

The main effect of time was the only factor found to significantly influence TRI levels, F (2, 64) = 5.41, p = 0.01. The main effect of group, F (1, 64) = 1.38, p = 0.25 and the interaction between group and time, F (2, 64) = 1.30, p = 0.27, had no significant influence on TRI levels. The results showed that in the experimental group, TRI level in mid-training did not differ significantly from the pre-training level. However, TRI levels in post-training was significantly lower compared to both mid- and pre-training levels. This suggested that TRI levels significantly reduce after a 12-week exercise regime. In addition, TRI decrease more rapidly after 6 weeks of training than before (Figure 5). For the control group, there were no significant differences in TRI levels during, pre-, mid-, and post-training, suggesting that lack of exercise does not lead to a decrease in the level of this parameter.

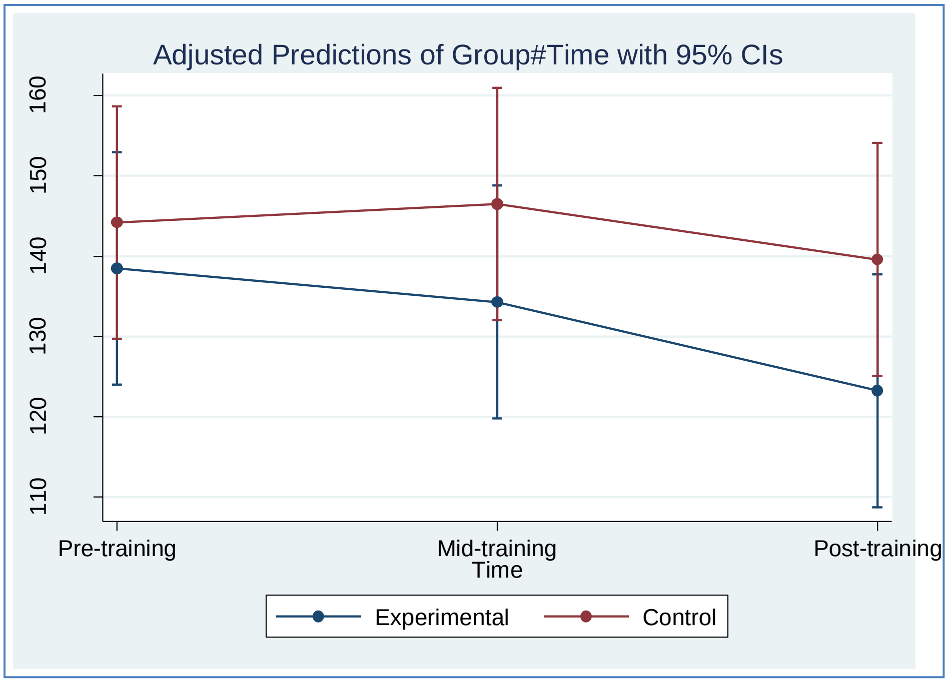

Figure 5: Predicted TRI interactions between group and time

The level of LDL decreased in the experimental group during both mid-training and post-training period relative to pre-training.

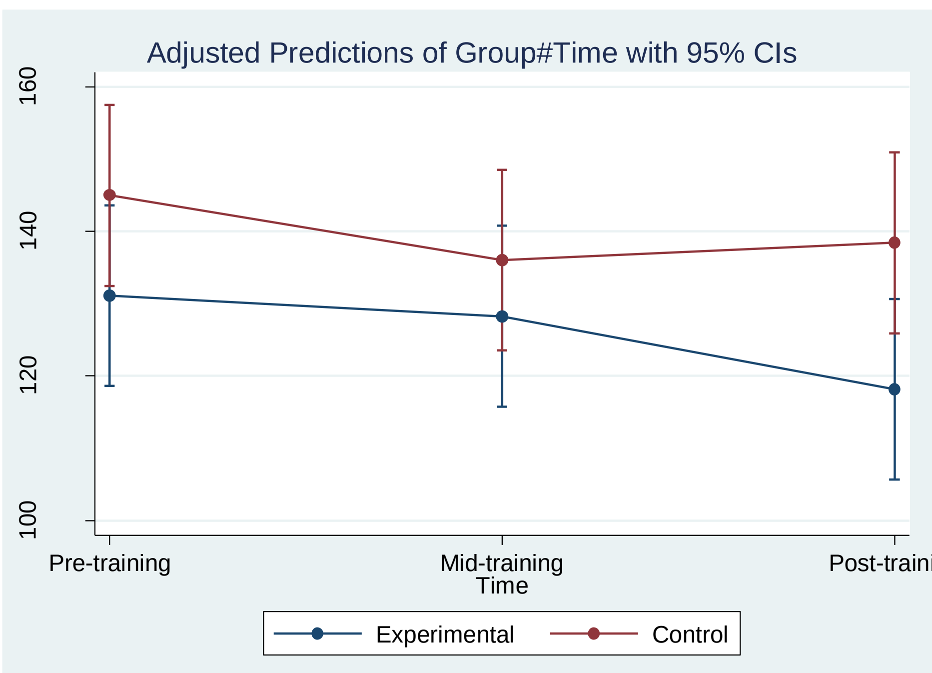

Figure 6: Predicted LDL interactions between group and time

The experimental and control groups differed significantly in LDL during post-training (mean difference: 20.28, z=2.25, p=0.02) but not during mid-training (mean difference: 7.79, z=0.86, p=0.39) or pre-training (mean difference: 13.88, z=1.54, p=0.12).

HbA1c decreased in the experimental group during both mid-training and post-training period compared to pre-training. The effect of time and group on the level of HbA1c was analysed using a mixed ANOVA. There were no outliers in the data as shown by a box plot examination while the parameter was normally distributed (Shapiro-Wilks test had $p > 0.05$). Levene's Test indicated error variance to be equal across the groups (all $p > 0.05$) while the sphericity assumption was tenable (Mauchly's Test: [$\chi 2(2) = 2.32$, p=0.31]). Hence, degree of freedom for the averaged tests was left as they were.

Significant main effects of group, $F(1, 64) = 6.18$, p=0.01 and time, $F(2, 64) = 21.00$, $p < 0.0001$ were found. The interaction between group and time, $F(2, 64) = 4.02$, $p = 0.02$, was also found to have a significant effect on the level of HbA1c.In the experimental group, there was a significant reduction of HbA1c (of 3%) after six weeks and an even more marked drop (of 8%) after 12 weeks. This showed that the exercise regimen would significantly lower HbA1c level after just six weeks. Continued exercises will further decrease the level of this parameter. In the control group, there was no drop of HbA1c level after week six but there was a significant decrease after 12 weeks, suggesting that knowledge about the seriousness of the condition might incline one to engage in activities that lower the factor. However, HbA1c level in the experimental group was significantly lower as compared to the control 12 weeks after training, showing that structured exercise regime are efficacious in the reduction of this parameter (Figure 7).

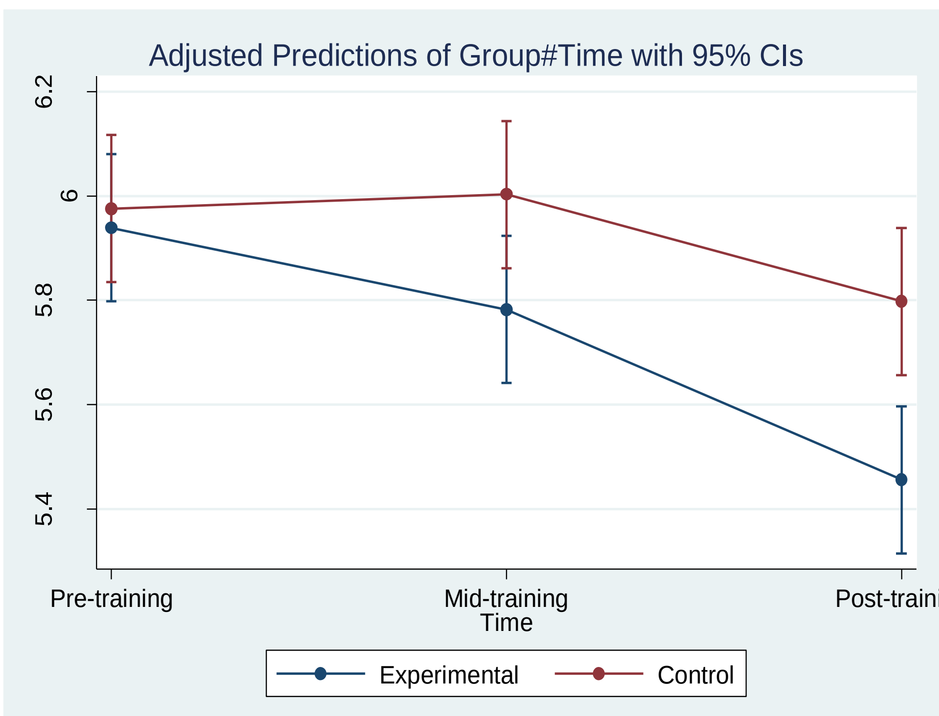

Figure 7: Predicted HbA1c interactions between group and time

DISCUSSION

The results in this study lead to a similar conclusion in a study done by Peyoosha & Rajan that demonstrated passive static stretching and Resistance exercises being effective treatment in reducing blood sugar levels (13).The recovery of insulin sensitivity is boosted by high-intensity aerobic exercises. Benefits from weight management, blood glucose control, and insulin sensitivity on tissues exercise are generally recommended for the treatment of pre- diabetes (14). Modification of lifestyle in regular physical activity has also shown a protective effect against the development of diabetes independent of age, obesity, parental history of diabetes and history of hypertension according to Erikson et al., (15). The study indicated the levels of FBG generally decreased in the experimental group during both mid-training and post-training period. Therefore this meant that exercise has been proved to be the most effective method of reducing the fasting blood glucose for pre-diabetes. In this study, it was established that fasting blood glucose is significantly decreasing after exercise. Physical exercise increases glucose uptake by the muscles and enhances storage of glucose. Level of FBG diminishes during the exercise because muscle contraction stimulates glucose uptake into the muscle even in the absence of insulin.

Cholesterol metabolism can positively be altered by participation in physical activity as well as a single exercise session (16). To increase the production and action of several enzymes functioning as enhancers that reverse cholesterol transport system, exercise is involved (17). Our study revealed that the levels of Total Cholesterol generally decreased in the experimental group during both mid-training and post-training period relative to pre-training. The results also showed HDL were significantly higher in the experimental than in the control group during post-training (z= -3.20.17, p=0.001). These findings meant that regular exercise is particularly helpful in improving HDL along with the total cholesterol and LDL decrease.

These findings were in agreement to other previous studies also done in Canada, for example Dunn et al. (16) assessed effects of a 6-month aerobic exercise training program. The exercise progressed from 50 to 85 % of maximum aerobic power for 20–60 min three times weekly. It was reported that there was a significant decreases in total cholesterol (-0.3 mmol/L, p\0.001) and in the total: HDL cholesterol ratio (-0.3, p\0.001). In this case, the set period for intervention was relatively long and the magnitude was relatively high. The decrease in HbA1c in this study is of clinical importance in positively affecting the management of pre-diabetes as well as in reducing the potential for development of complications from the disease. It is therefore important to interpret the findings that exercise regimen is effective in reducing hemoglobin HbA1c.

CONCLUSION

In conclusion, our study found that exercise regime reduces BMI, TC, TRI, LDL levels but after a long time of training. Increase in BMI leads to increase in FBG, TC, TRI, LDL, and HbA1c and the vice versa.

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