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The Impact of Exercise on Quality of Life, Physical Health, and Mental Health in Type 2 Diabetes Mellitus Patients: Meta-Analysis

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ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) is a prevalent metabolic disorder that is common on a global scale. Effective management in addition to medication involves implementing lifestyle modifications, including regular exercise. This study aimed to analyze and estimate the impact of exercise on improving quality of life, physical health, and mental health in type 2 diabetes mellitus patients.
Subjects and Method: This was a meta-analysis study using the PICO model which includes; P= type 2 diabetes mellitus patients; I= exercise; C= no exercise; and O= quality of life, physical health, and mental health. The articles obtained were from 2 databases, namely PubMed and Science-Direct. Keywords used include "exercise" OR "physical activity" AND "quality of life" OR "physical health" OR "mental health" AND "type 2 diabetes mellitus" AND "randomized control trial". The inclusion criteria of articles were a randomized control trial study design, publication year from 2018 to 2023, full-text, English language, and reported mean and standard deviation values. Data was analyzed using the PRISMA diagram and the Review Manager 5.3 application.
Results: This meta-analysis consisted of 13 articles originating from Canada, Denmark, Egypt, Ghana, Iran, Saudi Arabia, Spain, Taiwan, Turkey, and USA. The total sample size was 755 type 2 diabetes mellitus patients. Exercises improved the quality of life (SMD= 0.66; CI 95%= 0.20 to 1.11; p= 0.005); physical health (SMD= 0.91; CI 95%= 0.53 to 1.29; p= 0.001) and mental health (SMD= 0.82; CI 95%= 0.25 to 1.39; p= 0.005) in type 2 diabetes mellitus patients.
Conclusion: Exercise carried out regularly and measurably improves the quality of life, physical health, and mental health in type 2 diabetes mellitus patients.

Keywords: Exercise, quality of life, physical health, mental health, type 2 diabetes mellitus.

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BACKGROUND

Type 2 Diabetes Mellitus (T2DM) is a wide-spread and persistent metabolic disorder affecting millions of individuals globally, (Galicia-Garcia et al., 2020). In 2021, approximately 10.5% of adults, (536.6 million people) were affected by T2DM; and

the number is projected to increase up to 12.2%, that is 783.2 million people, by 2045 (Yan et al., 2022). Beyond its physical implications, T2DM has significant impacts on individuals' quality of life, social interactions, and overall well-being (Martino et al., 2020).

Managing Type 2 Diabetes Mellitus requires a multitude range of approaches including lifestyle changes (diet, exercise, weight management), medication when necessary, ongoing blood glucose monitoring, regular check-ups, comprehensive health care, and patient education (Davies et al., 2022; Sapra and Bhandari, 2023). In the pursuit of effective management and improved outcomes for those with T2DM, researchers have delved into the realm of exercise (Buresh and Berg, 2018; Kirwan et al., 2017). Exercise plays a pivotal role in enhancing the quality of life for individuals with T2DM (Cai et al., 2017; Tatikola et al., 2022).

Regular physical activity not only improves physical health by controlling blood sugar levels and reducing the risk of complications but also contributes to weight management and cardiovascular health (Kirwan et al., 2017; Hamasaki, 2016). Furthermore, exercise fosters social interaction and emotional well-being, combating the psychosocial challenges often associated with T2DM (Regeer et al., 2021). Engaging in structured exercise regimens or simply adopting a more active lifestyle can lead to significant improvements in overall well-being for T2DM patients, offering a holistic approach to managing this chronic condition and promoting a healthier, happier life (Kirwan et al., 2017). This study aimed to analyze and estimate the impact of exercise on improving quality of life, physical health, and mental health in type 2 diabetes mellitus patients.

SUBJECTS AND METHOD

1. Study Design

This research is a systematic review and meta-analysis using the PRISMA diagram. Article search was carried out based on the eligibility criteria of the PICO, including P= type 2 diabetes mellitus patients; I= exercise; C= no exercise; and O= quality of life, physical health, and mental health. Articles obtained came from two databases, namely PubMed, and ScienceDirect; with keywords "exercise" OR "physical activity" AND "quality of life" OR "physical health" OR "mental health" AND "type 2 diabetes mellitus" AND "randomized control trial".

2. Steps of Meta-Analysis

1) Create research questions using the PICO format, which involves defining the Population, Intervention, Comparison, and Outcome.
2) Search electronic and non-electronic databases such as PubMed, Science Direct, and Scopus for primary study articles.
3) Conduct a screening process to establish criteria for inclusion and exclusion, followed by a thorough critical assessment.
4) Gather data from the primary studies and compile effect estimates using the RevMan application.
5) Analyze the findings and formulate conclusions based on the interpreted results.

3. Inclusion Criteria

The inclusion criteria included full-text articles written in English with randomized control trial (RCT) study design, published from 2018 to 2023, The research subjects were type II diabetes mellitus patients, the relationship measure used was mean and standard deviation. The research outcome was Quality of life, Physical Health, and Mental Health.

4. Exclusion Criteria

Articles that were observational study, articles with no exercise as their intervention, and articles published in languages other than English. Articles with outcomes other than quality of life, physical health, and mental health.

5. Operational Definition of Variables

Exercise: refers to physical activity or structured movement that plays a crucial role in controlling and managing blood glucose levels. It involves structured and regular movements like walking, cycling, or aerobic workouts.

Quality of Life: refers to the overall well-being and satisfaction of individuals living with T2DM medical conditions.

Physical Health: refers to the physical well-being of individuals with T2DM. It includes factors like blood glucose control, managing symptoms (fatigue, excessive thirst, and frequent urination), and preventing or managing diabetes-related complications like neuropathy, retinopathy, and cardiovascular problems.

Mental Health: refers to the mental and emotional state of individuals living with T2DM, encompassing elements such as their emotional health, psychological well-being, and their ability to cope with the stress associated with managing a chronic condition like T2DM.

6. Study Instruments

Quality assessment of primary studies used a critical assessment checklist from the Randomized Controlled Trial (RCT) Study Design. In the context of a randomized controlled trial checklist, there are seven specific questions included. Each question can be answered with "Yes," "No," or "Unclear," and these responses are assigned scores of "2," "1," and "0," respectively. When the sum of all the scores for the questions equals or exceeds 14, it suggests that the primary studies exhibit a low level of bias. Whilst, if the cumulative score is less than 14, it indicates a higher risk of bias in the primary studies.

7. Data Analysis

The research in this study followed the PRISMA flowchart to gather articles and employed the Review Manager 5.3 software for analysis. The analysis involved determining the effect size and assessing the consistency of heterogeneity (I^2) within the chosen research findings.

RESULTS

In Figure 1, the PRISMA flowchart illustrates the procedure for evaluating relevant publications. Following the initial screening process, a total of 1,012 articles were included in our study. 15 duplicate records were removed, 205 records were marked as ineligible by automation tools and 379 records were unsuitable for other reasons. 55 articles were excluded and 75 articles could not be retrieved. Subsequently. 270 articles were further refined through filtering. This entailed excluding 85 articles with different outcomes, 125 articles with different interventions, and 60. Figure 2 shows an overview of the research areas used in this meta-analysis. There were 14 articles that included. from Canada, Denmark, Egypt, Ghana, Iran, Saudi Arabia, Spain, Taiwan, Turkey, and USA.

Following an assessment of the studies' quality, a cumulative count of 13 articles with a randomized controlled trial design was acquired. These articles serve as source material for a subsequent meta-analysis investigating the Impact of Exercise on Quality of Life, Physical Health, and Mental Health in Type 2 Diabetes Mellitus patients. Subsequently, the content of each article is extracted and summarized according to the research PICO.

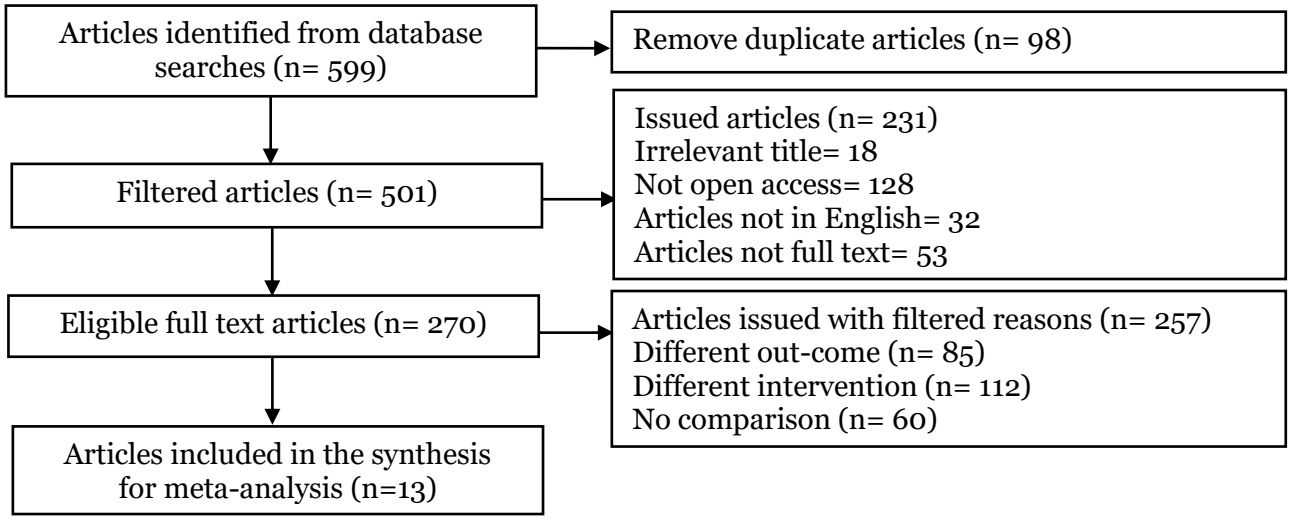

Figure 1. PRISMA flowchart

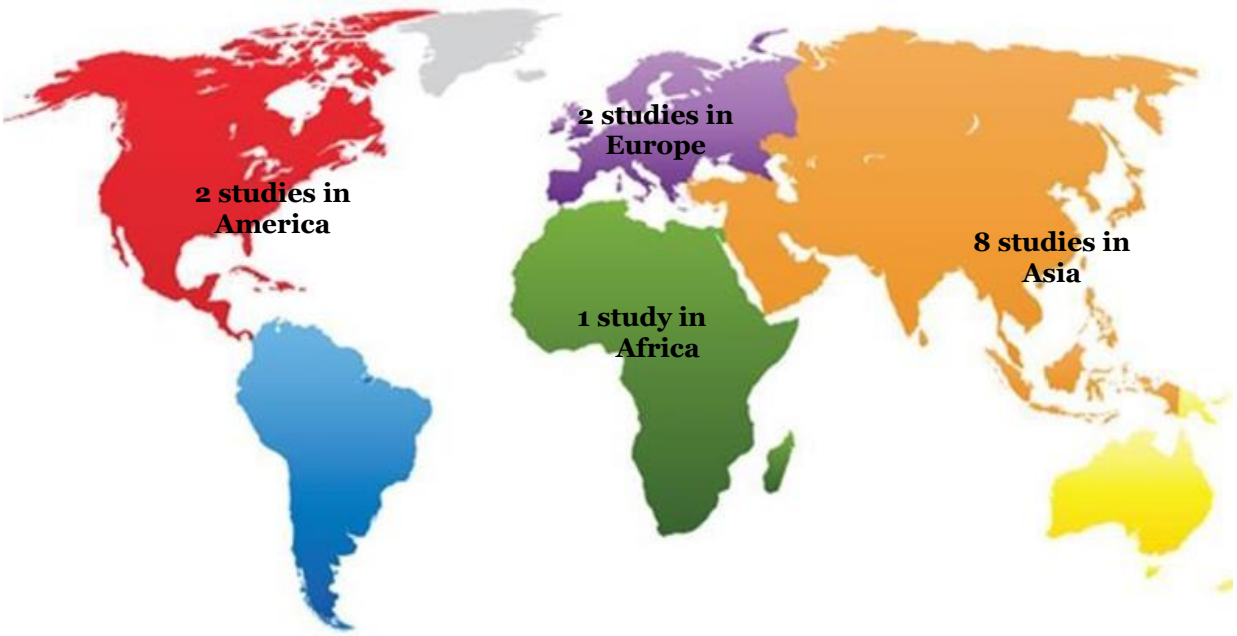

Figure 2. Map of the distribution of articles included in the meta-analysis

In Table 2 show an examination of primary research about the impact of exercise on quality of life, physical well-being, and mental health in type 2 diabetes mellitus patients was executed through a meta-analysis encompassing 13 articles. Consistencies observed across the studies encompassed the use of a randomized controlled trial design, the inclusion of subjects diagnosed with Type 2 Diabetes Mellitus, and the implementation of exercise interventions employing various modalities. Discrepancies among the studies were also noted, particularly concerning sample sizes, ranging from a minimum of 18 to a maximum of 95 participants.

Table 1. Critical appraisal checklist of randomized control trial studies

Author (years)	Criteria of Questions													6	Total
	1				2		3		4			5			
	a	b	c	d	a	b	a	b	a	b	c	a	b		
Arija et al. (2018)	2	2	2	2	2	2	0	0	0	2	2	2	2	2	22
Akinci et al. (2018)	2	2	2	2	2	2	0	0	0	0	2	2	2	2	20
Schmid et al. (2018)	2	2	2	2	2	2	0	0	0	0	2	2	2	2	20
Esmail et al. (2020)	2	2	2	2	2	2	0	0	0	2	2	2	2	2	22
Jamshidpour et al. (2020)	2	2	2	2	2	2	0	0	2	2	2	2	2	2	24
Muñoz et al. (2020)	2	2	2	2	2	2	0	0	2	2	2	2	2	2	24
Rias et al. (2020)	2	2	2	2	2	2	0	0	2	2	2	2	2	2	24
Tapehsari et al. (2020)	2	2	2	2	2	2	0	0	1	1	2	2	2	2	22
Abdelbasset et al. (2021)	2	2	2	2	2	2	0	0	2	1	2	2	2	2	25
Chien et al. (2022)	2	2	2	2	2	2	0	0	2	2	2	2	2	2	24
Molsted et al. (2022)	2	2	2	2	1	1	0	0	1	2	1	2	2	2	20
Ahmad et al. (2023)	2	2	2	2	2	2	0	0	2	2	2	2	2	2	24
Amin et al. (2023)	2	2	2	2	2	2	0	0	2	2	2	2	2	0	22

Description of the question criteria:

1. Formulation of research questions in the acronym PICO.

a. Is the population in the primary study the same as the population in the PICO meta-analysis?

b. What is the operational definition of intervention in primary studies is it the same as the definition intended in the meta-analysis?

c. What is the operational definition of comparator used in the same primary study as those planned in the meta-analysis?

d. What is the operational definition of the outcome variable (outcomes) studied in the primary study that are the same as those planned in the meta-analysis?

2. Methods for selecting research subjects.

a. Is the sample selected from the population so that the sample is representtative of the population?

b. Was the allocation of subjects to the experimental and control groups carried out by randomization?

3. Methods for measuring interventions and outcome variables.

a. Are the interventions and outcome variables measured with the same instruments (measuring tools) in all primary studies?

b. If the outcome variable (outcomes) is measured with different instruments, then the effect size used in the meta-analysis must be a standardized version, e.g Effect Size (Standardized Mean Difference).

4. Design-related bias.

a. Is done double-blinding, namely research subjects and research assistants who help measure outcome variables (outcomes) do not know the research subject's intervention status?

b. Isn't there a possibility? "Loss-to Follow-up Bias"?

c. Whether primary study researchers have made efforts to prevent or overcome such bias (for example, selecting highly motivated subjects, subjects who are easy to track, or providing incentives to subjects so they do not drop out)

5. Statistical analysis methods.

a. Is the data outcomes compared between the experimental group and the control group after the intervention?

b. Are all data analyzed according to randomization results?

6. Conflict of interest Is there no possibility of a conflict of interest? 0 = No 1 = Hesitant/Unclear 2 = Yes

Description of the answer score:

Table 2. PICO table summary of randomized control trial articles on primary study on impact of exercise on QoL, PH, and MH in T2DM patients (N= 755)

Author (year)	Country	Sampel	P	I	C	O
Arija et al. (2018)	Taiwan	81	T2DM Patient	Walking exercise 120 minutes in a week for 9 months.	No Exercise	Mental Health
Akinci et al. (2018)	Turkey	65	T2DM Patient	Aerobic and resistance exercises under supervision.	No Exercise	Physical Health, Quality of Life
Schmid et al. (2018)	USA	18	T2DM Patient	Yoga twice a week for 16 sessions.	No Exercise	Quality of Life
Esmail et al. (2020)	Canada	41	T2DM Patient	Dance/aerobic/ exercise	No Exercise	Mental Health, Physical Health
Jamshidpour et al. (2020)	Iran	28	T2DM Patient	Aerobic exercise and/ resistance training 3 times in a week for 8 weeks.	No Exercise	Mental Health, Physical Health, Quality of Life
Muñoz et al. (2020)	Spain	90	T2DM Patient	Whole body vibration (WBV) three times in a week for 8 weeks.	No Exercise	Mental Health, Physical Health, Quality of Life
Rias et al. (2020)	Taiwan	41	T2DM Patient	Walking 150 minutes in a week for 8 weeks.	No Exercise	Physical Health, Quality of Life
Tapehsari et al. (2020)	Iran	95	T2DM Patient	Physical Activity (such as walking, swimming, water sports, and physical exercises) 150 minutes a week for 3 months.	No Exercise	Mental Health, Physical Health
Abdelbasset et al. (2021)	Saudi Arabia	33	T2DM Patient	Stretching and walking exercise 2 times a week for 12 weeks.	No Exercise	Quality of Life
Chien et al. (2022)	Taiwan	40	T2DM Patient	Resistance training 12 weeks.	No Exercise	Mental Health, Physical Health
Molsted et al. (2022)	Denmark	72	T2DM Patient	Aerobic exercise and/ or resistance training 2 times in a week for 12 weeks.	No Exercise	Mental Health, Physical Health
Ahmad et al. (2023)	Egypty	72	T2DM Patient	Low volume and/or high volume of High Intensity Interval Training (HIIT) 3 times in a week for 8 weeks.	No Exercise	Mental Health, Physical Health
Amin et al. (2023)	Ghana	79	T2DM Patient	Aerobic exercise and/ or resistance training 3 times in a week for 36 sessions.	No Exercise	Mental Health, Physical Health

Table 3. SMD data on the effect of exercise on QoL in T2DM patient (N=297)

Author (year)	Exercise		No Exercise	
	Mean	SD	Mean	SD
Akinci et al. (2018)	0.72	0.24	0.61	0.25
Akinci et al. (2018)	0.77	0.08	0.61	0.25
Schmid et al. (2018)	91.90	8.98	89.50	8.70

Author (year)	Exercise		No Exercise	
	Mean	SD	Mean	SD
Rias et al. (2020)	61.09	7.15	44.98	8.33
Jamshidpour et al. (2020)	62.57	26.76	52.31	28.40
Muñoz et al. (2020)	0.90	0.09	0.89	0.10
Abdelbasset et al. (2021)	63.50	8.30	56.30	11.40

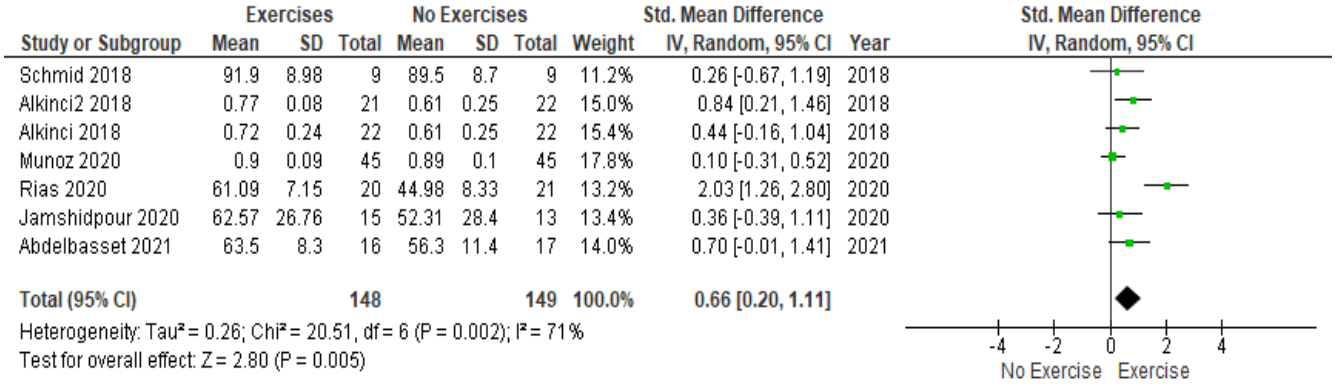

Figure 3. Forest Plot of the effect of exercise on quality of life in T2DM patient

The analysis results showed that there is an increase in the quality of life in T2DM patients who do exercise by 0.66 units compared to those who do not exercise (SMD= 0.66; CI 95%= 0.20 to 1.11; p= 0.005) and statistically significant. Data heterogeneity with a high intuitive index (I^2= 71%; p= 0.002), so this meta-analysis was carried out using the Random Effect Model.

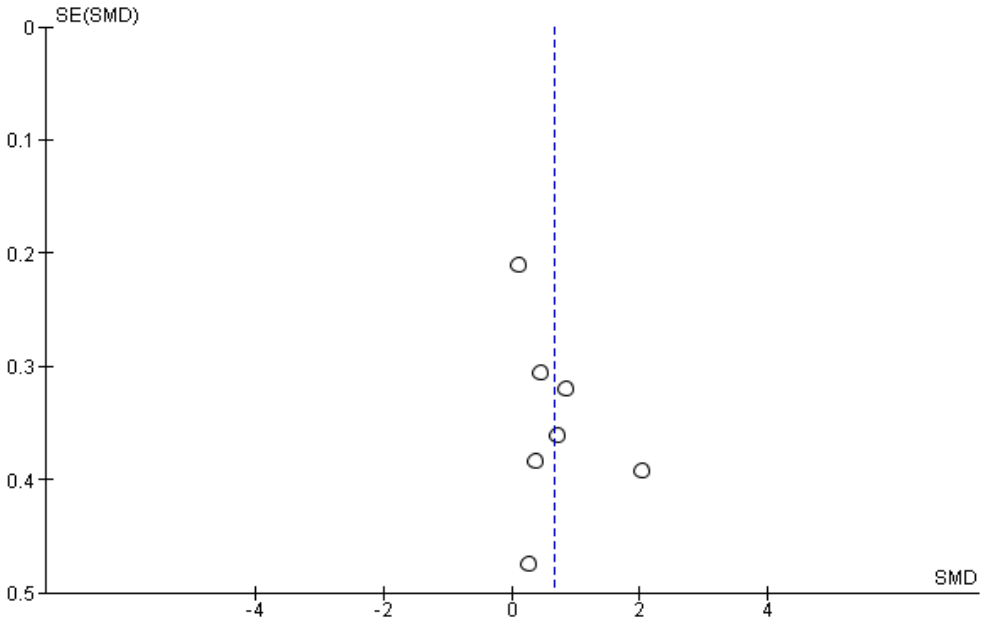

Figure 4. Funnel Plot of the effect of exercise on on quality of life in T2DM patient

The distribution of effect estimates from primary studies is more distributed to the left of the vertical line of mean estimates than to the right, indicating publication bias. The location of the publication bias in the forest plot is to the left of the line, the direc-

tion is different from the location of the diamond shape in the forest plot, so it means that the publication bias tends to reduce the actual effect of exercise on quality of life in T2DM patients (underestimate).

Table 4. SMD data on the effect of exercise on physical health in T2DM patient (N=818)

Author (year)	Exercise		No Exercise	
	Mean	SD	Mean	SD
Akinci et al. (2018[a])	503.59	41.10	490.90	59.70
Akinci et al. (2018[b])	539.26	37.40	490.90	59.70
Arija et al. (2018)	84.60	16.40	69.80	24.0
Esmail et al. (2020 [a])	0.31	0.53	0.27	1.06
Esmail et al. (2020 [b])	0.23	0.75	0.27	1.06
Jamshidpour et al. (2020)	71.67	23.74	54.13	27.09
Muñoz et al. (2020)	85.64	14.75	79.94	20.81
Rias et al. (2020)	60.81	3.24	44.98	8.33
Tapehsari et al. (2020)	27.42	3.34	22.58	3.71
Chien et al. (2022)	12.10	1.80	11.10	2.30
Ahmad et al. (2023[a])	48.69	5.49	42.23	5.82
Ahmad et al. (2023[b])	48.81	6.51	42.23	5.82
Amin et al. (2023)	76.50	7.60	56.80	8.40

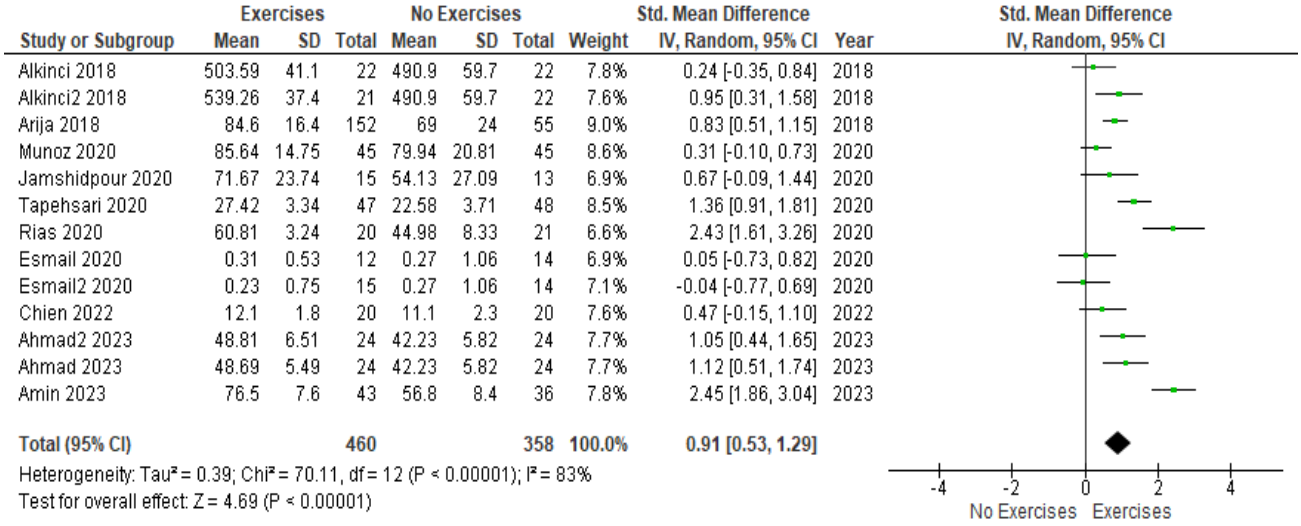

Figure 4. Forest Plot of the effect of exercise on physical health in T2DM patient

The results of the analysis show that there is an increase in the physical health of T2DM sufferers who do exercise by 0.91 units compared to those who do not exercise (SMD= 0.91; CI 95%= 0.53 to 1.29; p= 0.001) and statistically significant. Data heterogeneity with a high intuitive index (I^2= 83%; p= 0.001), so this meta-analysis was carried out using the Random Effect Model.

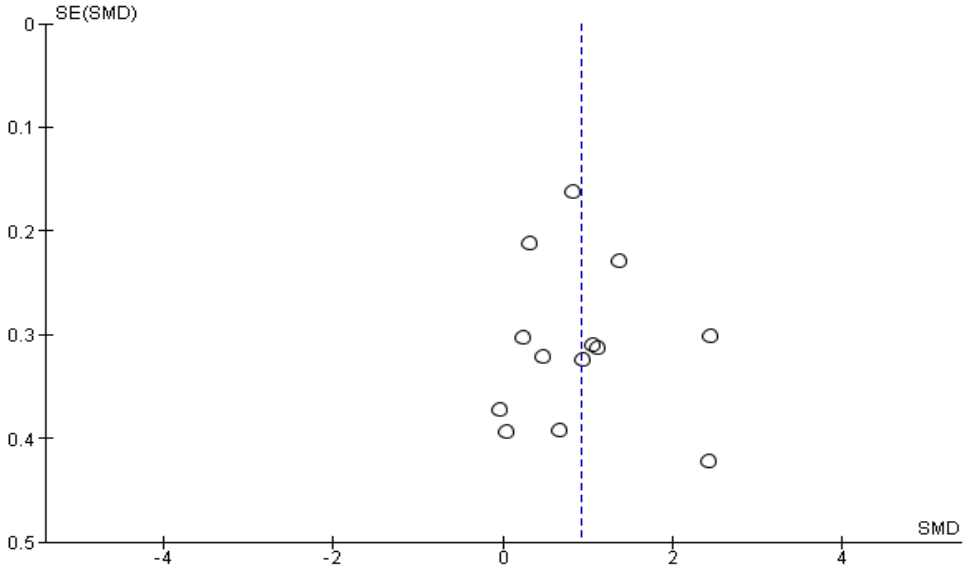

Figure 5. Funnel Plot of the effect of exercise on physical health in T2DM patient

The distribution of effect estimates from primary studies is more distributed to the left of the vertical line of mean estimates than to the right, indicating publication bias. The location of the publication bias in the forest plot is to the left of the line, the direction is different from the location of the diamond shape in the forest plot, so it means that the publication bias tends to reduce the actual effect of exercise on physical health in T2DM patients (under-estimate).

Table 5. SMD data on the effect of exercise on mental health in T2DM patients (N=523)

Author (year)	Exercise		No Exercise	
	Mean	SD	Mean	SD
Arija et al. (2018)	70.70	20.20	65.80	22.80
Jamshidpour et al. (2020)	74.72	23.39	50.88	25.10
Rias et al. (2020)	47.50	9.01	46.66	8.99
Molsted et al. (2022)	79.40	19.00	62.10	19.00
Ahmad et al. (2023[a])	50.41	6.46	44.21	3.21
Ahmad et al. (2023[b])	54.45	4.17	44.21	3.21
Amin et al. (2023)	56.40	15.60	56.40	15.60

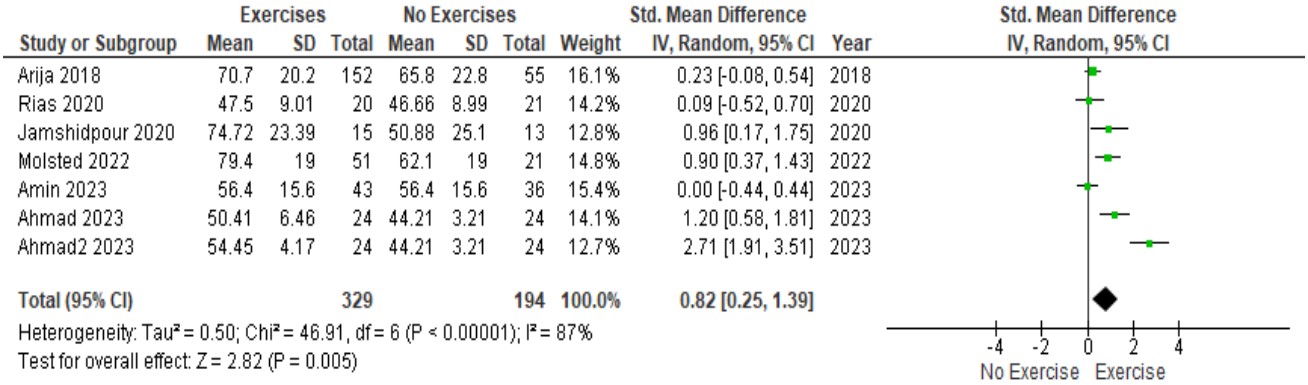

Figure 5. Forest Plot of the effect of exercise on mental health in type 2 DM patient

The results of the analysis show that there is an increase in the mental health in T2DM sufferers who do exercise by 0.82 units compared to those who do not exercise (SMD= 0.82; CI 95%= 0.25 to 1.39; p= 0.005) and statistically significant. Data heterogeneity with a high intuitive index (I^2= 87%; p= 0.001), so this meta-analysis was carried out using the Random Effect Model.

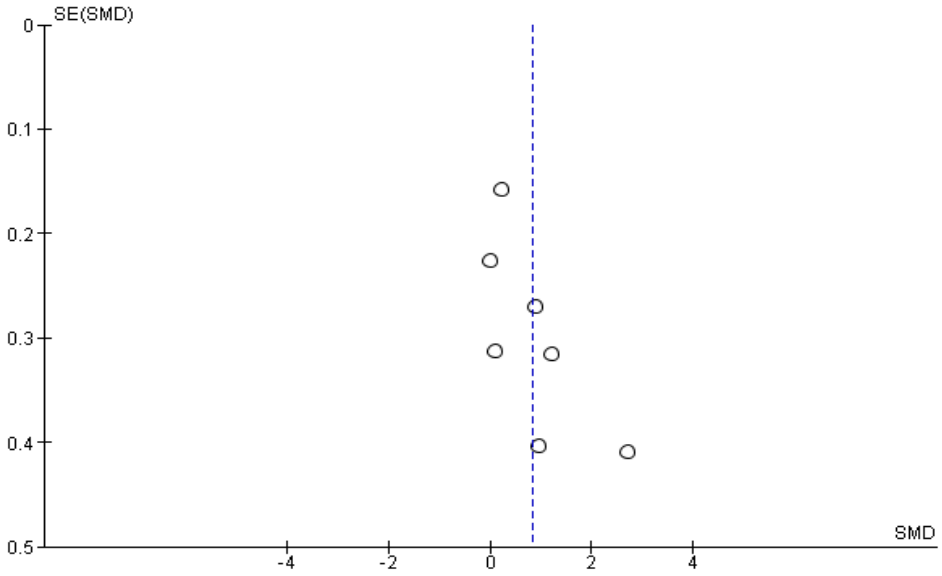

Figure 6. Funnel Plot of the effect of exercise on mental health in type 2 DM patient

The distribution of effect estimates from primary studies is more distributed to the right of the vertical line of mean estimates than to the left, indicating publication bias. The location of the publication bias in the forest plot is to the right of the line, and the direction is the same as the location of the diamond shape in the forest plot, so it means that the publication bias tends to increase the actual effect of exercise on mental health in T2DM patient (overestimate).

DISCUSSION

Exercises can improve metabolic health in T2DM patients throughout the body. This condition leads to increased insulin sensitivity, increased absorption and utilization of glycolipids, optimization of body mass index, etc. Recent research supports that cytokines such as osteocalcin, irisin, and adiponectin are closely related to metabolic diseases and exercise (Yang et al., 2019).

1. Effect of exercise on quality of life of T2DM

A total of 7 experimental research articles with an RCT design as a source of meta-analysis of the effect of exercise on quality of life in T2DM patients with results showing a statistically significant effect. Individuals with T2DM who exercise have an impact on improving quality of life by 0.66 units compared to patients who do not exercise (SMD= 0.66; 95% CI= 0.20 to 1.11; p= 0.005). The distribution of research data was declared heterogeneous (I^2= 71%; p= 0.002).

Aerobic exercise has been proven to be safe and effective for improving the quality of life of T2DM patients with stable medical conditions. Resistance training also has an impact on the quality of life of T2DM sufferers. Meanwhile, the influence of yoga

on the quality of life of T2DM patients still requires further research (Cai et al., 2017). T2DM is a disease that can develop into a chronic disease. If this happens, it will have an impact on reducing the patient's quality of life. This process can be prevented or slowed down through exercise (Chi and Wenbo, 2019).

2. Effect of exercise on the physical health of T2DM

A total of 13 experimental research articles with an RCT design as a source of meta-analysis of the effect of exercise on physical health in T2DM patients with results showing a statistically significant effect. Individuals with T2DM who exercise have an impact on improving physical health by 0.91 units compared to patients who do not exercise (SMD= 0.91; CI 95%= 0.53 to 1.29; p= 0.001). The distribution of research data was declared heterogeneous (I^2=83%; p=0.001).

Exercise has a positive effect on physical symptoms. findings stated that exercise carried out regularly was able to optimize physical function in T2DM patients (Gilani and Feizabad, 2019).

3. Effect of exercise on mental health of T2DM

A total of 7 experimental research articles with an RCT design as a source of meta-analysis of the effect of exercise on mental health in T2DM patients with results showing a statistically significant effect. Individuals with T2DM who exercise have an impact on improving mental health by 0.82 units compared to patients who do not exercise (SMD= 0.82; CI 95%= 0.25 to 1.39; p= 0.005). The distribution of research data was declared heterogeneous (I^2= 87%; p= 0.001).

T2DM can cause complications with mental health problems. This event is caused by an increase in symptom burden such as functional impairment and decreased quality of life, including brain vascular changes due to DM. Comorbid depression in DM patients is associated with a 1.5 unit increased risk of death, when compared with those who not experience depression (Youssef, 2019).

The conclusion is exercise can improve the quality of life, physical health, and mental health in individuals with T2DM. The exercises carried out must be routine and measurable. If this finding is applied by sufferers of T2DM, it will help them to be productive in life.

AUTHOR CONTRIBUTION

Bertha Sylvester Maingu, Isna Andriani, and Wardhatul Livia, as the researcher who selected topics, collected research data and analyzed the data. Bhisma Murti, and Elsa Tursina reviewed research documents.

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Nill or None.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

REFERENCES

Abdelbasset WK, Elsayed SH, Nambi G, Tantawy SA, Kamel DM, Eid MM, Moawd SA (2021). Potential Efficacy of Sensorimotor Exercise Program on Pain, Proprioception, Mobility, and Quality of Life in Diabetic Patients with Foot Burns: A 12-Week Randomized Control Study. Int J Burns Trauma. 47(3): 587–593. doi: 10.1016/j.burns.2020.08.002.

Ahmad AM, Mahmoud AM, Serry ZH, Mahmoud MM, Elghaffar HAA (2023). Effects of Low-versus High-Volume

High-Intensity Interval Training on Glycemic Control and Quality of Life in Obese Women with Type 2 Diabetes: A Randomized Controlled Trial. J Exerc Sci Fit. doi:10.1016/j.jesf.2023.08.003.

Akinci B, Yeldan I, Satman I, Dirican A, Ozdincler AZ (2018). The Effects of Internet-Based Exercise Compared with Supervised Group Exercise in People with Type 2 Diabetes: a Randomized Controlled Study. Clin. Rehabil. 32(6): 799–810. doi: 10.1177/026921-5518757052.

Amin M, Kerr D, Atiase Y, Samir MM, Driscoll A (2023). Improving Metabolic Syndrome in Ghanaian Adults with Type 2 Diabetes through a Home-Based Physical Activity Program: A Feasibility Randomised Controlled Trial. Int J Environ Res Public Health. 20(8): 1–12. doi: 10.3390/ijerph2008-5518.

Arija V, Villalobos F, Pedret R, Vinuesa A, Jovani D, Pascual G, Basora J, (2018). Physical Activity, Cardiovascular Health, Quality of Life and Blood Pressure Control in Hypertensive Subjects: Randomized Clinical Trial. Health and Qual. Life Outcomes. 16(1): 1-11. doi: 10.1186/s12955018-1008-6.

Buresh R, Berg K (2018). Exercise for The Management of Type 2 Diabetes Mellitus: Factors to Consider with Current Guidelines. J Sports Med Phys Fitness. 58(4):510–524. doi: 10.2373-6/S00224707.17.06969-9.

Cai H, Li G, Zhang P, Xu D, Chen L, (2017). Effect of Exercise on The Quality of Life in Type 2 Diabetes Mellitus: A Systematic Review. Qual Life Res. 26(3): 515–530. doi: 10.1007/s111360-16-1481-5.

Chi C, Wenbo T (2019). The Effect of Physical Activity on The Quality of Life in Patients with Type-2 Diabetes. Nursing Department, Medicine and Health College Hu Li Za Zhi. doi: 10.6-224/JN.20190-4_66(2).08.

Chien YH, Tsai JC, Wang DC, Chuang PH, Lin HT (2022). Effects of 12-Week Progressive Sandbag Exercise Training on Glycemic Control and Muscle Strength in Patients with Type 2 Diabetes Mellitus Combined with Possible Sarcopenia. Int J Environ Res Public Health. 19(22):1-12. doi: 10.339-0/ijer-ph192215009.

Davies MJ, Aroda VR, Collins BS, Gabbay RA, Green J, Maruthur NM, Rosas SE (2022). Management of Hyperglycemia in Type 2 Diabetes, 2022. ADA Diabetes Care. 45(11): 2753–2786. doi: 10.2337/dci220034.

Esmail A, Vriceanu T, Lussier M, Predovan D, Berryman N, Houle J, Karelis A (2020). Effects of Dance/Movement Training vs. Aerobic Exercise Training on cognition, physical fitness and quality of life in older adults: A randomized controlled trial. J Bodyw Mov. 24(1): 212-220. doi: 10.1016/j.jbmt.20-19.05.004.

Garcia UG, Vicenta AB, Jebari S, Sebal AL, Siddiqi H, Uribe KB, Ostolaza H, et al. (2020). Pathophysiology of Type 2 Diabetes Mellitus. Int J Mol Sci. 21(17):1–34. doi: 10.3390/ijms21-176-275.

Gilani SRM, Feizabad AK (2019). The Effects of Aerobic Exercise Training on Mental Health and Self-Esteem of Type 2 Diabetes Mellitus Patients. Health Psychol Res. 7(1): 10-14. doi: 10.4081/hpr.2019.6576.

Hamasaki H (2016). Daily Physical Activity and Type 2 Diabetes: A Review. World J Diabetes. 7(12): 243. doi: 10.4239/-wjd.v7.i12.243.

Jamshidpour B, Bahrpeyma F, Khatami MR (2020). The Effect of Aerobic and

Resistance Exercise Training on The HealthRelated Quality of Life, Physical Function, and Muscle Strength among Hemodialysis Patients with Type 2 Diabetes. J Bodyw Mov. 24(2): 98–103. doi: 10.1016/j.jbmt.2019.10.003.

Kirwan JP, Sacks J, Nieuwoudt S (2017). The Essential Role of Exercise in The Management of Type 2 Diabetes. Cleve Clin J Med. 84(7): 15-21. doi: 10.3949/ccjm.84.s1.03.

Martino G, Caputo A, Bellone F, Quattropani MC, Vicario CM (2020). Going Beyond The Visible In Type 2 Diabetes Mellitus: Defense Mechanisms And Their Associations With Depression And Health-Related Quality Of Life. Front Psycol. 11(2). doi: 10.3389/fpsyg.2020.00267.

Molsted S, Jensen TM, Larsen JS, Olesen LB, Eriksen SBM, Rehling T, Rasmussen SS (2022). Changes of Physical Function and Quality of Life in Patients with Type 2 Diabetes after Exercise Training in a Municipality or a Hospital Setting. J Diabetes Res. doi: 10.1155/2022/5751891.

Muñoz FJD, Villafania S, Gorgillo MAG, Mocholi MAA, Mateo DC, Adsuar J, Gusi N (2020). Effects of 8-Week Whole-Body Vibration Training on The Hba1c, Quality of Life, Physical Fitness, Body Composition and Foot Health Status in People with T2DM: A Double-Blinded Randomized Controlled Trial. Int J Environ Res Public Health. 17(4): 1–13. doi: 10.3390/ijerph17041317.

Regeer H, Nieuwenhuijse EA, Vos RC, Jong CK, Empelen PV, Koning EJP, Bilo HJG (2021). Psychological Factors Associated with Changes in Physical Activity in Dutch People with Type 2 Diabetes Under Societal Lockdown: A Cross-Sectional Study. Endocrinol Diabetes Metab. 4(3): 1–9. doi: 10.1002/edm2.249.

Rias YA, Kurniawan AL, Chang CW, Gordon CJ, Tsai HT (2020). Synergistic Effects Of Regular Walking And Alkaline Electrolyzed Water On Decreasing Inflammation And Oxidative Stress, And Increasing Quality Of Life In Individuals With Type 2 Diabetes: A Community Based Randomized Controlled Trial. Antioxidants. 9(10):1–17. doi: 10.3390/antiox9100946.

Sapra A, Bhandari P (2023). Diabetes. Orlando: StatPearls.

Schmid AA, Atler KE, Malcolm MP, Grimm LA, Klinedinst TC, Marchant DR, Portz JD (2018). Yoga Improves Quality of Life and Fall Risk-Factors in A Sample of People with Chronic Pain and Type 2 Diabetes. Complement Ther Clin Pract. 31: 369–373. doi: 10.1016/j.ctcp.2018.01.003.

Tapehsari BS, Alizadeh M, Khamseh ME, Seifouri S, Nojomi M, (2020). Physical Activity and Quality of Life in People with Type 2 Diabetes Mellitus: A Randomized Controlled Trial. Int. J. Prev Med. 11(9): 1–6. doi: 10.4103/-ijpvm.IJPVM.

Tatikola SP, Natrajan V, Desai VK, Asirvatham AR, Rajsekhar H (2022). Effect of Various Exercise Protocols on Neuropathic Pain in Individuals with Type 2 Diabetes with Peripheral Neuropathy: A Systematic Review and Meta-Analysis. Diabetes Metab Syndr. 16(9). doi: 10.1016/j.dsx.2022.102603.

Yan Y, Wu T, Li C, Liu Q, Li F, (2022). Prevalence, Awareness and Control of Type 2 Diabetes Mellitus and Risk Factors in Chinese Elderly Population. BMC Public Health. 22(1): 1–6. doi: 10.1186/s12889022-13759-9.

Yang D, Yang Y, Han R (2019). Physical Exercise as Therapy for Type 2 Dia-

betes Mellitus: From Mechanism to Orientation. Ann Nutr Metab. 74(4): 313–321. doi: 101-159/000500110.

Youssef MK (2019). Effect of Walking and Aerobic Exercise on Physical Performance and Depression in Cases of Type 2 Diabetes Mellitus. Egypt J Intern Med. 31(2): 142–148. doi: 10.4103/e-jim.ejim_116_18.