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"Effect Of Aerobic Exercises Combined With Flexibility Exercises On Aerobic Capacity And Quality Of Life In Type Ii Dm Patient"

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ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) is a prevalent metabolic disorder that negatively impacts physical health and quality of life. Individuals with T2DM often experience decreased aerobic capacity, which is linked to increased morbidity and mortality. Traditional exercise interventions focus primarily on aerobic activity, but the role of flexibility exercises remains underexplored. This study aims to investigate the combined effects of aerobic and flexibility exercises on improving both aerobic capacity and quality of life in T2DM patients, addressing a critical gap in current research.

Materials and methodology: This experimental study was conducted with 68 patients in the age group of 40-60years with known case of T2DM since 1year, receiving treatment at a tertiary care center in Latur. Aerobic capacity was assessed by Karvonen's formula and quality of life was assessed by SF-36. The exercise protocol was carried out for 8 weeks, 3 days per week, in experimental group each exercise session consisted of 5-10 mins of warm-up exercise 10-50 mins of aerobic conditioning, 5-10 mins of cool down and flexibility exercises were given.

RESULT: Group A showed a highly significant improvement in both Vo2MAX and SF-36 scores post-intervention. The intervention appeared to greatly enhance both cardiovascular fitness and quality of life. Group B showed a significant improvement in SF-36 (quality of life) but not in Vo2MAX. This suggests that the intervention had a more profound effect on their perceived quality of life than on their cardiovascular fitness. Inter-group comparisons show that Group A had significantly better results in terms of Vo2MAX improvement post-intervention, while SF-36 improvements were comparable between the two groups. These results indicate that the intervention was more effective in improving cardiovascular fitness in Group A while both groups benefited in terms of quality-of-life improvement. The statistical significance in the p-values underlines the reliability of these findings.

Conclusion: The results indicate that a combined aerobic and flexibility exercise regimen significantly enhances aerobic capacity and improves the quality of life in patients with T2DM. These findings support the integration of both types of exercise into rehabilitation programs for T2DM, promoting better health outcomes and overall well-being. Future research should explore long-term effects and adherence strategies to sustain these benefits.

KEYWORDS: Type 2 diabetes mellitus, aerobic exercise, flexibility exercise, aerobic capacity, quality of life.

I.INTRODUCTION

Diabetes was first documented by the Egyptians and is characterized by weight loss and polyuria. However, it was the Greek physician Aertaeus who coined the term diabetes mellitus (DM). In Greek, diabetes means "to pass through" and mellitus is the Latin word for honey (referring to sweetness). Diabetes is an important cause of prolonged ill health and premature mortality, and claims more lives per year than HIV-AIDS with nearly 1 death every 10 seconds.(1) The etiological classification of diabetes has now been widely accepted, with type 1 and type 2 diabetes being the two main types of diabetes, and type 2 diabetes accounting for the majority (>85%) of total diabetes prevalence.(2) A chronic metabolic condition needing urgent care, diabetes is one of the most serious health issues.(3) 90 to 95% of all diabetic patients have type II diabetes mellitus, which is one of the major causes of morbidity and death.(4) Type II Diabetes Mellitus is now far more common than it was previously. It is anticipated that 380 million people will have diabetes by 2025, up from the 246 million who have it today, according to the International Diabetes Federation. A poor diet and a lack of exercise appear to be the main risk factors for diabetes.(5) Affected individuals have a heightened risk of developing type II diabetes but may delay its onset with physical activity and other lifestyle changes.(6,7) Type II diabetes results from progressive loss of insulin secretion usually also with insulin resistance.(6) Its short-term side effects can be prevented by taking medication accurately following healthy diet and physical activity, thus the long-term complications will be delayed. As a part of lifestyle modification, physical activity plays an important role in the prevention and better management of the disease, as well as its related co-morbidities.(7) It is well established that diabetic patients substantially benefit from different types of physical activities.(7) These skeletal muscle-related parameters, the degree of pancreatic beta-cell insufficiency, the degree of liver insulin resistance, and the accompanying hepatic glucose production will all affect a person's total blood glucose level.(7)Aerobic exercise refers to the type of repetitive, structured physical activity that requires the body's metabolic system to use oxygen to produce energy. Aerobic exercise improves the capacity of the cardiovascular system to uptake and transport oxygen. Aerobic activity can be undertaken in many different forms, with the common feature that it is achieved at a heart rate of 70–80% of a person's age-appropriate maximum. Aerobic exercise is considered the cornerstone of endurance training, characterized by moderate energy expenditure over a prolonged period of time. Aerobic power or endurance is measured by VO_2 max, a person's maximal oxygen uptake.(8) Aerobic exercise training, or conditioning, is augmentation of the energy utilization of the muscle by means of an exercise program. The improvement of the muscle's ability to use energy is a direct result of increased levels of oxidative enzymes in the muscles, increased mitochondrial density and size, and an increased muscle fiber capillary supply(9) Maximum oxygen consumption (VO2 max) reflects person's maximum capacity to absorb, transport and consume oxygen. Practically, VO2 max is considered to be equivalent to the highest VO2 value obtained in peak exertion which usually classified as cardio-respiratory fitness(10) There is also evidence that among patients with Type II Diabetes Mellitus, the maximal oxygen uptake (VO2max) values are lower compared with the healthy individuals.(11) This phenomenon may be contributed to specific pathogenic mechanisms including hyperglycemia, low capacity density and alteration in oxygen delivery. Clinically and statistically, regular exercise has significant effect on VO2 max in type 2 diabetic patients.(10)Flexibility and balance exercises are likely important for older adults with diabetes. Limited joint mobility is frequently present resulting in part from the formation of advanced glycation end products, which accumulate during normal aging and are accelerated by hyperglycemia.(12)

II. MATERIALS AND METHODS

Study population and sample

The study included 68 patients in the age group 40-60 years for about 8 weeks. The comparative study was conducted at YCRH, Latur. Participants were selected according to inclusion and exclusion criteria. The aim, objective and method of study was explained to the participants, Ethical clearance was taken from the Institute Ethical Committee of Maharashtra Institute of Physiotherapy, and written consent was obtained from all patients at the time of study enrollment.

Inclusive criteria were: (1) Age: 40-60 years, (2) Gender: both male and female, (3) Known case of type 2 diabetes mellitus since 1 year, (4) Patients who are able to complete 6 min walk test, (5) Patients who are able to obey the command.

Exclusive criteria were: (1) Patients having musculoskeletal disorders (fractures, dislocation, deformity) (2) Patients having Alcohol and drug addiction, (3) Patients having acute and chronic inflammatory disease.

Methodology

The exercise protocol will be carried out for 3 days per week, for 8 weeks. Each exercise session consisted of aerobic exercises combined with flexibility exercises. All participants will undergo the same assessment protocol which will be measured at the start of 8 week and at the end of 8 week.

Group A – Experimental group (It includes Aerobic Exercise with Flexibility Exercise.)

Aerobic exercises-1) Warm up exercise - Spot marching for 1 min 2) Aerobic conditioning program -Stepping at stepper of 9 inches height for 10 minutes. Cycling for 20 minutes at the resistance of 5. 3)Cool down exercises -Active range of motion exercises of all the peripheral joints of upper limb and lower limb. Exercise prescription was individualized, with an initial intensity of 40%-60% of VO2MAX and duration of 10-30 minutes. Exercise duration will be increased by 5-10% weekly (To maximum of 60 minutes). **Flexibility exercises**- Participants received 3 sessions/week of flexibility exercises for 8 weeks. The participants comprised of individualized exercise training program. It includes static & dynamic stretching exercises. 1) Static stretching (hold for 15 secs) Overhead triceps stretch: Standing with feet wide apart. Bring left hand up to gently pull right elbow downwards. Hamstring stretch: Sit on ground and extend one leg. Keep the other leg towards inner thigh. Lean forward, bending but not rounding the back as if reaching for the toes. 2)Dynamic stretching Lunges: Lunge forward with one leg, hold for 10-30seconds and return back to an upright standing position - Standing Iliotibial band stretch: Stand near wall to balance. Cross the left ankle behind right ankle. While balancing with right arm, stretch towards the right side. Hold static or dynamic stretch for 10-30seconds, 2-4 repetitions of each exercise. Exercise duration and frequency will be increased 5-10% weekly. Group B – Control group (Counselling for regular general mobility exercises).

III. STATISTICAL ANALYSIS

Data were analyzed using Graph Pad InStat software – Trial version 3.10. The data were entered into an Excel spreadsheet, tabulated, and subjected to statistical analysis. Various statistical measures were used for this study which include mean, standard deviation (SD) and test of significance such as paired 't' & unpaired 't' tests. The comparison between groups for baseline demographics such as age, and sex was analyzed by descriptive statistics. The baseline demographic between the groups was evaluated. Pre and post interventional outcome measure scores within a group were analyzed by the Paired 't' test. Unpaired 't' test was used to compare the difference in scores between the two groups.

RESULT

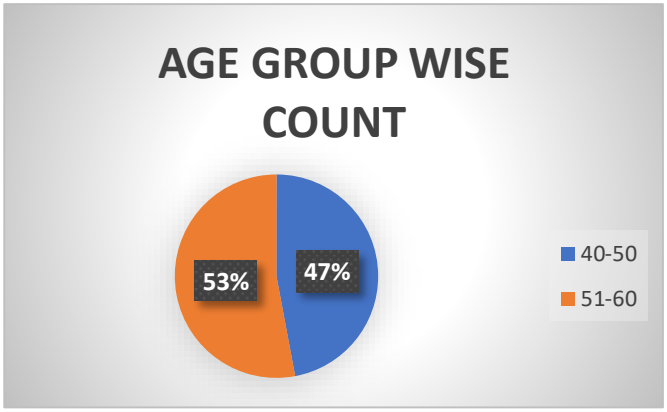
1.Findings related to Descriptive Statistics

TABLE NO.1.

Shows the age group wise distribution

AGE GROUP WISE	
	COUNT
40-50	32
51-60	36

MEAN	SD
50.27941	5.894206



GRAPH NO.1.

Shows the age group wise distribution

TABLE NO.2.

Shows that gender wise distribution for Group A and Group B

GENDER WISE DISTRIBUTION FOR GROUP A AND GROUP B

	GROUP-A	GROUP-B
MALE	20	24
FEMALE	14	10

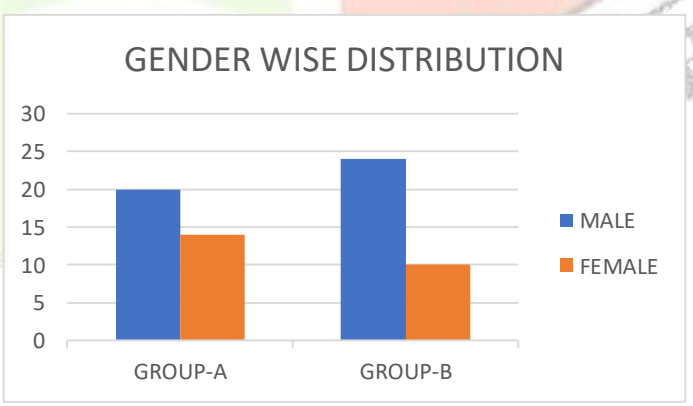
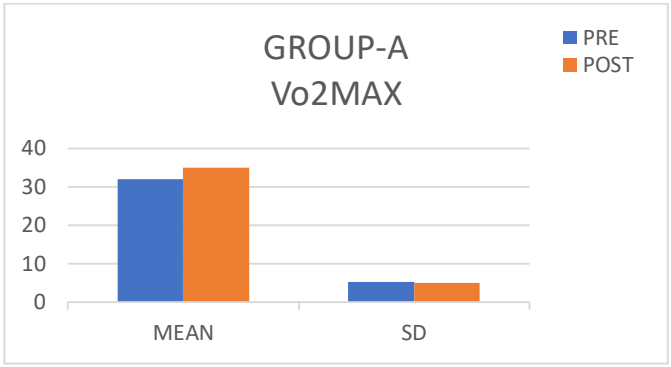


TABLE NO.3.

Shows that Vo2MAX in Group-A

	MEAN	SD	T Value	P Value	Significant
PRE	31.918	5.142	2.0369	P<0.001	Highly significant
POST	34.9706	4.833			

The change in Vo2MAX from pre to post-intervention in Group A is statistically highly significant. The p-value (p<0.001) indicates that this change is highly significant.



GRAPH NO.3.

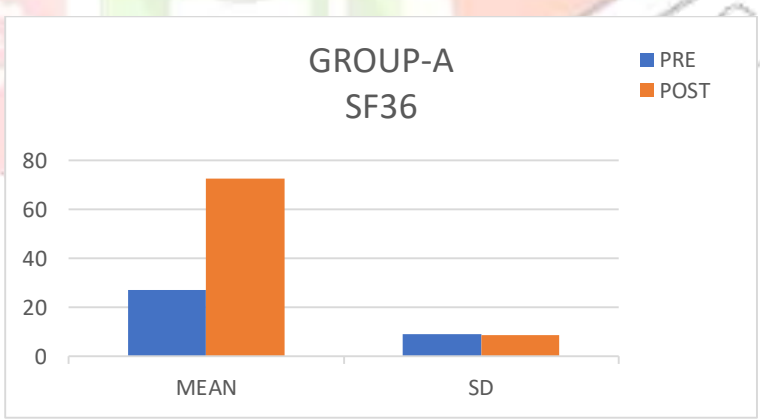
Shows that Vo2MAX in Group-A

TABLE NO.4.

Shows that SF-36 in Group-A

	MEAN	SD	T Value	P Value	Significant
PRE	27.1765	8.847	2.03	P<0.001	Highly significant
POST	72.6765	8.39			

The SF-36 scores show a substantial improvement in quality of life in Group A after the intervention. The p-value (p<0.001) again indicates this change is highly significant.



GRAPH NO.4.

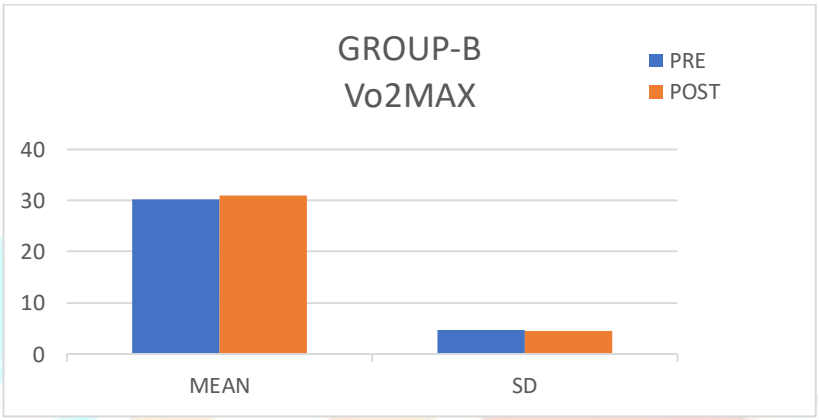
Shows that SF-36 in Group-A

TABLE NO.5.

Shows that Vo2MAX in Group-B

	MEAN	SD	T Value	P Value	Significance
PRE	30.2059	4.73401	2.0369	p>0.05	Not significant
POST	30.8824	4.56445			

Unlike Group A, Group B does not show a statistically significant improvement in Vo2MAX. The p-value of p>0.05suggests that the change could be due to random variation and is not significant at the typical p>0.05 threshold.



GRAPH NO.5.

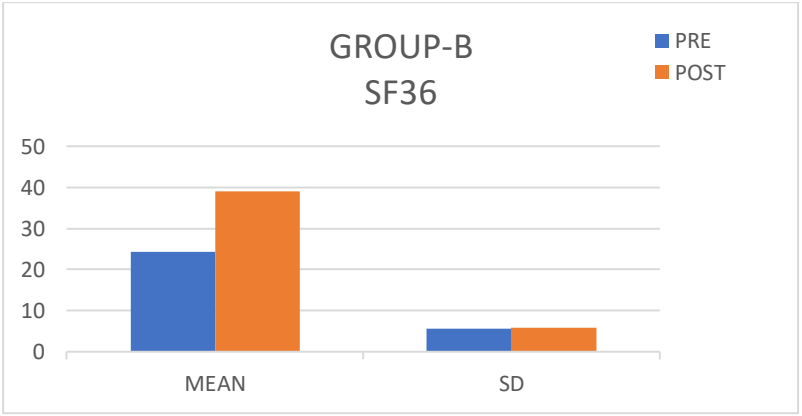
Shows that Vo2MAX in Group-B

TABLE NO.6.

Shows that SF36 in Group-B

	MEAN	SD	T Value	P Value	Significance
PRE	24.2941	5.5351	2.03	P<0.001	Highly significant
POST	39.1176	5.855			

Group B shows a significant improvement in SF-36 scores post-intervention, indicating a marked enhancement in the quality of life. The p-value (p<0.001) confirms that this change is highly significant.



GRAPH NO.6.

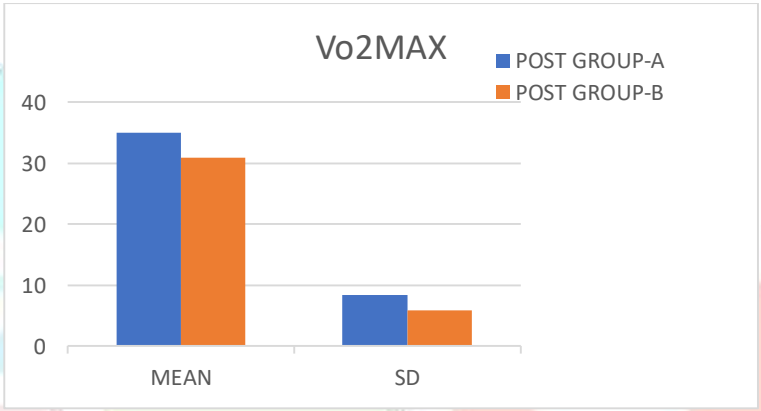
Shows that Vo2MAX in Group-B

TABLE NO.7.

Shows that inter group analysis of VO2 MAX in post-post group A & B

	MEAN	SD	T Value	P Value	Significance
POST GROUP A	34.9706	8.39452	1.99	P<0.001	Highly significant
POST GROUP B	30.8824	5.85566			

The inter-group comparison reveals that Group A had a significantly higher Vo2MAX post-intervention compared to Group B. This suggests that the intervention was more effective in improving cardiovascular fitness in Group A than in Group B.



GRAPH NO.7.

Shows that inter group analysis of VO2MAX in post-post group A & B

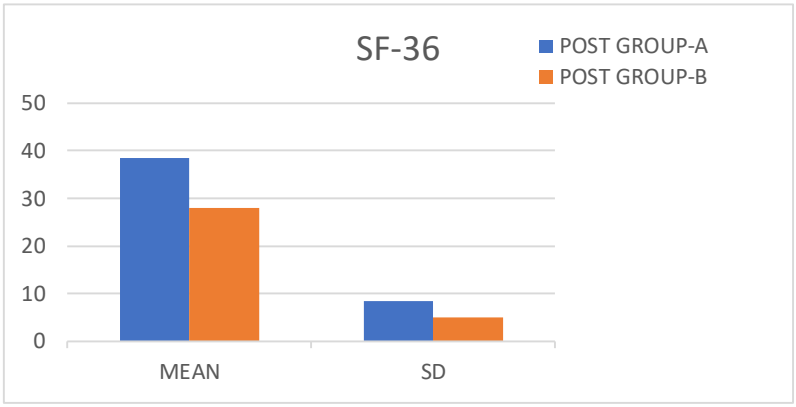
Vo2MAX is a key indicator of cardiovascular fitness, representing the maximum rate of oxygen consumption measured during incremental exercise. It is a critical measure in endurance sports and physical fitness.

TABLE NO.8.

Shows that inter group analysis of SF-36 in post-post group A & B

	MEAN	SD	T Value	P Value	Significance
POST GROUP A	38.4631	8.3945	2.004	P<0.001	Highly significant
POST GROUP B	39.1176	5.855			

Both groups showed highly significant improvements in SF-36 scores post-intervention. The statistical comparison between Group A and Group B shows a minor difference, but the improvement in quality of life was comparable in both groups.



GRAPH NO.8.

Shows that inter group analysis of SF-36 in post-post group A & B

IV. DISCUSSION

The current study was aimed to evaluate the effect of aerobic exercises combined with flexibility exercises on aerobic capacity and quality of life in type 2 DM patients. The study included 68 subjects of type 2 DM which are further divided into experimental (group A) (n=34) and control group (group B) (n=34) where there were (58.8% males) and (41.1% females) in experimental group and, (70.58 % males) and (29.4% females) in control group ranging from 40-60 years old. It was 8 weeks supervised program in which experimental group received aerobic and flexibility exercises and control group received counselling for general mobility exercises. The variables measured in the study were Vo2 max by Karvonen's formula and quality of life was measured by SF36. The result showed that there was highly significant difference in aerobic capacity (Vo2 max) and quality of life in experimental group also there was highly significant result found on quality of life in control group and there was no significant difference found in aerobic capacity (Vo2 max). Also, when we compared post values of Vo2 MAX and SF36 we found a significant difference in Vo2 MAX and SF36 in experimental group compared to control group.

In the present study there is a significant improvement in aerobic capacity in experimental and control group after 8 weeks of intervention. So, while comparing result between experimental and control group it showed statistically significant difference. As the p value for aerobic capacity was $p<0.001$. Hence according to the result aerobic and flexibility exercises for 8 weeks is more effect in type 2 DM patients. Similarly in the study done by Yan et al, reported that after a 12-week aerobic program, HbA1c level was reduced by 1.1% and VO2 max was increased, as well. Also, the study done by Hong Cai et al reported that after a 12-13 weeks aerobic exercise was safe and effective to improve the quality of life in patients with type 2 diabetes who were medically stable.

The pathophysiology behind the effects of aerobic exercises combined with flexibility exercises on aerobic capacity and quality of life in patients with type 2 diabetes mellitus (DM) involves several interconnected physiological mechanisms: Aerobic exercises (such as jogging, cycling, or swimming) increase the body's sensitivity to insulin, allowing cells to more effectively take up glucose from the bloodstream. This helps in better glycemic control in type 2 DM patients. Aerobic exercises stimulate glucose uptake and utilization by skeletal muscles, even in the absence of insulin. This effect is mediated by increased expression and activity of glucose transporters (GLUT4) on muscle cell membranes. Regular aerobic exercise contributes to weight loss or maintenance of healthy body weight, reducing adipose tissue mass and improving lipid profiles. This decrease in body fat is associated with improved insulin sensitivity and better control of blood glucose levels. Aerobic

exercises lead to cardiovascular adaptations such as increased stroke volume, improved cardiac output, and enhanced peripheral blood flow. These adaptations help in delivering oxygen and nutrients more efficiently to tissues, including muscles and organs affected by diabetes. Aerobic exercises promote mitochondrial biogenesis in skeletal muscle cells. Mitochondria are crucial for energy production through aerobic metabolism and their increase enhances the capacity for aerobic respiration, thereby improving endurance and aerobic capacity. Incorporating flexibility exercises (like stretching and yoga) alongside aerobic activities helps maintain joint mobility and muscular health. This can prevent musculoskeletal complications often seen in diabetic patients, such as stiffness and reduced range of motion. Regular exercise, including flexibility exercises, has been shown to reduce stress, anxiety, and depression, which are common in individuals with chronic diseases like diabetes. Improved mood and psychological well-being contribute to an overall better quality of life. Exercise has anti-inflammatory effects by reducing circulating levels of inflammatory markers and promoting an anti-inflammatory environment in the body. This is significant because chronic inflammation is implicated in the pathophysiology of type 2 diabetes and its complications.

V.CONCLUSION

The results indicate that a combined aerobic and flexibility exercise regimen significantly enhances aerobic capacity and improves the quality of life in patients with T2DM. These findings support the integration of both types of exercise into rehabilitation programs for T2DM, promoting better health outcomes and overall well-being. Future research should explore long-term effects and adherence strategies to sustain these benefits.

VI. LIMITATIONS AND FUTURE SCOPE

Limitations: 1) The study was limited to tertiary care unit. 2)The study was bounded to age group 40-60years.

Suggestions: Research may continue to explore how the integration of flexibility exercises can improve cardiovascular fitness more effectively than aerobic exercise alone. This could lead to tailored exercise programs that optimize patient outcomes. Future studies could investigate specific quality of life metrics, such as psychological well-being, mobility, and overall health perceptions, providing a holistic view of how combined exercise regimens affect patients. The use of wearable technology and mobile health applications could be explored to monitor exercise intensity and adherence, potentially improving outcomes. Findings from this research could inform public health initiatives and guidelines aimed at managing type 2 diabetes through physical activity, potentially leading to broader community health strategies.

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