EFFECTS OF 8-WEEK MODERATE-INTENSITY EXERCISE ON LIPID PROFILES IN PREDIABETIC ADULTS: A GENDER-COMPARISON STUDY

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ABSTRACT

Objectives: To determine the effect of moderate-intensity exercise in prediabetic individuals on lipid profile and to explore gender differences.

Methods: This was a pre- and post-design experimental study carried out in the Physiology Department, Institute of Basic Medical Sciences, Khyber Medical University, Peshawar, Pakistan, fifty prediabetic participants in the 18-to 35-year-old age group were recruited and underwent a moderate exercise for 8 weeks. Exercise was monitored with pedometers

Results: Highly significant changes in lipid profile were observed in the female population at post-intervention. Cholesterol levels decreased from 170 ± 38 to 142 ± 27 mg/dL (P < 0.001), Triglyceride (TG) levels from 182 ± 44 to 154 ± 42 mg/dL (P = 0.001) low density lipoprotein (LDL) from 113 ± 13 to 100 ± 13 mg/dL (P < 0.001). High density lipoprotein (HDL) showed a statistically significant difference from 59 ± 8.5 to 62 ± 10.2 mg/dL (P < 0.001) in female gender. Also, there were highly significant changes in lipid profile in the male population post-intervention. Cholesterol levels decreased from 196 ± 34 to 151 ± 29 mg/dL (P < 0.001), TG levels from 205 ± 52 to 165.4 ± 30 mg/dL (P < 0.001), LDL from 118 ± 11 to 105 ± 10 mg/dL (P < 0.001), and in contrast HDL showed a statistically significant increase from 56 ± 8 to 62.5 ± 6 mg/dL (P < 0.001) in male population.

Conclusions: Exercise significantly helped reduce all lipid profile parameters for both groups with similar effect sizes.

Keywords: Prediabetes, moderate exercise, lipid profile

INTRODUCTION

Prediabetes is a health condition marked by elevated blood sugar levels that do not qualify as full-blown type 2 diabetes. In Pakistan, the prevalence of prediabetes is 14.4%, according to the International Diabetes Federation, 2022. Prediabetes is on the rise, and eight out of ten prediabetics are unaware of their condition (1). Patients with type 2 diabetes often display characteristic plasma lipid and lipoprotein abnormalities, such as low-density lipoprotein (LDL) cholesterol levels and elevated triglycerides (2). The development of lipid abnormalities in diabetes involves multiple factors, including adipose tissue, insulin resistance, inflammation, and other mediators.

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The dyslipidemia associated with type 2 diabetes relates to insulin resistance and often appears early, even before overt diabetes develops. Much of the atherogenic dyslipidemia seen in insulin resistance starts with hypertriglyceridemia (3). Gender differences also exist in lipid metabolism (4). Besides gender, age, and physical activity, hormonal differences influence lipid profiles as well (5). Androgens may contribute to increased weight and fat mass, which can lead to greater insulin resistance (6). Obese males often have lower testosterone levels, partly due to increased estrogen production by the enzyme aromatase in adipose tissue (7). Exercise training can positively affect glycemic control and lipid profiles by enhancing the activity of lipoprotein lipase, which lowers triglycerides and increases high-density lipoprotein (8). Although extensive research has studied how exercise impacts lipid profiles in people with diabetes, a gap remains in understanding gender differences. Our study aims to evaluate the effect of moderate exercise (heart rate 70±5% of the predicted maximum heart rate) on lipid profiles in males and females within the prediabetic group and to determine if there are gender-based differences in response to exercise.

METHODOLOGY

This investigation was part of a larger experimental study with a purposive pre- and post-design over 8 weeks, using moderate-intensity exercise as an intervention to assess its effects on the diabetic profile of prediabetic participants aged 18 to 35 years. This focus was chosen due to the rising trend of sedentary lifestyles and high-carbohydrate diets within this age group. All experimental work was conducted from February 2019 to January 2020 in the Physiology Department at the Institute of Basic Medical Sciences (IBMS), Khyber Medical University (KMU), Peshawar, Pakistan. Ethical approval was obtained from the Ethical Review Board of Khyber Medical University under DIR/KMU-EB/BP/000580 dated April 9, 2019, and all procedures adhered to the Declaration of Helsinki (1964). Fifty prediabetic volunteers, aged 18 to 35 years (n = 50), with no history of chronic or active health issues, participated in the study. The sample size was calculated using G*Power 3.1.9.2, based on data from two previous studies. The mean and standard deviation of TAC were derived from a sample of 26 in each group, with a power of 0.95 and α = 0.05 (9). TAC values of 1.325 ± 0.16 for prediabetics and 1.711 ± 0.13 for individuals with normal glucose tolerance, as reported by Mohieldein *et al.*, 2015 (10), were used for the calculation, resulting in a sample size of 10, with 5 participants in each group. To account for potential attrition over the 8-week intervention, 50 participants were recruited, with 22 females and 28 males. The inclusion criteria for prediabetes included fasting blood glucose levels of 100-125 mg/dL and glycated hemoglobin between 5.7-6.4%, according to the American Diabetes Association guidelines of 2025. After explaining the procedure to each participant, informed consent was obtained. Exclusion criteria included those having diabetes, hypertension, renal disease, or any other acute or chronic illness. Moderate exercise intensity was defined as 70 ± 5% of everyone's maximum heart rate. Step counts were recorded using Xiaomi Mi Band 2 pedometers, which were synced with a Chinese-made Mi Fit app on a cell phone, complemented by manual recordings on a chart for five days each week over an eight-week period. Pre-exercise total cholesterol, triglycerides (TG), LDL, and HDL levels were measured using standardized kits. Participants were familiarized with the treadmill, and after three baseline sessions conducted over three consecutive days, step counts were standardized for all participants. All parameters were reassessed after eight weeks.

RESULTS

Data analysis using paired sample t-tests revealed highly significant changes in lipid profile in the female population at post-intervention. Cholesterol levels decreased from 170 ± 38 to 142 ± 27 mg/dL (P < 0.001), TG levels from 182 ± 44 to 154 ± 42 mg/dL (P = 0.001), LDL from 113 ± 13 to 100 ± 13 mg/dL (P < 0.001), and in contrast HDL showed a statistically significant difference from 59 ± 8.5 to 62 ± 10.2 mg/dL (P < 0.001) in female gender as in table 1.

Table 1 Comparison of Lipid Profile in Female Population at Pre- and Post-Intervention

Lipid Profile	Female Gender (n=22) Mean ± SD		P value
	Preintervention	Postintervention	
Chol (mg/dL)	170 ± 38	142 ± 27	**< 0.001**
TG (mg/dL)	182 ± 44	154 ± 42	**0.001**
LDL (mg/dL)	113 ± 13	100 ± 13	**< 0.001**
HDL (mg/dL)	59 ± 8.5	62 ± 10.2	**< 0.001**

Chol = cholesterol, TG = triglycerides, LDL= low density lipoprotein, HDL = high density lipoproteins

Additionally, paired t-tests showed significant changes in the lipid profile of the male population after the intervention. Cholesterol levels decreased from 196 ± 34 to 151 ± 29 mg/dL (P < 0.001), TG levels from 205 ± 52 to 165.4 ± 30 mg/dL (P < 0.001), LDL from 118 ± 11 to 105 ± 10 mg/dL (P < 0.001), and HDL showed a statistically significant increase from 56 ± 8 to 62.5 ± 6 mg/dL (P < 0.001) in the male population, as shown in table 2.

Table 2 Comparison of Lipid Profile in Male Population at Pre- and Post-Intervention

Lipid Profile	Male Gender (n=28) Mean ± SD		P value
	Preintervention	Postintervention	
Chol (mg/dL)	196 ± 34	151 ± 29	**< 0.001**
TG (mg/dL)	205 ± 52	165.4 ± 30	**< 0.001**
LDL (mg/dL)	118 ± 11	105 ± 10	**< 0.001**
HDL (mg/dL)	56 ± 8	62.5 ± 6	**< 0.001**

hol = cholesterol, TG = triglycerides, LDL= low density lipoprotein, HDL = high density lipoproteins

Further analysis of the data using the independent sample t-test showed a reduction in triglycerides and low-density lipoproteins in both females and males. However, gender differences were generally not statistically significant. Baseline cholesterol levels were higher in males than in females, with a p-value of 0.015. Levels decreased in both groups after the protocol, and the gender difference was not statistically significant. High-density lipoproteins increased in males but remained unchanged in females, as shown in Table 3.

Table 1 Comparison of Lipid Profile Between Female and Male Population at Pre- and Post-Intervention

Lipid Profile	Mean±SD		P value
	Female N=22	Male N=28	
PreTG mg/dL	182 ± 44	205 ± 52	0.103
PostTG mg/dL	154 ± 42	165.4 ± 30	0.271
PreLDL mg/dL	113 ± 13	118 ± 11	0.218
PostLDL mg/dL	100 ± 13	105 ± 10	0.109
PreHDL mg/dL	59 ± 8.5	56 ± 8	0.292
PostHDL mg/dL	62 ± 10.2	62.5 ± 6	0.139
PreChol mg/dL	170 ± 38	196 ± 34	**0.015**
PostChol mg/dL	142 ± 27	151 ± 29	0.260

Chol = cholesterol, TG = triglycerides, LDL= low density lipoprotein, HDL = high density lipoproteins

DISCUSSION

The present study demonstrates that an 8-week moderate-intensity exercise intervention significantly improved lipid profiles in both male and female participants in the prediabetic population. These findings underscore the critical role of regular physical activity as a non-pharmacological strategy for mitigating dyslipidemia and reducing cardiovascular risk even before the onset of overt diabetes mellitus. The observed improvements in lipid parameters affirm the beneficial influence of exercise on metabolic health and provide further evidence for the incorporation of lifestyle-based interventions in early preventive care.

At baseline, mean total cholesterol levels among both males and females were within the normal range (<200 mg/dL); however, triglyceride (TG) and low-density lipoprotein (LDL) cholesterol levels were borderline high, while high-density lipoprotein (HDL) levels remained within normal limits. Comparative analysis revealed that males exhibited higher total cholesterol, TG, and LDL levels both before and after the intervention than females did. Notably, while both sexes demonstrated significant improvements following the exercise program, a gender-specific difference was observed in baseline total cholesterol levels. This observation aligns with existing evidence indicating that lipid metabolism differs between males and females due to variations in hormonal milieu, body composition, and fat distribution patterns.

Females typically have a higher body fat percentage and lower muscle mass than males, with fat distributed predominantly in subcutaneous depots, such as the gluteofemoral and abdominal regions. These sex-based variations in adipose tissue distribution are associated with differences in substrate utilization: females exhibit a greater propensity for lipid storage and higher whole-body insulin sensitivity, whereas males tend to rely more on lipid oxidation. Sex hormones modulate such metabolic distinctions and are further influenced by nutritional status and physical fitness. Estrogen exerts a protective effect on lipid metabolism by enhancing HDL cholesterol concentrations and modulating LDL receptor activity (11). This hormonal protection, mediated via estrogen receptor subtypes (Estrogen Receptor alpha, Estrogen Receptor beta, and G-protein-coupled Estrogen Receptor), contributes to the lower total cholesterol and LDL levels typically observed in premenopausal women. According to Mohr *et al.,* 2019, however, this advantage diminishes at post-menopause, leading to increased TG and LDL levels and decreased HDL concentrations. A key finding of our study was that, while both genders showed similar improvements in lipid profile parameters, a gender-specific difference was observed in baseline total cholesterol levels. This aligns with the existing literature, which suggests that lipid metabolism differs between males and females due to variations in hormonal regulation, body composition, and fat distribution. Estrogen, for instance, has been shown to exert protective effects on lipid (12). Conversely, males typically exhibit higher baseline LDL cholesterol levels, which may explain the differences in total cholesterol (13). Estrogen can activate the sympathetic nervous system, leading to increased subcutaneous adiposity in women. Estrogen and estrogen receptors can increase subcutaneous fat in adipocytes and inhibit the accumulation of visceral fat.

In the present study, higher TG, cholesterol, LDL, and HDL levels were noted in males compared with females, which may be attributed to dietary differences—specifically, greater consumption of high-carbohydrate and high-fat foods among men. The reduction in LDL observed post-intervention may reflect HDL-mediated LDL clearance and the direct lipid-lowering effects of exercise. Interestingly, the modest elevation in TG levels following exercise could also suggest intensity-dependent metabolic adaptations in lipid utilization. The statistically significant difference in baseline cholesterol levels between sexes ($p = 0.015$) supports the hypothesis of intrinsic gender-based metabolic disparities. These findings differ from those of Alzahrani *et al*., 2019, who reported higher lipid levels in females, likely reflecting differences in study populations, including older age, a predominance of diabetic participants, and a higher proportion of females.(14).

According to Mohr *et al.,* 2019, our findings suggest that although women may exhibit greater reductions in total cholesterol and LDL than men, these differences often fail to reach statistical significance. Similar outcomes have been reported in studies demonstrating significant decreases in cholesterol and TGs and concurrent increases in HDL following as little as three weeks of structured training (15,16). These results collectively support the hypothesis that the estrogenic environment during reproductive years contributes to more favorable lipid metabolism in females, promoting enhanced fat oxidation and lower carbohydrate utilization during exercise (17). Consequently, despite a higher adipose tissue percentage, females generally exhibit greater insulin sensitivity than males, potentially providing transient protection against insulin resistance and subsequent type 2 diabetes mellitus. However, this metabolic advantage may diminish under conditions of chronic hyperglycemia, leading to increased susceptibility to insulin resistance and dyslipidemia (18).

The mechanisms underlying the observed exercise-induced improvements in lipid profiles are likely multifactorial. Regular physical activity enhances insulin sensitivity, reduces visceral adiposity, and promotes favorable lipid metabolism through increased lipoprotein lipase activity and reduced hepatic triglyceride synthesis (19). By contrast, sedentary lifestyles contribute significantly to the development of insulin resistance, dyslipidemia, and cardiovascular disease. Although the specific types of exercise most effective for mitigating these risks remain to be fully elucidated, the current study provides evidence that moderate-intensity exercise improves lipid parameters. The observed reductions in triglycerides, increases in HDL cholesterol, and overall optimization of lipid profiles highlight the metabolic benefits of sustained physical activity in individuals with prediabetes (20).

Overall, our findings reinforce that moderate-intensity exercise has beneficial effects on lipids in both sexes, particularly when exercise duration and intensity are similar. However, baseline gender differences in total cholesterol require further study to understand the hormonal and metabolic factors underlying these differences. Future research with larger sample sizes, more extended intervention periods, and hormonal profiling is recommended to better understand sex-specific responses to exercise in prediabetes.

CONCLUSION

In conclusion, our study showed that moderate-intensity exercise significantly improves lipid profiles in prediabetic individuals, with similar benefits observed in both males and females. These results highlight the importance of including regular physical activity in lifestyle interventions for managing prediabetes, regardless of gender.

It is possible that 8 weeks of exercise were not sufficient for complete adaptation. This also suggests that programmed exercise should be planned for a duration of longer than 8 weeks. Furthermore, the results of our research will serve as a tool for designing structured exercise programs aimed at improving metabolic fitness, providing appropriate physical training for the prediabetic population to revert to a healthy state. Future studies should focus on identifying the most effective preventive strategies, including physical fitness programs, for the prevention and management of prediabetes and diabetes, particularly in regions with limited financial resources, such as Pakistan and other diverse settings.

STRENGTHS AND LIMITATIONS

We used the exercise protocol for eight weeks that equally benefited both groups. A longer duration of exercise intervention may have shown some difference between genders.

AUTHORS' CONTRIBUTIONS

Zubia Shah designed the study, conducted blood tests, developed the exercise protocol, and performed the data analysis. Farida Ahmad helped with subject recruitment and exercise protocol. Fatima Fayyaz assisted with recruitment, data collection, exercise protocol, and data entry, while Ushna Zoofeen contributed to data entry and analysis.

ACKNOWLEDGMENTS

We acknowledge the participants for their contributions to the study and are grateful for the valuable assistance of the lab technicians in the Department of Physiology at Khyber Medical University.

CONFLICTS OF INTEREST

No reported conflict of interest.

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