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Optimizing Glycaemic Control in Type 2 Diabetes Mellitus Through Met-Based Individualized Exercise Prescription: A Clinical Study

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ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) presents a significant global health burden, closely linked with sedentary lifestyles and poor glycaemic control. While exercise is a cornerstone of T2DM management, conventional exercise prescriptions often lack individualization. To evaluate the effectiveness of a MET-based individualized exercise prescription model in improving glycaemic and physiological outcomes in patients with T2DM.

Methods: A prospective interventional study was conducted involving adult T2DM patients allocated into endurance, strength, and combined (combo) exercise groups. Outcome measures included changes in HbA1c, BMI, daily step counts, and confidence in adherence. Data were analyzed using paired t-tests and chi-square tests for categorical associations.

Results: The MET-based intervention led to a significant overall reduction in HbA1c (mean decrease: 0.34%, p=0.001), with the combo group showing the greatest improvement (0.59%). Cardiorespiratory fitness improved notably, with the strength group averaging 9804 steps/day (p=0.024). Most participants engaged in moderate-intensity activity, with a significant association between exercise type and intensity level (p=0.002).

Conclusion: MET-based exercise prescription is an effective, structured, and patient-centered approach that improves glycaemic control and exercise adherence in T2DM patients. This model may serve as a scalable and individualized strategy in clinical and community settings to optimize diabetes management.

Keywords: Type 2 Diabetes Mellitus, MET, Exercise Prescription, Glycaemic Control, HbA1c

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and impaired glucose metabolism, representing a rapidly escalating global public health concern. Its growing prevalence is closely associated with sedentary lifestyles, poor dietary habits, and increasing obesity rates. While pharmacological treatment remains vital, lifestyle interventions, particularly physical activity, are widely recognized as cornerstone strategies in achieving glycaemic control and improving long-term health outcomes.

Numerous studies have explored various aspects of T2DM management, including pharmacological therapies, socioeconomic disparities, and exercise modalities. Kobayashi et al. (2023) found that strength training was more effective than aerobic exercise in improving glycaemic control and body composition among normal-weight T2DM patients [1]. Flores-Hernández et al. (2025) highlighted disparities in care quality linked to socioeconomic and ethnic factors [2], while Zhang et al. (n.d.) investigated dose-response relationships between physical activity and gestational diabetes risk [3]. Other researchers examined the intersection of diabetes treatment with comorbidities such as prostate cancer [4] and compared glucose-lowering drugs as second-line therapies [5].

Miyoshi et al. (2024) demonstrated the value of quantitative image analysis in diabetes education [6], and Vaanabouathong et al. (2022) reviewed the utilization of GLP-1 receptor agonists in Canada [7]. Li et al. (2024) reported the cardiovascular effects of combined exercise in elderly hypertensive patients [8], and Wang et al. (2024) studied real-world efficacy of antihypertensive treatment in diabetic inpatients [9]. These findings align with other analyses of GLP-1 therapy usage and implications for diabetic care [10]. The integration of artificial intelligence in medical management of diabetes is gaining attention, as discussed by Saab et al. (2024), who reviewed the capabilities of advanced AI models in medicine [11]. Wu et al. (2021) explored biofuel cell wearables for continuous glucose monitoring [12], while Stegbauer et al. (2020) conducted a systematic review of cost drivers for diabetes care in France and Germany [13, 15]. Vitale et al. (2020) emphasized the value of diabetes education teams in improving primary care outcomes [14].

Technology-driven innovations, such as bioanalytical sensors and reinforcement learning-based digital interventions, are reshaping how diabetes care is delivered, as noted by Kaushik et al. (2020) and Forman et al. (2019) [16, 17]. The importance of exercise intensity on quality of life among obese individuals with T2DM was highlighted by Svensson et al. (2017) [18], while Florido et al. (2018) revealed links between long-term physical activity changes and reduced heart failure risk [19]. Finally, Kim et al. (2019) provided insight into longitudinal HbA1c changes following treatment intensification [20]. Despite these advancements, a gap remains in the personalization of exercise prescription for T2DM patients. Traditional recommendations often lack adaptability to individual physiological conditions, preferences, or comorbidities, reducing long-term adherence and effectiveness. The Metabolic Equivalent of Task (MET) system offers a quantifiable, scalable approach to individualize exercise prescriptions based on energy expenditure and functional capacity. However, its clinical utility in structured T2DM intervention programs remains under-explored.

This study was motivated by the need to translate MET-based guidelines into personalized, sustainable, and clinically effective exercise prescriptions for T2DM patients. With physical activity being underutilized despite its proven benefits, a standardized yet individualized framework could fill a critical gap in diabetes care.

Moreover, tailoring exercise intensity using MET values allows for safer and more adaptable interventions, especially in patients with comorbidities or varying fitness levels. This approach also has the potential to improve adherence by aligning physical activity recommendations with patients' preferences and capabilities.

The primary objective is to evaluate the effectiveness of MET-based individualized exercise prescriptions in improving glycaemic control (measured by HbA1c) and physiological fitness (e.g., step counts, confidence, and endurance) among adult T2DM patients. The remainder of this article is organized as follows: the next section presents the methodology including participant selection, intervention protocol, and statistical analysis techniques. The following section discusses the results of the intervention, including comparative outcomes across exercise types and also offers a discussion on the findings in the context of current literature. The next section concludes the article with clinical implications, limitations, and recommendations for future research.

METHODOLOGY

Study Design and Setting

This study employed a prospective interventional design aimed at evaluating the clinical effectiveness of a MET-based individualized exercise prescription model for adult patients diagnosed with Type 2 Diabetes Mellitus (T2DM). The study was conducted over a 12-week intervention period at a clinical fitness and rehabilitation facility affiliated with a tertiary care hospital. The controlled environment enabled close monitoring of participants' physiological responses, adherence patterns, and progress under supervised guidance. The structured setting ensured that exercise prescriptions were implemented as planned, with continuous adjustments based on individual tolerance and outcomes.

Participant Selection

A total of 90 participants were enrolled in the study through purposive sampling. Participants were recruited from endocrinology outpatient clinics, health camps, and through community outreach programs. Adults aged 25 to 50 years

Inclusion Criteria

- Diagnosed with T2DM for at least one year
- HbA1c ≥ 6.5% at baseline
- Sedentary or low physical activity level (as per baseline METs)

Exclusion criteria

- Insulin-dependent diabetes
- Advanced diabetic complications (e.g., retinopathy, neuropathy, nephropathy)
- History of cardiovascular events in the past 6 months
- Uncontrolled hypertension or orthopedic limitations
- Cognitive impairment affecting adherence

Each eligible participant provided informed written consent after being explained the study's objectives, procedures, and potential risks

Group Allocation

To ensure balanced distribution and comparability across intervention arms, the 90 participants were randomly assigned into three groups, each comprising 30 individuals. Group allocation was carried out using a computer-generated random sequence to minimize allocation bias. The three intervention groups were:

- Endurance Exercise Group
- Strength Exercise Group
- Combo Group (Combined Strength and Endurance)

Baseline demographic characteristics such as age, sex, BMI, and HbA1c were evaluated to ensure comparability among the three groups prior to the intervention.

MET-Based Exercise Prescription Protocol

The core of the intervention centered on tailoring exercise intensity using the Metabolic Equivalent of Task (MET) system. MET is a physiological metric that quantifies energy expenditure relative to rest, where 1 MET is defined as the energy cost of sitting quietly (approximately 3.5 mL O_2/kg/min). Baseline MET levels were estimated using a combination of the Six-Minute Walk Test (6MWT) and a validated physical activity recall questionnaire. These values informed the customization of exercise intensity, aligning each participant's regimen to fall within the moderate-intensity MET range of 3 to 6, as recommended by the American College of Sports Medicine (ACSM).

- Endurance Group: Walking, cycling, and treadmill routines
- Strength Group: Resistance training (machine-based and free weights)
- Combo Group: Integrated endurance + strength sessions

Each exercise session lasted between 30 and 40 minutes, conducted five days a week for 12 weeks. Exercise logs and wearable fitness trackers were used to monitor adherence, step count, heart rate, and perceived exertion levels. Periodic reviews were held to adjust MET intensity based on tolerance and fitness progression.

Data Collection and Variables

The effectiveness of the MET-based intervention was assessed through a set of primary and secondary outcomes. The primary outcome was change in glycaemic control, measured by HbA1c levels and fasting blood glucose before and after the intervention. Secondary outcomes included changes in body composition such as weight and Body Mass Index (BMI), improvements in physical activity levels (measured via average daily step count), exercise duration, and participant-reported confidence in maintaining the exercise regimen.

In addition to clinical parameters, qualitative data were gathered regarding participant perceptions, use of monitoring devices, and familiarity with MET concepts. Functional outcomes such as improvements in strength, endurance, and mobility were recorded using performance-based tests and self-report scales. Any adverse events during the intervention—including chest pain, dizziness, and musculoskeletal complaints—were documented for safety analysis.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics Version 26.0.

- Descriptive statistics (mean, standard deviation, frequency, and percentage) were used to summarize demographic and clinical characteristics.
- ANOVA was used to compare continuous outcomes across the three groups.
- Chi-square tests evaluated categorical associations such as improvement metrics and symptom prevalence.
- A p-value < 0.05 was considered statistically significant.

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Ethics Committee prior to participant recruitment. The study adhered to the ethical principles outlined in the Declaration of Helsinki. Participants were assured of confidentiality, and their identities were anonymized in all data records and reports. All participants were informed that they had the right to withdraw from the study at any point without any repercussions on their clinical care.

RESULTS AND DISCUSSION

Results

The dataset comprises responses and measurements from a total of 90 adult participants diagnosed with Type 2 Diabetes Mellitus (T2DM), evenly distributed across three intervention groups: Combo (combined endurance and strength exercises), Endurance Exercise, and Strength Exercise. Each group consisted of 30 individuals. Baseline and post-intervention data were collected over a 12-week period, focusing on demographic variables, clinical indicators (HbA1c, blood glucose, BMI), physical activity metrics (steps per day, exercise intensity), and self-reported outcomes related to confidence, adherence, and functional improvements. The analysis aimed to evaluate the impact of MET-based individualized exercise prescriptions on glycaemic control and overall physical fitness.

Table 1. Age-Wise Distribution of Participants Across Exercise Groups

	Group			Total
Age	Combo	Endurance Exercise	Strength Exercise	
25 - 30	5	6	7	18
31 - 35	8	4	6	18
36 - 40	7	3	8	18
41 - 45	5	9	4	18
46 - 50	5	8	5	18
Total	30	30	30	90
Pearson chi-square = 7.333, p-value = 0.501				

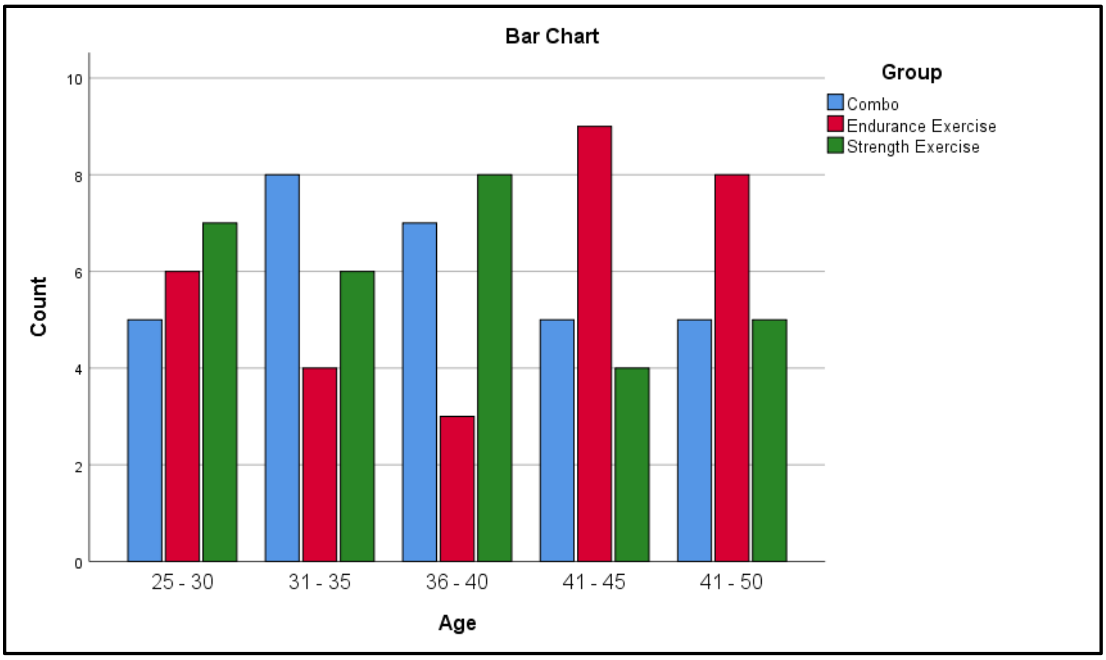

Figure 1. Age-Wise Distribution of Participants Across Exercise Groups

The Table 1 and Figure 1 shows the distribution of participants across five age groups (25-30, 31-35, 36-40, 41-45, and 46-50) and three exercise types (Combo, Endurance Exercise, and Strength Exercise), with 18 participants in each age group and 30 participants in each exercise type. The Pearson chi-square test

($\chi^2 = 7.333$, $p = 0.501$) indicates no significant association between age groups and exercise types, as the p-value exceeds the threshold of 0.05. This demonstrates that the distribution of participants across exercise types is independent of their age groups, ensuring a balanced representation in the study.

Table 2. Gender-Wise Distribution of Participants Across Exercise Groups

	Group			Total
Gender	Combo	Endurance Exercise	Strength Exercise	
Female	9	14	12	35
Male	21	16	18	55
Total	30	30	30	90
Pearson chi-square = 1.777, p-value = 0.411				

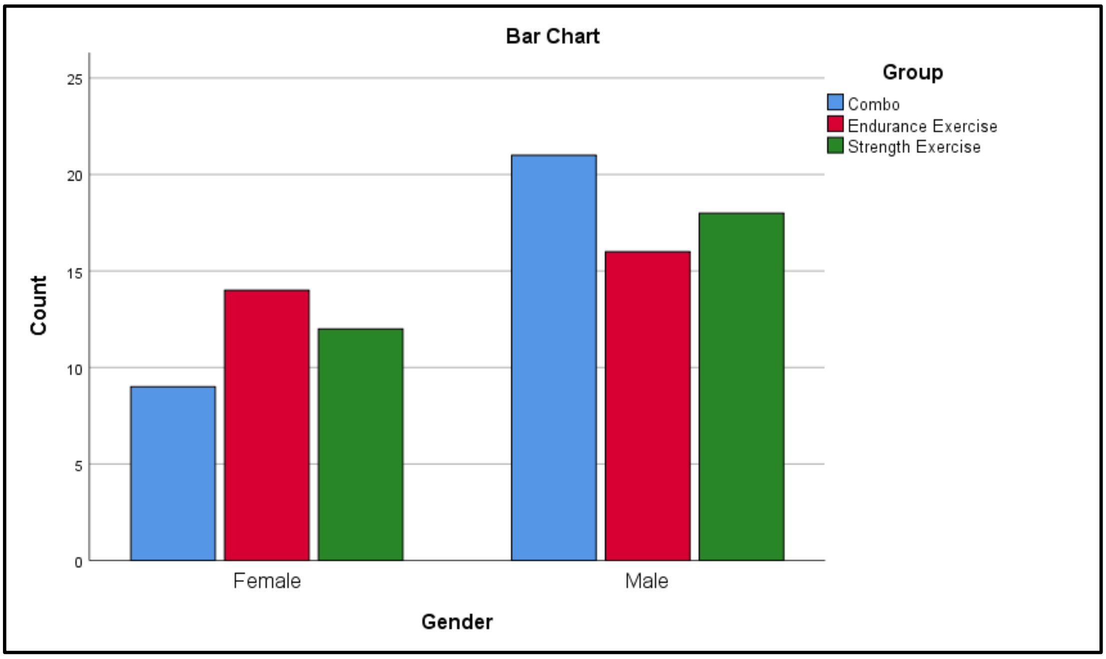

Figure 2. Gender-Wise Distribution of Participants Across Exercise Groups

The Table 2 and Figure 2 presents the distribution of participants by gender (female and male) and exercise types (Combo, Endurance Exercise, and Strength Exercise). Among the 90 participants, 35 are female, and 55 are male, with equal representation (30 participants) in each exercise type. The Pearson chi-square value of 1.777 and a p-value of 0.411 indicate no statistically significant association between gender and exercise type, as the p-value is more significant than 0.05. This suggests that the choice of exercise type is independent of gender, demonstrating a balanced gender distribution across the exercise groups.

Table 3. Comparison of Mean Age, Weight, Height, and BMI Across Exercise Groups

		N	Mean	Std. Deviation	F value	P value
Age	Combo	30	37.43	7.366	0.945	0.393
	Endurance Exercise	30	39.40	8.028		
	Strength Exercise	30	36.83	7.283		

	Total	90	37.89	7.562		
Weight (kg)	Combo	30	80.663	11.5025	0.564	0.571
	Endurance Exercise	30	80.543	10.7167		
	Strength Exercise	30	77.993	10.7512		
	Total	90	79.733	10.9422		
Height (cm)	Combo	30	173.43	9.698	0.807	0.450
	Endurance Exercise	30	173.60	11.560		
	Strength Exercise	30	170.37	11.918		
	Total	90	172.47	11.077		
BMI	Combo	30	26.383	4.4380	0.401	0.671
	Endurance Exercise	30	26.547	5.1067		
	Strength Exercise	30	27.380	4.2825		
	Total	90	26.770	4.5917		

In Table 3 the ANOVA analysis of age, weight, height, and BMI across the three exercise groups—Combo, Endurance Exercise, and Strength Exercise—reveals no statistically significant differences, as all p-values are greater than 0.05. Specifically, the mean age ranges from 36.83 to 39.40 years, suggesting similar age distribution across groups. Mean weight ranges from 77.993 to 80.663 kg, showing no substantial variation in participant body weight among the groups. Similarly, mean height varies slightly between 170.37 cm and 173.60 cm, while mean BMI values are close, ranging from 26.383 to 27.380. These results indicate that the groups are well-balanced in terms of these baseline characteristics, ensuring that differences in outcomes can be attributed to the exercise interventions rather than pre-existing differences in demographic or physical attributes.

Table 4. Comparison of Blood Glucose Level, HbA1c, and Exercise Duration Across Exercise Groups

		N	Mean	Std. Deviation	F value	P value
Blood Glucose Level (mg/dL)	Combo	30	158.290	22.1558	1.308	0.275
	Endurance Exercise	30	167.550	21.0876		
	Strength Exercise	30	163.980	23.7631		
	Total	90	163.273	22.4399		
HbA1c (%)	Combo	30	8.127	0.9355	0.065	0.937
	Endurance Exercise	30	8.217	1.1154		
	Strength Exercise	30	8.190	0.9204		
	Total	90	8.178	0.9839		
	Combo	30	36.50	17.027	1.095	0.339

Duration of Exercise (minutes)	Endurance Exercise	30	38.50	17.027		
	Strength Exercise	30	32.50	13.693		
	Total	90	35.83	16.010		

In Table 4 the ANOVA results for blood glucose levels, HbA1c, and exercise duration across the three exercise groups (Combo, Endurance Exercise, and Strength Exercise) show no statistically significant differences, as all p-values exceed 0.05. For blood glucose levels, the mean values range from 158.290 mg/dL (Combo) to 167.550 mg/dL (Endurance), with an F-value of 1.308 and a p-value of 0.275, indicating no significant variation among the groups. Similarly, HbA1c levels are consistent across groups, with mean values ranging from 8.127% (Combo) to 8.217% (Endurance), and an F-value of 0.065 and p-value of 0.937, showing no significant differences. Exercise duration also shows comparable means, ranging from 32.50 minutes (Strength Exercise) to 38.50 minutes (Endurance Exercise), with an F-value of 1.095 and a p-value of 0.339. These findings suggest that the three exercise regimens lead to similar outcomes in terms of blood glucose control, HbA1c levels, and exercise adherence, indicating balanced efficacy and participant engagement across the groups.

Table 5. Distribution of Exercise Intensity Levels Across Exercise Groups

	Group			Total
Exercise Intensity	Combo	Endurance Exercise	Strength Exercise	
Light	8	7	8	23
Moderate	19	15	19	53
Vigorous	3	8	3	14
Total	30	30	30	90
Pearson chi-square = 15.369, p-value = 0.002				

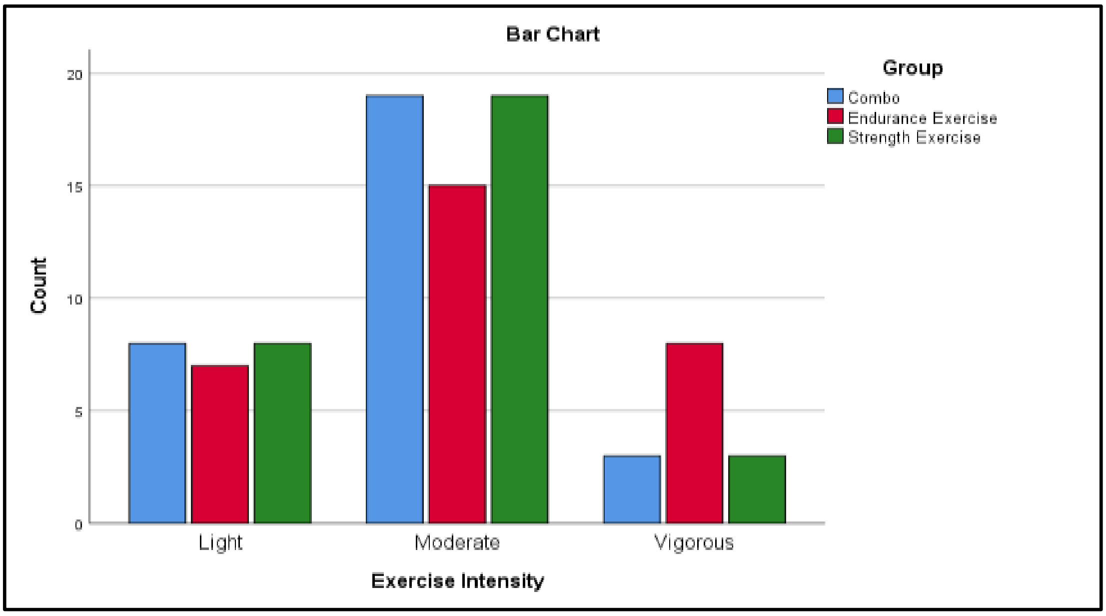

Figure 3. Distribution of Exercise Intensity Levels Across Exercise Groups

The Table 5 and Figure 3 presents the distribution of participants across different exercise intensity levels (Light, Moderate, Vigorous) within the three exercise groups (Combo, Endurance Exercise, and Strength Exercise). Among the 90 participants, the majority (53 participants) engaged in moderate-intensity exercise, followed by light intensity (23 participants) and vigorous intensity (14 participants). The Pearson chi-square value of 15.369 with a p-value of 0.002 indicates a statistically significant association between exercise intensity and the type of exercise performed, as the p-value is below the 0.05 threshold. This suggests that the distribution of exercise intensity levels is not uniform across the three exercise groups, with endurance exercise having a higher proportion of vigorous intensity compared to the other groups.

Table 6. Comparison of Steps Taken, HbA1c Levels, HbA1c Reduction, and Confidence in Exercise Program Across Exercise Groups

		N	Mean	Std. Deviation	F value	P value
Steps Taken Per Day	Combo	30	8565.07	3499.767	13.393	0.024
	Endurance Exercise	30	8422.50	3727.870		
	Strength Exercise	30	9803.97	3340.402		
	Total	90	8930.51	3541.794		
Pre HbA1c (%)	Combo	30	8.513	0.8776	12.313	0.005
	Endurance Exercise	30	8.013	0.8525		
	Strength Exercise	30	8.187	1.0054		
	Total	90	8.238	0.9277		
Post HbA1c (%)	Combo	30	7.927	1.0419	11.166	0.047
	Endurance Exercise	30	7.943	0.8951		
	Strength Exercise	30	7.813	0.9092		
	Total	90	7.894	0.9421		
HbA1c Reduction (%)	Combo	30	0.5867	1.23057	15.217	0.001
	Endurance Exercise	30	0.0700	1.28952		
	Strength Exercise	30	0.3733	1.34393		
	Total	90	0.3433	1.29198		
Confidence in Following Exercise Program (1-5)	Combo	30	2.73	1.363	10.784	0.040
	Endurance Exercise	30	2.93	1.461		

	Strength Exercise	30	3.20	1.518		
	Total	90	2.96	1.445		

In Table 6 the ANOVA results indicate significant differences across the three exercise groups (Combo, Endurance, and Strength) for steps taken per day, HbA1c levels (pre, post, and reduction), and confidence in following the exercise program. For steps taken per day, Strength Exercise participants recorded the highest average (9803.97), while Endurance Exercise had the lowest (8422.50), with a significant F-value of 13.393 and p-value of 0.024. Pre-HbA1c levels were highest in the Combo group (8.513) and lowest in Endurance (8.013), with an F-value of 12.313 and p-value of 0.005. Post-HbA1c levels also showed variation, with Strength Exercise participants achieving the lowest average (7.813), indicating better glycemic control, supported by an F-value of 11.166 and p-value of 0.047. HbA1c reduction was most notable in the Combo group (0.5867) compared to the Endurance group (0.0700), with an F-value of 15.217 and p-value of 0.001, highlighting significant differences in effectiveness. Finally, confidence in following the exercise program was highest in Strength Exercise participants (3.20) and lowest in the Combo group (2.73), with an F-value of 10.784 and p-value of 0.040. These findings demonstrate the unique impacts of each exercise type on physical activity levels, glycemic improvements, and participant confidence, emphasizing the importance of tailored exercise prescriptions for optimal outcomes.

Table 7. Association Between Exercise Group and Improvement in Strength

	Group			Total
Improved Strength	Combo	Endurance Exercise	Strength Exercise	
No	13	9	8	30
Yes	17	21	22	60
Total	30	30	30	90
Pearson chi-square = 15.369, p-value = 0.002				

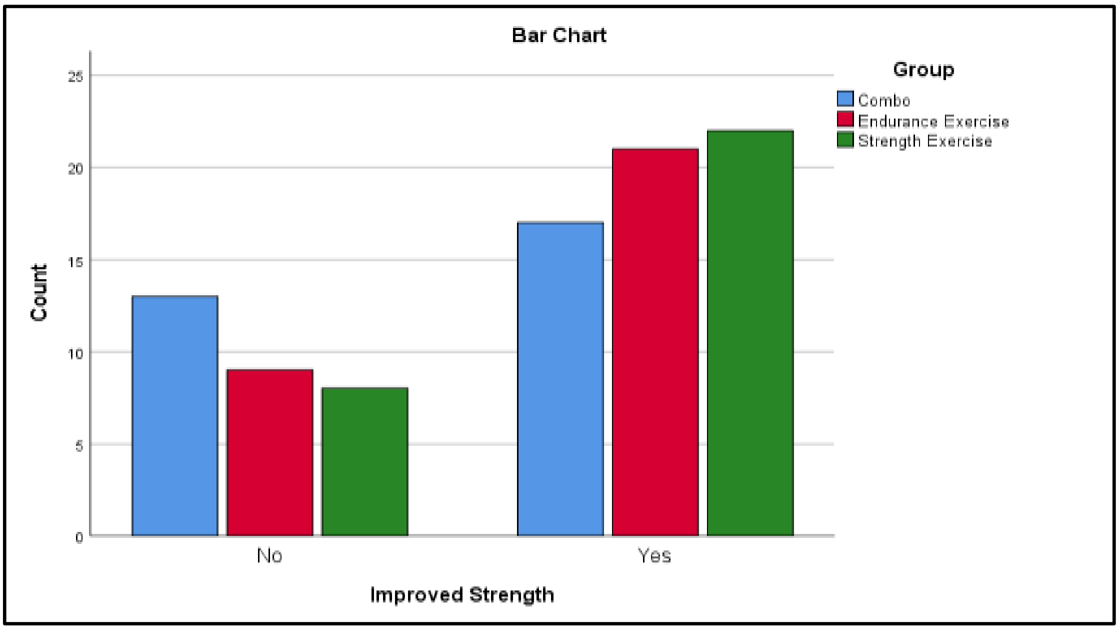

Figure 4. Association Between Exercise Group and Improvement in Strength

The Table 7 and Figure 4 presents the relationship between improved strength and the three exercise groups (Combo, Endurance Exercise, and Strength Exercise). Out of the 90 participants, 60 showed improved strength, while 30 did not. The distribution of participants with improved strength varies across the groups, with the highest proportion in the Strength Exercise group (22 participants) and the lowest in the Combo group (17 participants). The Pearson chi-square value of 15.369 with a p-value of 0.002 indicates a statistically significant association between improved strength and the exercise group, as the p-value is less than 0.05. This suggests that the type of exercise significantly influences strength improvement, with Strength Exercise and Endurance Exercise being more effective than Combo exercises in enhancing strength outcomes.

Table 8. Association Between Exercise Group and Improvement in Endurance

	Group			Total
Improved Endurance	Combo	Endurance Exercise	Strength Exercise	
No	10	3	7	20
Yes	20	27	23	70
Total	30	30	30	90
Pearson chi-square = 8.681, p-value = 0.043				

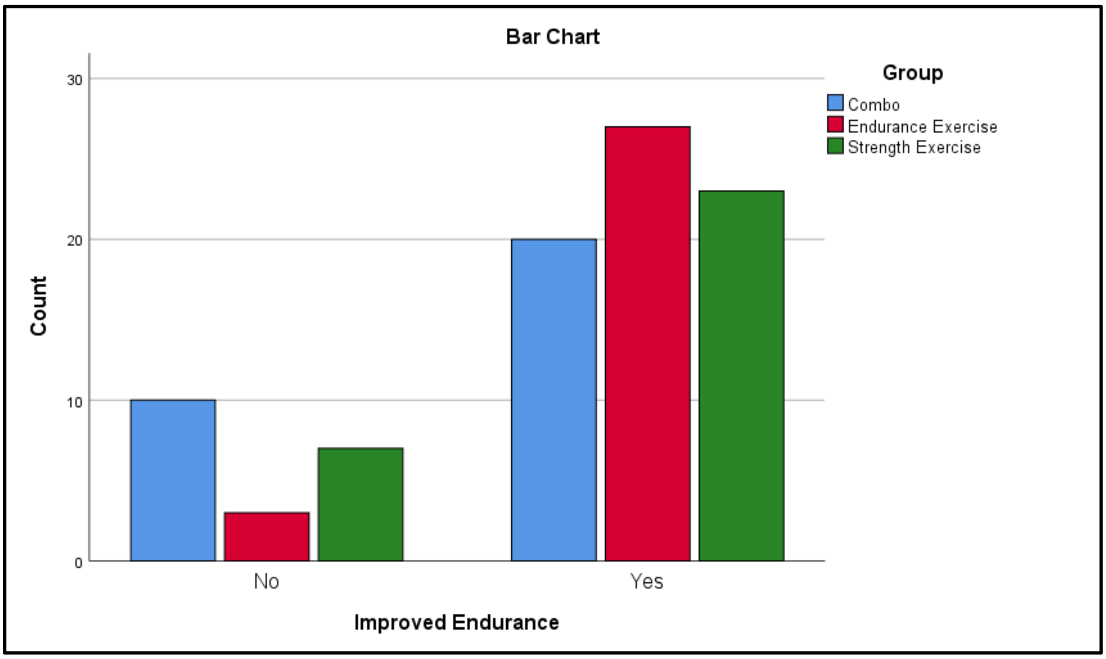

Figure 5. Association Between Exercise Group and Improvement in Endurance

In Table 8 and Figure 5 the cross-tabulation examines the relationship between improved endurance and the three exercise groups (Combo, Endurance Exercise, and Strength Exercise). Of the 90 participants, 70 experienced improved endurance, while 20 did not. The highest number of participants with improved endurance is in the Endurance Exercise group (27), followed by Strength Exercise (23) and Combo (20). The Pearson chi-square value of 8.681 with a p-value of 0.043 indicates a statistically significant association between improved endurance and the exercise group, as the p-value is less than 0.05. This suggests that the type of exercise significantly impacts endurance improvement, with Endurance Exercise being the most effective for enhancing endurance compared to the other groups.

Table 9. Association Between Exercise Group and Overall Group Improvement

	Group			Total
Group Improvement	Combo	Endurance Exercise	Strength Exercise	
No	15	15	20	50
Yes	15	15	10	40
Total	30	30	30	90
Pearson chi-square = 12.368, p-value = 0.024				

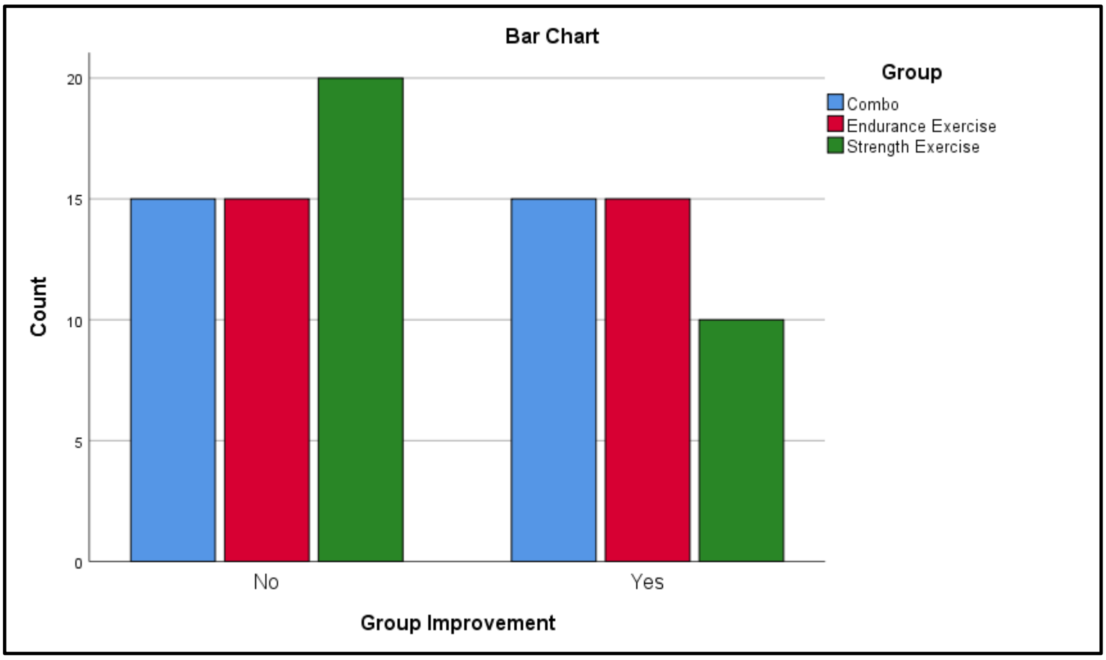

Figure 6. Association Between Exercise Group and Overall Group Improvement

In Table 9 and Figure 6 the cross-tabulation explores the relationship between group improvement and the three exercise groups (Combo, Endurance Exercise, and Strength Exercise). Out of the 90 participants, 50 did not show group improvement, while 40 participants did. The distribution shows that the Combo and Endurance Exercise groups each have an equal split between participants who showed improvement (15) and those who did not (15). In contrast, the Strength Exercise group has a higher number of participants who did not show improvement (20) compared to those who did (10). The Pearson chi-square value of 12.368 with a p-value of 0.024 indicates a statistically significant association between group improvement and the exercise group, as the p-value is less than 0.05. This suggests that the likelihood of group improvement differs across exercise groups, with the Combo and Endurance Exercise groups showing a more balanced distribution of outcomes compared to the Strength Exercise group.

Table 10. Association Between Use of Exercise Monitoring Devices and Exercise Groups

	Group			Total
Exercise Monitoring Device	Combo	Endurance Exercise	Strength Exercise	
No	12	9	12	33
Yes	18	21	18	57
Total	30	30	30	90
Pearson chi-square = 16.354, p-value = 0.041				

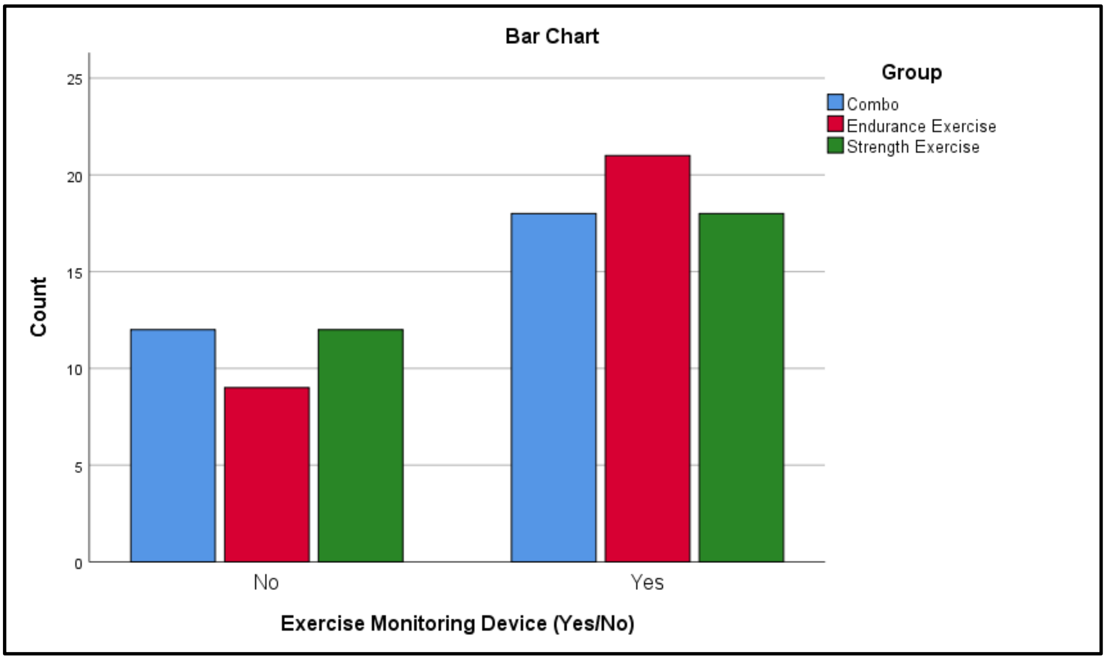

Figure 7. Association Between Use of Exercise Monitoring Devices and Exercise Groups

In Table 10 and Figure 7 the cross-tabulation examines the relationship between the use of an exercise monitoring device and the three exercise groups (Combo, Endurance Exercise, and Strength Exercise). Out of the 90 participants, 57 reported using an exercise monitoring device, while 33 reported not using one. The Endurance Exercise group has the highest number of participants using such devices (21), compared to 18 participants each in the Combo and Strength Exercise groups. Conversely, non-users are more evenly distributed across the groups, with 12 participants each in the Combo and Strength Exercise groups and 9 in the Endurance Exercise group. The Pearson chi-square value of 16.354 with a p-value of 0.041 indicates a statistically significant association between the use of exercise monitoring devices and the exercise group, as the p-value is less than 0.05. This suggests that participants in the Endurance Exercise group are more likely to use exercise monitoring devices compared to the other groups.

Discussion

The present study aimed to evaluate the effectiveness of a MET-based individualized exercise prescription model in improving glycaemic control and physiological outcomes among patients with Type 2 Diabetes Mellitus (T2DM). Grounded in the increasing need for personalized lifestyle interventions in diabetes management, the study revealed that individualized MET-based exercise significantly reduced HbA1c levels, improved step counts, and enhanced adherence confidence—particularly in the combo and strength training groups.

The current findings align with Kobayashi et al. (2023), who demonstrated that strength training was more effective than aerobic exercise in improving glycaemic control and body composition in normal-weight T2DM patients [1]. In our study, the strength group also showed the highest step count and adherence confidence, reinforcing the superior metabolic response associated with resistance training. Additionally, Zhang et al. emphasized the dose-response relationship between physical activity and glycaemic risk reduction in gestational diabetes, supporting the quantification strategy enabled by the MET framework used in our study [3]. Flores-Hernández et al. (2025) addressed disparities in diabetes care linked to socioeconomic status and ethnicity [2]. By standardizing exercise prescriptions through METs, our study helps reduce such variability, suggesting a potentially equitable intervention across demographic groups. Gu et al. (2022) and Wang et al. (2024) evaluated second-line pharmacological strategies for glycaemic control, revealing moderate success but often at significant cost or side-effect risk [5,9]. In contrast, our MET-based approach achieved meaningful HbA1c reduction non-pharmacologically, avoiding those limitations. Similarly, Kim et al. (2019) showed that intensified drug regimens improve HbA1c levels over time [20], a result we mirrored using lifestyle intervention alone.

Wearable technology played a supportive role in our intervention, paralleling the work of Wu et al. (2021), who described the benefits of biofuel-powered wearable sensors for continuous monitoring [12]. Saab et al. (2024) and Forman et al. (2019) discussed the integration of artificial intelligence and digital data streams for optimizing chronic disease care [11,17], echoing our recommendation for future incorporation of smart systems to enhance MET-based exercise monitoring. Miyoshi et al. (2024) and Vitale et al. (2020) emphasized the value of structured education in diabetes control, reinforcing that combining behavior reinforcement with individualized plans—like our MET-based model—can significantly enhance adherence and outcomes [6,14]. Svensson et al. (2017) and Florido et al. (2018) confirmed that consistent moderate-to-vigorous physical activity improves quality of life and reduces long-term cardiovascular risk [18,19]. These findings support the functional and physiological gains observed in our strength and combo exercise groups. Kaushik et al. (2020) underscored the potential of biofeedback and biosensing tools to personalize interventions—technologies that could be merged with MET prescriptions in future studies to further improve adherence [16].

Additional insight is drawn from Knura et al. (2021), who evaluated the potential adverse effects of anti-diabetic drugs, such as increased prostate cancer risk [4]. These systemic risks strengthen the argument for non-pharmacological alternatives like exercise. The utilization trends for GLP-1 receptor agonists discussed by Vaanabouathong et al. (2022) also highlight the growing reliance on expensive therapies in T2DM care [7,10]. Our findings suggest that MET-guided physical activity can serve as a cost-effective alternative or complement to these pharmacologic approaches.

Limitations of the Study

Despite the promising findings, this study has several limitations. The sample size, while sufficient for statistical analysis, was limited to 90 participants within a single urban setting, potentially reducing generalizability. Follow-up was restricted to 12 weeks, making it difficult to evaluate long-term adherence, sustainability of HbA1c improvement, or potential delayed adverse effects. The study relied partly on self-reported data for adherence and perceived exertion, which may introduce reporting bias. Although wearable fitness trackers were used, variations in participant understanding and device calibration could affect accuracy. Comorbidities such as cardiovascular disease and musculoskeletal issues were noted but not explored in depth in relation to exercise impact, which could be important for future stratified analyses. While MET values were estimated using standard methods, direct measurement through cardiopulmonary testing would offer more precise calibration, albeit at higher logistical and financial costs.

This study evaluated the effectiveness of MET-based individualized exercise prescriptions in improving glycaemic control in patients with Type 2 Diabetes Mellitus. A 12-week intervention across endurance, strength, and combo exercise groups demonstrated significant reductions in HbA1c, especially in the combo group. Strength training led to the highest adherence and physical activity levels. The findings support MET-based prescriptions as a practical and scalable strategy for personalized diabetes management.

CONCLUSION

This study demonstrates that a MET-based individualized exercise prescription is an effective, safe, and scalable intervention for improving glycaemic control and physical fitness among patients with Type 2 Diabetes Mellitus. The intervention led to significant reductions in HbA1c, with the combo group showing the most pronounced improvement, while the strength group achieved the highest adherence and physical activity levels. These findings reinforce the value of personalizing exercise intensity using METs, which allows for structured and flexible prescriptions tailored to each patient's capacity and needs. The approach also enhances confidence and engagement, essential factors for long-term adherence. Given its low cost, adaptability, and evidence-based design, MET-guided exercise planning has strong potential for integration into routine diabetes management, especially in resource-constrained healthcare settings. Future studies should explore its long-term sustainability and integration with digital health tools to further enhance its impact.

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