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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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 (I²) 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.
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

<table>
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<td>Amin et al. (2023)</td>
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<td>2</td>
<td>0</td>
<td>0</td>
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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 representative 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?

Description of the answer score:

0 = No
1 = Hesitant/Unclear
2 = Yes

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)

<table>
<thead>
<tr>
<th>Author (year)</th>
<th>Country</th>
<th>Sample</th>
<th>P I C O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rias et al. (2020)</td>
<td>Taiwan</td>
<td>41</td>
<td>T2DM Patient Walking exercise 120 minutes in a week for 9 months. No Exercise Mental Health</td>
</tr>
<tr>
<td>Tapehsari et al. (2020)</td>
<td>Iran</td>
<td>95</td>
<td>T2DM Patient Physical Activity (such as walking, swimming, water sports, and physical exercises) 150 minutes a week for 3 months. No Exercise Mental Health</td>
</tr>
<tr>
<td>Abdelbasset et al. (2021)</td>
<td>Saudi Arabia</td>
<td>33</td>
<td>T2DM Patient Stretching and walking exercise 2 times a week for 12 weeks. No Exercise Quality of Life</td>
</tr>
<tr>
<td>Chien et al. (2022)</td>
<td>Taiwan</td>
<td>40</td>
<td>T2DM Patient Resistance training 12 weeks. No Exercise Mental Health, Physical Health</td>
</tr>
<tr>
<td>Molsted et al. (2022)</td>
<td>Denmark</td>
<td>72</td>
<td>T2DM Patient Aerobic exercise and or resistance training 2 times in a week for 12 weeks. No Exercise Mental Health, Physical Health</td>
</tr>
<tr>
<td>Ahmad et al. (2023)</td>
<td>Egypt</td>
<td>72</td>
<td>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</td>
</tr>
<tr>
<td>Amin et al. (2023)</td>
<td>Ghana</td>
<td>79</td>
<td>T2DM Patient Aerobic exercise and or resistance training 3 times in a week for 36 sessions. No Exercise Mental Health, Physical Health</td>
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Table 3. SMD data on the effect of exercise on QoL in T2DM patient (N=297)

<table>
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<th>Author (year)</th>
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<tr>
<td></td>
<td>Mean</td>
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<td>0.72</td>
<td>0.24</td>
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<td>Akinci et al. (2018)</td>
<td>0.77</td>
<td>0.08</td>
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<tr>
<td>Schmid et al. (2018)</td>
<td>91.90</td>
<td>8.98</td>
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Table 1. Comparison of mean exercise and no exercise quality of life with Type 2 DM patients

<table>
<thead>
<tr>
<th>Author (year)</th>
<th>Exercise Mean</th>
<th>Exercise SD</th>
<th>No Exercise Mean</th>
<th>No Exercise SD</th>
</tr>
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<tr>
<td>Rias et al. (2020)</td>
<td>61.09</td>
<td>7.15</td>
<td>44.98</td>
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<td>Jamshidpour et al. (2020)</td>
<td>62.57</td>
<td>26.76</td>
<td>52.31</td>
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<td>63.50</td>
<td>8.30</td>
<td>56.30</td>
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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 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-
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 (I² = 83%; p = 0.001), so this meta-analysis was carried out using the Random Effect Model.
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 (underestimate).

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

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<th>SD</th>
<th>No Exercise Mean</th>
<th>SD</th>
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<td>56.40</td>
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**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 (I²=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 (I²= 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.

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