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Efficacy of an intensive lifestyle modification program on anthropometric measurements and gulcose parameters in the middle aged prediabetic population of Karad

Dr. Shukrangi Shende[1], Dr. Poovishnu Devi Thangavelu[2]

[1]MPT, Department of Cardio Pulmonary Physiotherapy, Krishna Viswa Vidyapeeth Deemed to be University, Karad, Maharashtra.

Email ID: shukrangis@gmail.com

[2]Dean Academics & Professor, Department of Cardio Pulmonary Physiotherapy, Krishna Viswa Vidyapeeth Deemed to be University, Karad, Maharashtra.

Email ID: deanacademicskcp@kvv.edu.in

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ABSTRACT

Background: Prediabetes is a metabolic disorder marked by high blood glucose levels that does not match the criteria for diabetes diagnosis. It is linked to insulin resistance, a condition of poor glucose metabolism which results from reduced insulin sensitivity in the muscles and liver. The pathophysiological markers of prediabetes include insulin resistance and poor glucose tolerance, which can be brought on by the confluence of behavioural, environmental, and genetic variables. Chronic insulin resistance declines insulin output over time by causing beta-cell dysfunction in the pancreas. This progression elevates the risk of type 2 diabetes and its associated dangers, such as neuropathy and cardiovascular disorders. A first-line strategy to lower the risk of type 2 diabetes is an intensive lifestyle modification program, which involves diet adjustments and planned physical activities. This study aims to evaluate the effectiveness of an intensive lifestyle modification program in middle-aged prediabetic population based on anthropometric measurements and glucose parameters.

Methodology: A quasi-experimental study was conducted to evaluate the efficacy of an intensive lifestyle modification program consisting of aerobic training and resistance exercises, dietary changes. One hundred and fifty-three participants were enrolled in the study. Anthropometric assessments included BMI and waist-to-hip ratio (WHR), glucose parameters included measures of fasting blood glucose levels, psychological stress was calculated using the Perceived Stress Scale-10 questionnaire, while the physical activity levels were measured using the IPAQ-SF questionnaire. Chi-square and paired t-tests were used to analyse data before and after the intervention.

Results: The sample included 153 participants. At 6 months, the participants demonstrated a significant improvement in fasting blood glucose, body mass index (BMI), waist-to-hip ratio, perceived stress, and physical activity levels ($p<0.05$)

Conclusion: Anthropometric and glycaemic indices, stress levels, and physical activity are all markedly improved in the middle-aged prediabetic population by the rigorous lifestyle change program. According to these results, systematic lifestyle interventions are crucial as a non-pharmacological approach to halting the progression from prediabetes to type 2 diabetes.

Keywords: *Prediabetes, fasting blood glucose, anthropometric measurements, and lifestyle modification*

1. INTRODUCTION

Prediabetes is a condition which occurs before the diagnosis of diabetes mellitus.In adults with prediabetes, the blood sugar levels are greater than usual, but they may not exhibit any signs or symptoms of diabetes mellitus [1]. Prediabetes is progressively being recognised as an important metabolic condition that poses a higher risk of progressing to type 2 diabetes(T2D) in future [2]. According to diabetes's pathophysiology and natural history, there is a protracted prediabetic phase which can exist undetected for many years [3]. There are high chances of developing different pathologies in individuals, which are normally associated with that disease, such as diabetic retinopathy, neuropathy and macrovascular complications [2, 3]. The criteria most commonly used to define prediabetes, based on the World Health Organisation (WHO) for impaired glucose tolerance(IGT), are [140-199 mg/dL] and impaired fasting glucose (IFG) is [110-125 mg/dL] [2]. The diagnostic criteria for prediabetes based on the American Diabetes Association (ADA) are as follows: IGF (100-125 mg/dL) [4]. In 2021, the global adult population of 5.8% (298 million) aged 20 - 79 years were evaluated to have IFG, which will expand to 6.5% (414 million) by the year 2045 [5]. In India, the overall prevalence of prediabetes was 15.3% according to WHO criteria, and according to ADA criteria, it is 32.8%, and this study was initiated by the phased ICMR- INDIAB [6]. The state of Maharashtra has a weighted prevalence of 12.8% of prediabetes [7].

Prediabetes patients with impaired fasting glucose tend to have higher or "inappropriate" endogenous glucose production compared to those with normal glucose regulation. This is because they have hepatic insulin resistance, reduced hepatic glucose clearance, and a decreased capacity of glucose to stimulate it's own uptake and suppress its own production. Beta cell dysfunction and skeletal muscle resistance, which results in delayed glucose uptake, are the main characteristics of impaired glucose tolerance[8,9,10]

As civilization continues to advance rapidly, population ageing has emerged as a clear issue impacting public health. The primary risk factor for both diabetes and prediabetes is advanced age. Given that age variations result in modifications to clinical and socio-demographic traits, age may be a significant factor affecting the contribution of risk factors for prediabetes [11]. It is an absolute necessity to identify prediabetes in middle age as it not only poses a high chance of developing type 2 diabetes but often coexists with a variety of other health challenges such as obesity, high blood pressure, and elevated blood fats [12]. It is a well-established fact that with age the function of islets is declining. It has been noted that this decline triggers the weakened insulin action, which consecutively is responsible for lipid and glucose metabolism disorders [13]. There is a clear correlation between age and the occurrence of prediabetes. Therefore, we can definitely state that one of the main factors contributing to the development of prediabetes is age [12]. Testing for the risk of prediabetes should start at least at the age of 35 years. In asymptomatic individuals, with an assessment for risk factors medical surveillance for prediabetes and type 2 diabetes should be done [14]. Effective indicators of metabolic conditions, which include prediabetes are anthropometric measurements like body mass index (BMI), waist-to-hip ratio (WHR) [15,17]. The lifelong risk of prediabetes and diabetes is significantly increased by obesity [16].

Sedentary lifestyle is also one of the primary reason for developing prediabetes and then diabetes, as people are less active, their BMI increases [18]. The metabolic condition is also greatly affected by anxiety, depression, and stress. Semi-urban populations have been reported with higher stress levels because of longer work shifts, complex schedules, social isolation, and minimal support on both a personal and professional level. One of the essential risk factors for diabetes is psychological stress. Health behaviours such as food choice, medication intake, and physical activity can be severely affected by psychological stress, leading to the risk of type 2 diabetes [19, 20]

Most of the population with prediabetes within the next 10 years will develop type 2 diabetes if they do not change their lifestyle as stated by the National Institute of Diabetes and Digestive and Kidney Diseases [21]. In addition, studies have associated lifestyle modification to improved health and emotional outcomes in mixed gender groups with the risk of diabetes [22]. It is imperative for physiotherapists to stress the critical role that lifestyle changes play in halting the development of type 2 diabetes, especially in high-risk patients. The International Diabetes Federation (IDF) states that, lifestyle modifications are affordable, scalable, and have a low chance of negative consequences, they are strongly advised. Diabetes prevention has been found to benefit from the inclusion of physical exercise, dietary changes, and psychological support [23]. Exercise is a key component of lifestyle therapies from a physiotherapeutic perspective. It has beneficial effects on gut microbiota, lipid metabolism, and inflammatory indicators in addition to helping to improve insulin sensitivity and blood glucose management [24]. Furthermore, a more sustainable and comprehensive approach to addressing prediabetes is lifestyle adjustment, as relying exclusively on pharmaceutical interventions may increase financial burden and other health hazards [25]. Maintaining lifestyle change over time is a well-known worldwide difficulty, and few research addressed the sustainability of lifestyle changes in response to interventions [26,27]

Adopting and sustaining physical activity is essential for blood glucose control and general health in people with prediabetes [28]. According physiotherapists point, any kind of physical activity improves glycaemic management. Resistance exercise, in particular, has been demonstrated to improve glycaemic control in prediabetic individuals via a number of methods. One important method includes using glucose as fuel, which causes blood glucose levels to drop as a result of exercise induced muscle glycogen depletion [29]. Other advantages include increased lean muscle mass, decreased visceral adipose tissue (VAT), improved glucose metabolism, improved endothelial function, improved pancreatic beta-cell function, and increased production of glucose transporter type 4 (GLUT-4), which improves insulin sensitivity and glucose uptake [29]. Resistance training should be done at least twice a week in addition to 150-300 minutes of moderate-to-vigourous physical activity (MVPA), according to World Health Organization (WHO) [30] . Interval training at a moderate level has shown promising results in a number of glycaemic variability metrics [29]. High-intensity interval training (HIIT) may also be even more beneficial for controlling prediabetes, according to current research, which has positive impact on muscular strength, insulin resistance, and VO2 max [31]. Better glycaemic control and general health outcomes for people risk of prediabetes can achieved by physiotherapists integrating these evidence-based exercise techniques into customised treatment regimens.

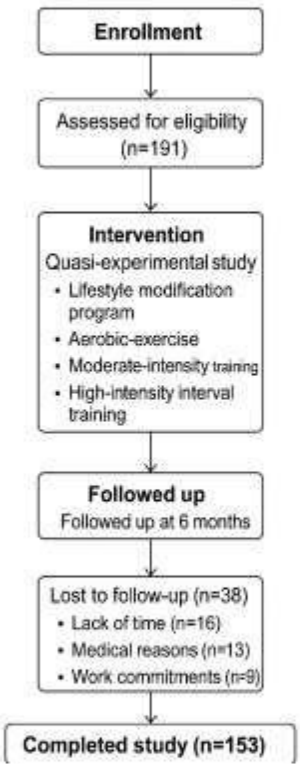
2. METHODOLOGY

A quasi-experimental study was conducted to investigate the efficacy of an intensive lifestyle modification program on anthropometric measurements and glucose parameters among middle-aged prediabetic individuals. The study was conducted at Krishna Hospital and Medical Research Center (KH&MRC), Karad, India, between March 2023 and March 2025. Inclusion criteria was individuals who were diagnosed to have prediabetes, of either sex, aged 35-46 years with fasting blood glucose levels ranging in between 110-125 mg/dL, with BMI ranges of 25 kg/m² - 39.9 kg/m², having a sedentary lifestyle and not having any engagement in structured physical activities. Exclusion criteria included participants undergoing any other form of exercise routine or treatment plans, individuals with severe physical or cognitive disability and pregnant women or those who are contraindicated to physical activity. The ethical approval was obtained from the Institutional Ethics Committee of Krishna Vishwa Vidyapeeth, Krishna Institute of Medical Sciences (Deemed to be University), Karad.

A total of 191 participants were enrolled in this study. Among them only 153 participnats completed the protocol for over the course of six months, the intervention constituted an effective lifestyle change program which had a planned aerobic and resistance training were performed atleast five days a week for 50 to 60 minutes each session. Aerobic component included aerobic dance, brisk walking, running, and a combination of aerobic exercises, while resistance training concentrated on body weight exercises and mild weightlifting, adapted to individual fitness levels to prevent injuries [32, 33]. Additionally, there were educational seminars on stress management, dietary modifications, lifestyle changes, and self-monitoring blood glucose levels. Blood tests were performed to measure fasting blood glucose levels (FBG) at baseline and after intervention. Psychological stress was measured using the Perceived Stress Scale-10 (PSS-10) [19]. Additionally, the International Physical Activity Questionnaire-Short Form (IPAQ-SF) was used to utilized for assessing participants levels of physical activity both at baseline and end of the study [34].

The sample size was 153 with 20% attrition rate with 80% power and 95% confidence level.Using SPSS version 25.0, the study was statistically analyzed using chi-square tests for categorical variables and paired t-tests for comparing pre-test and post-test results. The Kolmogorov-Smirnov was employed to assess the normality assumptions. Demographics of all the participants recruited in the study were described using descriptive statistics.

Figure no. 01: Flow of participants using Consort flow Diagram



3. RESULTS

The study examined the effects of an intensive lifestyle modification program on anthropometric measurements and glucose parameters in the middle-aged prediabetic population of Karad. A total of 191 participants were enrolled into the study, of which only 153 completed the course of 6 months lifestyle change program.

In this study a population of 153 participants, age varied from 35 to 46 years with a mean age of 40.25 ± 3.62 years, with 75 females (49%) and 78 males (51%). Family history of diabetes mellitus were recored in 100 (65.4%), smoking was reported by 28.8% and alcohol intake was reported by 32.7% of participants. (Table no. 01)

At baseline, the average weight was 76.64 ± 4.49 kg. The baseline fasting blood glucose levels were 117.48 ± 4.24. The anthropometric measurements mean value was, BMI 26.49 ± 1.55 and WHR 0.91 ± 0.066. The baseline mean score of the perceived stress scale-10 (PSS-10) was 21.51 ± 4.02 while the IPAQ-SF for physical activity was 638.26 ± 245.81, (Table no. 02).

At the end of study, significant improvements were seen in every outcome that was examined after the six-month intervention. Among the individuals, the mean weight dropped by 4.11 kg, from 74.35+-4.49 to 70.24=-4.69 kg(p<0.001).

The fasting blood glucose levels declined from 117.48+-4,24 to 107.93+-6.52(p<0.001). the BMI levels dropped from 26.49+-1.55 to 25.04+-1.55(p=0.004) and the WHR levels dropped from 0.91+-0.07 to 0.88+-0.06(p<0.001). There was significant reduction in psychological stress levels ranging from 21.51+-4.02 to 17.01+-4.49(p<0.001). A significant increase with a mean improvement of 519.95 from 638.26+-245.81 to 1158.21+-481.19(p<0.001) was noted in the physical activity levels.

Table no: 01. Descriptive statistics of categorical variables among overall participants in the study (n = 153)

Variables	Frequency (n)	Percentage %
Sex		
Female	75	49%
Male	78	51%
Family history		
No	53	34.6%
Yes	100	65.4%
Smoking		
No	109	71.2%
Yes	44	28.8%
Alcohol		
No	103	67.3%
Yes	44	28.8%
Habits		
No	82	53.6%
Yes	71	46.4%

Table no: 02. Descriptive statistics of outcome variables at baseline among overall participants in the study (n = 153)

Variables	Mean (SD)	Min- max (range)	IQR
Age,years	40.25 ± 3.62	35 - 46 (11)	7
Weight, kg	74.64 ± 4.49	66 - 88 (22)	8
BMI, kg/m2	26.49 ± 1.55	23.3 - 32.5 (9.2)	2.3
FBG,mg/dL	117.48 ± 4.24	110 - 125 (15)	6
WHR,cm	0.91 ± 0.066	0.78 - 1.10 (0.32)	0.12
PSS-10	21.51 ± 4.025	12 - 28 (16)	7
IPAQ-SF	638.26 ± 245.81	198 - 1200 (1002)	446

Table no 03 : Comparison of pre-test and post-test outcome measures among the participants (using paired t test, n =153)

Outcome measures	Pre-test		Post-test		mean diff (95%CI)	t value	P value
	Mean ±SD	SE	Mean ±SD	SE			
Weight	74.35±4.49	0.36	70.24±4.69	0.38	4.11 (3.95, 4.27)	49.72	< 0.001
BMI	26.49±1.55	0.13	25.04±1.55	0.13	1.46 (1.39, 1.52)	45.15	0.004
WHR, cm	0.91±0.07	0.01	0.88±0.06	0.01	0.03 (0.01, 0.06)	23.06	<0.001
FBG, mg/dL	117.48±4.24	0.34	107.93±6.52	0.53	9.55 (8.97,10.13)	32.50	<0.001
PSS	21.51±4.02	0.33	14.73±4.49	0.36	4.50 (4.27, 4.73)	38.62	< 0.001
IPAQ	638.26±245.81	19.87	1158.21	481.19	-519.95 (-563.72, -476.18)	-23.47	<0.001

Table no 04: Comparison of lifestyle and family history factors by Sex in study participants using Chi-square tests (n=153)

	Overall, n (%) 153 (100%)	**Female**	**Male**	**Chi-square χ^2**	**p value**
Family history					
No	53 (34.6)	27 (36)	26 (33.3)	**0.120 (phi 0.028)**	**0.729**
Yes	100 (65.4)	48 (64)	52 (66.7)		
Smoking					
No	109 (71.2)	73 (97.3)	36 (46.2)	**48.883 (phi 0.565)**	**< 0.001**
Yes	44 (28.8)	02 (2.7)	42 (53.8)		
Alcohol					
No	103 (67.3)	72 (96)	31 (39.7)		
Yes	50 (32.7)	03 (4)	47 (60.3)	**55.03 (phi 0.601)**	**< 0.001**
Habits					
No	82 (53.6)	38 (50.7)	44 (56.4)	**0.507 (0.058)**	**0.476**
Yes	71 (46.4)	37 (49.3)	34 (43.6)		

Table no 05: Comparison of health and lifestyle variables between male and female participants

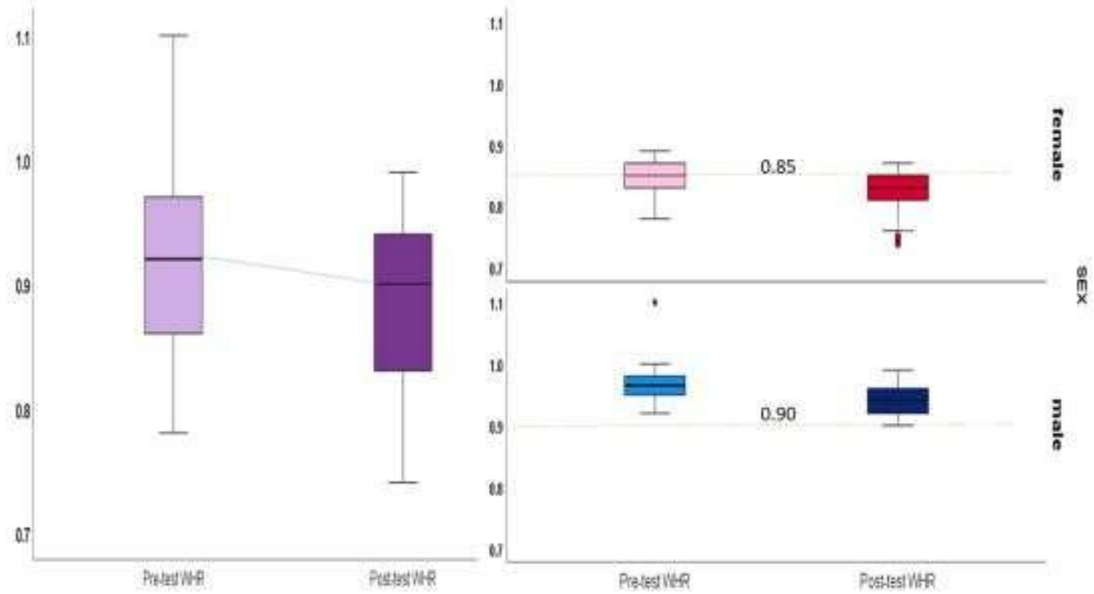
Variables	**Male**			**Female**			**Mean Diff**	**t value**	**p value**
	Mean	**SD**	**SE**	**Mean**	**SD**	**SE**			
Weight	76.04	4.22	0.47	72.59	4.095	0.47	-3.45	-5.12	**0.000**
BMI	26.08	1.25	0.14	26.92	1.717	0.19	0.82	3.42	**0.001**
FBG	118.06	4.18	0.47	116.88	4.25	0.49	-1.18	-1.73	0.084

WHR	0.96	0.033	0.003	0.85	0.029	0.03	-0.117	-23.05	**0.000**
PSS	22.32	3.97	0.45	20.67	3.93	0.45	-1.654	-2.58	**0.011**
Physical activity level	671.63	263.61	29.8	603.56	222.29	25.66	-68.06	-1.72	0.087

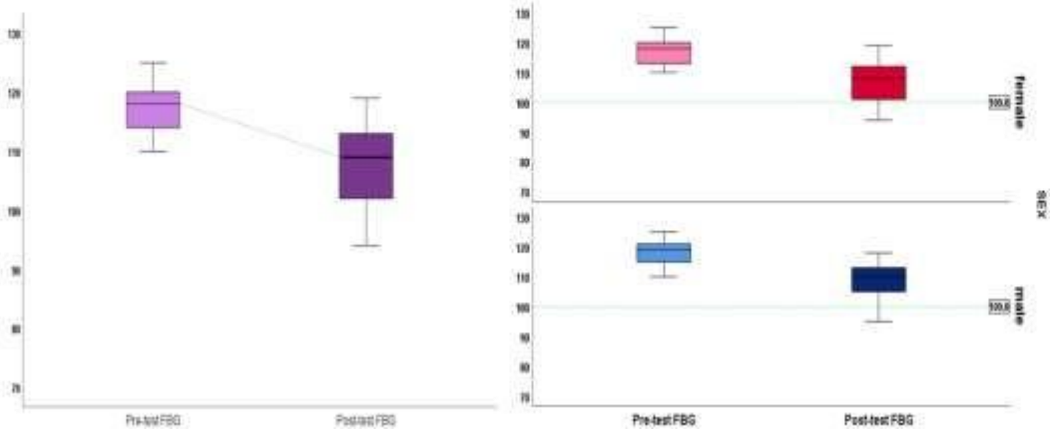
Table no 06: Within the group comparison of pre-test and post-test values of treatment effects of patient-reported outcome measures (using paired t test, n =153)

Outcome measures	Pre-test			Post-test							
	mean	**SD**	**SE**	**mean**	**SD**	**SE**	**mean diff**	**95%CI of mean diff**		**t value**	**P value**
Weight	74.35	4.49	0.36	70.24	4.69	0.38	4.11	3.95	4.27	49.72	< 0.001
BMI	26.49	1.55	0.13	25.04	1.55	0.13	1.46	1.39	1.52	45.15	0.004
WHR	0.91	0.07	0.01	0.88	0.06	0.01	0.03	0.03	0.03	23.06	< 0.001
FBG	117.48	4.24	0.34	107.93	6.52	0.53	9.55	8.97	10.13	32.50	< 0.001
PSS	21.51	4.02	0.33	17.01	4.49	0.36	4.50	4.27	4.73	38.62	< 0.001
Physical activity level	638.26	245.81	19.87	1158.21	481.19	38.90	- 519.95	- 563.72	- 476.18	- 23.47	< 0.001

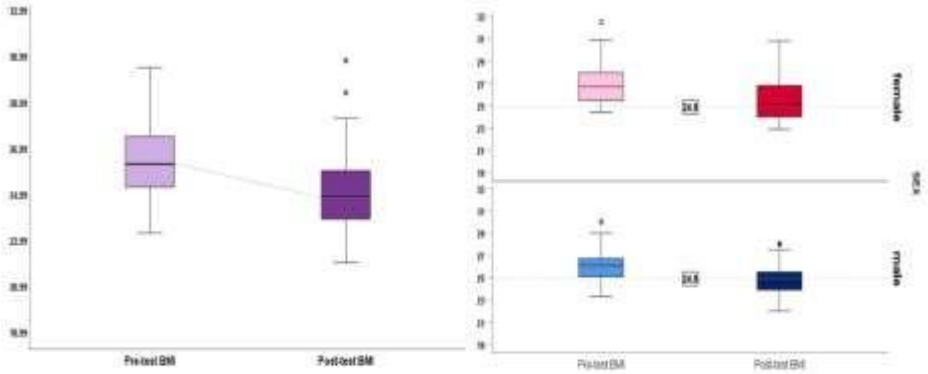
Graph no 01: Post intervention differences of BMI levels between pre-test and post-test groups and between male and female participants.



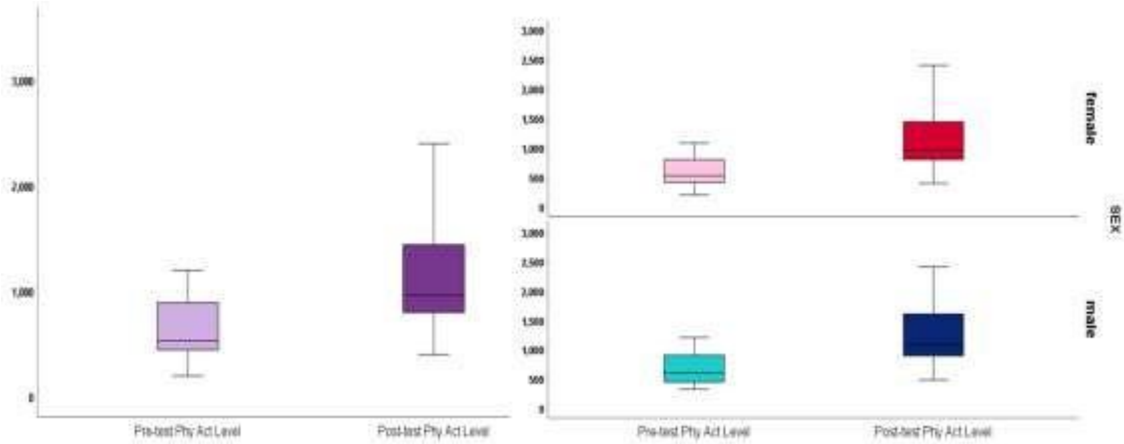
Graph no 02: Post intervention differences of waist-to-hip ratio between pre-test and post-test groups and between male and female participants.



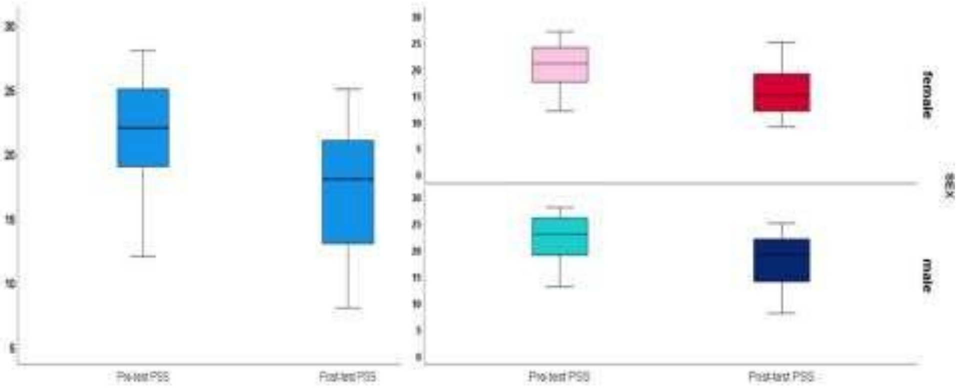
Graph no 03: Post intervention differences of Fasting blood glucose levels between pre-test and post-test and male and female participants.



Graph no 04: Post intervention differences of Perceived Stress Scale Levels between pre-test and post-test groups and between male and female participants.



Graph no 05: Post intervention differences between physical activity levels between pre-test and post-test groups and between male and female participants.



4. DISCUSSION

The current study shows that middle-aged individuals with prediabetes in Karad can greatly improve their metabolic, anthropometric, psychological health, and physical activity indicators by following a structured Intensive Lifestyle Modification Program (ILSP). Particularly in the middle age, when physiological changes increase the likelihood of insulin resistance, the results highlight the effectiveness of lifestyle modifications as a non-pharmacological strategy to slow the progression of prediabetes to type 2 diabetes. Since weight loss and BMI reduction immediately lower the insulin resistance, they are essential for preventing diabetes.

The observed mean decrease of 4.11 kg in body weight and 1.46 kg/m² in BMI is in line with International guidelines, including those set forth by the Finnish Diabetes Prevention Study (DPS) and the Diabetes Prevention Program (DPP). According to these research, type 2 diabetes can be significantly postponed or prevented with a 5-7% decrease in body weight [33, 35]. Additionally, the waist-to-hip ratio (WHR) significantly reduced from 0.91 to 0.88, indicating a decrease in visceral adiposity. This is important for reducing cardiovascular risk, especially in the middle-aged adults who are more likely to develop central obesity as a result of age-related metabolic changes [36].

Behavioural theories explain how organised how treatments promote behavioural change which include the Health Belief Model (HBM) and the Transtheorectical Model (TTM). Middle-aged participants in this study underwent phases of change, from reflection to action, and sustained their gains throughout the intervention period, driven by health concerns and knowledge of possible consequences connected to diabetes [37, 38]

Improved glycaemic control, as seen by decrease in fasting blood glucose (FBG) by 9.55 mg/dL, shows how effective the program is. In the middle-aged population, where insulin resistance frequently peaks, such improvements are crucial. The results of the study support the findings of the Indian Diabetes Prevetion Programme (IDPP) and other studies by Knowler et al., demonstrating that even small changes in lifestyle can have a clinically meaningful impact on metabolism [39, 40].

The Insulin Sensitivity Theory, which claims that alterations in lifestyle improve skeletal muscle absorption of glucose and reduce hepatic glucose synthesis, lends more credence to these findings. To improve glycaemic outcomes in the population under study, the ILMP targeted dietary and aerobic activity, two important factors that contribute to insulin resistance [41].

A mean improvement of 6.78 reduction in perceived stress were the outcomes of the ILMP's holistic approach, which combined psychological and physical therapies. This all-encompassing approach is supported by the Biopsychosocial Model of Health, which acknowledges that better psychological resilience and less stress are critical for preserving glycaemic control and general health [42].

The shift from sedentary to moderately active lives, in line with WHO physical activity guidelines, is highlighted by the notable increase in IPAQ scores(519 MET-min /week). Frequent, structured physical activity improves psychological well-being in addition to metabolic health. Self-efficacy and social support, according to Bandura's Social Cognitive Theory, are essential for sustaining higher levels of physical activity, particularly for middle-aged people juggling job and family obligations [43].

The study emphasis on middle-aged adults (those between the ages of 35 and 46) is particularly essential because of their increased risk of developing diabetes. Before beta-cell failure becomes irreversible, tailored therapies can still restore prediabetic symptoms throughout the critical middle-age period. According to the IDF's International guidelines, upto 80% of people with prediabetes may develop diabetes within ten years if they do not receive treatment, therefore prevention is crucial throughout this time [44].

In light of the rising rates of diabetes and prediabetes in India, our study emphasises how urgently scalable ILMPs in community settings are needed. It is possible to maximise adherence and results, behavioural change theories can be integrated with realistic, culturally appropriate interventions. Due to their high risk and propensity to respond favourably to preventive measures that prioritise work productivity and family well-being, middle-aged adults should be the focus of lifestyle interventions designed for them by policymakers and healthcare practitioners.

5. CONCLUSION

This study demonstrated that there was substantial improvement in physical activity levels through the intervention program which included structured aerobic exercises and resistance exercises for six months. The significance of planned lifestyle interventions as a successful non-pharmacological method to lower the risk of developing type 2 diabetes from prediabetes is highlighted by these findings. A feasible and useful strategy is provided by this program for diabetes prevention because prediabetes is becoming more common in semi-urban areas.

6. LIMITATIONS

One of the limitations of our study is that, the study was carried out only in one center so the external validity may be limited. And, the six-month research period might be too short to evaluate the long-term impacts of lifestyle changes on anthropometric measurements and glycaemic management.

7. FUTURE RECOMMENDATIONS

Future studies should aim to include several centres to improve generalisability. Performing follow-up studies over an extended period of time to assess the long-term effects of lifestyle changes on anthropometric and glycaemic indicators. Also, the future studies should implement using randomized controlled trials to bolster the body of data.

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