Unveiling novel insights into Type 2 Diabetes management: a meta-analysis and statistical synthesis of nursing and physiotherapy intervention literatura

Desvelando nuevas perspectivas en el manejo de la Diabetes Mellitus Tipo 2: un meta-análisis y síntesis estadística de la literatura sobre intervenciones de enfermería y fisioterapia

Authors

Eman A. Shokr [1]
Rasha M. El-Marakby [2]
Kamlah A. Al-Olimat [3]
Rasha Abdulhalim Alqadi [4]
Hadeel Alsirhani [5]
Soher Ahmed Awad Abdelaziz [6]
Asmaa K. Hassan [7]
Amira M. Afify [8]

[1] Faculty of Nursing, Al-Zaytoonah University of Jordan, Airport Street, Amman (Jordan)
[2] Department of Physical Therapy, Faculty of Applied Medical Sciences, Irbid National University, Irbid (Jordan)
[3] Department of Maternal and Child Health, School of Nursing, Zarqa University, Zarqa (Jordan)
[4] Department of Medical-Surgical Nursing, North Private College of Nursing, Arar (Saudi Arabia)
[5] Department of Physical Therapy and Health Rehabilitation, College of Applied Medical Sciences, Jouf University, Sakaka 72388 (Saudi Arabia)
[6] Department of Nursing, Faculty of Nursing, Assiut University (Assiut, Egypt)
[6] Department of Nursing, Faculty of Nursing, Zarqa University, Zarqa (Jordan)
[7] Department of Nursing, Faculty of Nursing, Zarqa University, Zarqa (Jordan)
[8] Department of Physical Therapy for Internal, Cardio Pulmonary and Geriatric Medicine, Faculty of Physical Therapy, Al-Ryada University for Science and Technology (Egypt)

Corresponding author:
Eman A. Shokr
e.shokr@zuj.edu.jo

How to cite in APA

shokr, E., El-Marakby, R., AL-Olimat, K., Alqadi, R., Alsirhani, H., Abdelaziz, S., Afify, A. (2025). Unveiling novel insights into Type 2 Diabetes management: a meta-analysis and statistical synthesis of nursing and physiotherapy intervention literature. *Retos*, *68*, 585–595. https://doi.org/10.47197/retos.v68.116122

Abstract

Introduction: Effective management of type 2 diabetes mellitus (T2DM) requires a multidisci-plinary approach. This study aims to quantify the combined effect of nursing and physiotherapy interventions on outcomes in adults with T2DM.
Objective: To evaluate the impact of nursing and physiotherapy interventions on key outcomes in T2DM patients.
Methodology: A systematic review and meta-analysis wasconducted following PRISMA guide-lines (search conducted until July 2024) across PubMed, Scopus, Web of Science, Cochrane, and Google Scholar. Randomized controlled trials and controlled clinical trials involving adults with T2DM, focusing on nursing (patient education and/or self-care support) and/or physiotherapy (exercise training and/or physical therapy) interventions, were included. Eighteen studies (N=1,243) were analyzed using random effects models for mean difference pooling.
Results: Key outcomes included HbA1c, BMI, physical function, and quality of life (QoL). The combined nursing and physiotherapy intervention significantly improved glycemic control (HbA1c 7.0% vs. 7.5%, weighted mean difference −0.52%, 95% CI −0.68 to −0.36, p<0.001), re-duced BMI (MD −1.2 kg/m^2, 95% CI −1.7 to −0.7, p<0.001), improved exercise capacity (+45m in 6-minute walk, 95% CI 30–60), and QoL (+5.1 SF36 physical points, 95% CI 3.0–7.2).
Conclusion: Combined nursing and physiotherapy interventions significantly improved self-care behaviors, metabolic control, and functional outcomes in T2DM patients. These findings support the recommendation for collaborative nursing-physiotherapy programs in diabetes care.Type 2 Diabetes Mellitus; Nursing Intervention; Physiotherapy; Exercise Therapy; Patient Education; Meta-Analysis; Glycemic Control.

Keywords

Type 2 Diabetes Mellitus; nursing intervention; physiotherapy; exercise therapy; patient education; meta-analysis; glycemic.

Resumen

Introducción: La gestión efectiva de la diabetes mellitus tipo 2 (DM2) requiere un enfoque multidisciplinario. Este estudio tiene como objetivo cuantificar el efecto combinado de las intervenciones de enfermería y fisioterapia sobre los resultados en adultos con DM2.
Objetivo: Evaluar el impacto de las intervenciones de enfermería y fisioterapia en los resultados clave en pacientes con DM2.
Metodología: Se realizó una revisión sistemática y un metaanálisis siguiendo las directrices PRISMA (búsqueda realizada hasta julio de 2024) en PubMed, Scopus, Web of Science, Cochrane y Google Scholar. Se incluyeron ensayos controlados aleatorios y ensayos clínicos controlados que involucraron adultos con DM2, centrados en intervenciones de enfermería (educación del paciente y/o apoyo al autocuidado) y/o fisioterapia (entrenamiento físico y/o terapia física). Se analizaron 18 estudios (N=1,243) utilizando modelos de efectos aleatorios para el agrupamiento de las diferencias medias.
Resultados: Los resultados clave incluyeron HbA1c, IMC, función física y calidad de vida (QoL). La intervención combinada de enfermería y fisioterapia mejoró significativamente el control glucémico (HbA1c 7.0% frente a 7.5%, diferencia media ponderada −0.52%, IC 95% −0.68 a − 0.36, p<0.001), redujo el IMC (DM −1.2 kg/m^2, IC 95% −1.7 a −0.7, p<0.001), mejoró la capacidad de ejercicio (+45m en la caminata de 6 minutos, IC 95% 30–60) y la QoL (+5.1 puntos SF36 físicos, IC 95% 3.0–7.2).
Conclusión: Las intervenciones combinadas de enfermería y fisioterapia mejoraron significativamente los comportamientos de autocuidado, el control metabólico y los resultados funcionales en pacientes con DM2. Estos hallazgos apoyan la recomendación de programas colaborativos de enfermería y fisioterapia en el cuidado de la diabetes.

Palabras clave

Diabetes Mellitus tipo 2; intervención de enfermería; fisioterapia; terapia de ejercicio; educación del paciente; metaanálisis; control glucémico.

Introduction

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by hyperglycemia, resulting either from relative insulin deficiency, oral or injected, or from diminished sensitivity to its effects, or a combination of both. The epidemic of the disease has increased dramatically: 11.1% of adults worldwide (over 590 million people) have diabetes, which is over 90% of type 2 (Shafiee et al., 2018). According to Hassan et al. (2020), diabetes is one of the top 10 global causes of morbidity and mortality as per the World Health Organization. Thus, when not controlled, T2DM leads to damage of the macrovascular and microvascular systems (for example, retinopathy, nephropathy, and cardiovascular disease) (Usman et al., 2021), contributing to a substantial burden on patients, families, and healthcare systems.

The current management of T2DM primarily focuses on pharmacotherapy (oral agents, insulin) and general lifestyle advice. While regular exercise and dietary modification are cornerstone therapies for managing T2DM (Parchwani et al., 2013), the successful implementation of these lifestyle changes often requires coordinated support. This is where the roles of nurses and physiotherapists become critical. Nurses and physiotherapists complement each other in providing comprehensive care. Nurses build trust with patients, empowering them through diabetes education and supporting them in making lasting behavioral changes that can be extended into everyday life (Wang et al., 2013). Physiotherapists, in turn, design and assist with exercise programs to improve insulin sensitivity, muscle strength, balance, and mobility (Wang et al., 2013). Together, these healthcare professionals help patients manage T2DM more effectively by enhancing self-care and functional capacity.

Despite the growing evidence supporting integrated care, many patients with T2DM still do not achieve optimal control. T2DM is inherently complex, influenced by a combination of behavioral, environmental, and physiological factors (Ofori & Unachukwu, 2014). Therefore, personalized and multidisciplinary management strategies are essential to optimizing treatment outcomes, considering both individual patient characteristics and comorbid factors (Williams et al., 2022).

Significance of Study

The objective of this study is to determine the effect of nurse led combined education and physiotherapy delivered exercise program in adults with T2DM on glycemic control, functional capacity, quality of life. To determine whether the integrated intervention is better than standard care in reducing hemoglobin A1C (HbA1c), improving physical performance, and yielding patient reported outcomes. We evaluate the effects of a collaborative care model and seek to identify best practices for the management of the diabetes and inform for future guidelines for comprehensive patient centered care.

Additionally, this research is then concerned with filling the void in T2DM education by developing a module which specifically targets individuals with an early onset of T2DM and provides specific information on family support, body image and mental health (Wilmot & Idris, 2014). Increasingly, chronic diseases such as diabetes are advocated to be managed by multidisciplinary strategies based on education, exercise training and self-management support (Al-Ghabeesh, Khalifeh, & Rayan, 2024). Meta-analytic synthesis of nursing and physiotherapy interventions is timely as isolated reviews have shown benefits of nursing and physiotherapy separately (Beaudin et al., 2022), yet clinicians and policy makers have lacked clear picture of them combined impacts. For instance, there is study in systematic reviews that indicates nursing – led education reduces blood glucose and HbA1c in diabetic patients (Dailah, 2024). Similarly, the exercise interventions in the physiotherapist guidance can improve glycemia control, reduce body weight and enhance physical function (Sigal et al., 2006). Nonetheless, to date there has been no single comprehensive met analysis to determine the impact of the integrated nursing plus physiotherapy program on the T2DM outcomes. We fill this evidence gap by pooling qualitatively data from trials in which both approaches—the fetus as well as the provider—are randomized. By achieving this, we hope to provide such statistical robust insights to aid in the development of standard diabetes management protocols. The findings of this study can inform practitioners in how to structure care for patients (e.g. co-location of joint nurse-PT clinics), and institutions in whether they should invest in interventions that have been proven to be beneficial (Lee et al., 2021).

Hypotheses

H_0: Combined nursing and physiotherapy interventions do not have a significant effect on glycemic control, physical function, or patient-reported outcomes compared to standard care.

H_1: Combined nursing and physiotherapy interventions significantly improve glycemic control, physical function, and patient-reported outcomes compared to standard care.

Research Questions

This meta-analysis was designed to answer the following primary questions

- Glycemic Control: Does participation in a combined nursing and physiotherapy intervention increase glycemic parameters in adults with T2DM compared to standard care?
- Physical and Functional Outcomes: How do these interventions impact the physical function and associated metabolic measures (such as exercise capacity or BMI or lipid profiles, etc.)?
- Patient-Reported Outcomes: Do nursing offered with physiotherapy programs provide additional benefits to patient reported outcomes, like quality of life, self-efficacy, or adherence over and above usual care?
- Moderators: For which patients and which interventions (i.e. are there characteristics of the patient or intervention (e.g. age, duration of intervention) that are associated with greater benefit?

Literature Review

Structured self-management education programs given in groups have shown better glycemic control than that achieved by standard care in subjects with type 2 diabetes mellitus (Harbi et al., 2022).

Interventions for T2DM have commonly been studied independently in relation to nursing and physiotherapy. Education and self-management is an aspect of nursing intervention in diabetes. They form part of these structured teaching sessions on diet and medication, tele monitoring of blood sugar or nurse led clinics. Subramanian et al. (2020) have reported that, such interventions could significantly improve glycemic control and related behaviors in Meta analyses. For example, a systemic review in 2025 found solid evidence that patient education by nurses persistently declined HbA1c and fasting glucose in patients with type 2 diabetics (Kim & Hur, 2021). There are a number of key elements identified that included personalized counseling, dietary planning and psychosocial support. Also, nursing led lifestyle programs (including diet and exercise) have been associated with weight management and cholesterol control. Moreover, trust building and contact with nurses are crucial in increasing adherence to a treatment and a healthy habit (Wadden et al., 2020). Therefore, the literature emphasizes that effective nursing care in T2DM should improve the patient's knowledge of how to perform the proper self-care and motivate them to take action to bring change, as outcomes measured in self-care and clinical outcomes will improve.

The metabolic and functional sequelae of T2DM are engaged by physiotherapy and exercise interventions. Aerobic, resistance exercise or balance and gait exercises and/or neuromuscular therapies (diabetic neuropathy for example) are often prescribed by physiotherapists (Bani Salameh, 2017). When it comes to T2DM management, structured physical activity is deemed crucial and ACSM consensus suggests a combination of aerobic and resistance programs for all patients (Crossman, 2023). It has been shown that exercise training improves insulin sensitivity and reduces HbA1c when there are numerous trials. For instance, a meta-analysis that was conducted recently discovered that average HbA1c reduction with resistance training alone was 0.39 % compared with control (Doupis et al., 2021). A number of other studies have shown clinically meaningful glucose lowering even with low intensity activity (i.e. tai chi, walking) in people with type 2 diabetes. Physiotherapy interventions in addition to glycaemia, enhance muscular strength, endurance and balance. Regular exercise therapy brings patients tens of meters in walking distance, and hurts less neuropathic pain (Haas et al., 2012). Summarily, the evidence for exercise based physiotherapy for improving metabolic as well as physical outcomes in T2DM is well supported however implementation to real world settings differs.

However, there is a dearth of evidence on combined nursing and physiotherapy students. There are a few integrative approaches (e.g. multidisciplinary lifestyle clinics or community programs), but their synthesis of effects is not found in the literature. The current situation is that no one can claim to provide

all aspects of care for the diabetic patient (Wu & Armstrong, 2008), whereas multi professional teams are able to address the varied needs of a diabetic patient adequately. Nevertheless, many published trials tend to focus on one education or one exercise. However, to our knowledge, no prior meta-analysis has undertaken pooling of the data form trials that involved both nurse-led and PT led interventions for T2DM (Grey et al., 2009). This represents a critical gap. Hence there is a need for a holistic review to decide whether the combination of education or Self Care Support (EDCS) with guided physical training will result in additive or synergic benefits. This gap will be addressed in order to inform whether multi-disciplinary intervention models do outperform traditional care and inform future research and practice.

Gaps in Existing Literature

Evidence is compelling that nursing-led diabetes education and physiotherapy exercise programs both confer benefits while the combination of these interventions has not adequately been sized for its effect. Relatively little attention has been given to overall patient centered outcomes in these reviews (Stewart, 2004) which have been limited to specific outcomes (e.g. HbA1c, foot ulcer healing) or a single discipline. For instance, in analyses of diabetes, glycemic indices are the common outcome measures(Siaw and Lee, 2018); for rehabilitation, a common outcome is functional gainFontaine et al., 2024). Few studies exist, however, that examine how nurse driven self-care strategies interact with therapist guided physical activity. Nevertheless, it is conceivable that their conjunction could lead to more improvements than either could alone, but supporting high quality evidence is scarce. Also, trials thus far have different designs and frequently leave out the viewpoint of the other discipline (thy PT conducted exercise investigation will ordinarily be without formal diabetes education). Hence, there exists a need to synthesize this in a comprehensive manner. To fill this gap we apply a systematic approach identifying and statistically combining all available data in T2DM for nursing plus physiotherapy interventions, in a novel effort to determine the collective efficacy of the two.

Methodology

Initial search strategy was a rigorous one in the major databases. A complete literature search was conducted electronically in Cochrane, PubMed, Web of Science, Embase, CINAHL, AMED, and SPORTDiscus for studies published from inception until the end of July 2024. Keywords used for the search strategy included diabetes mellitus, nursing, self-management, exercise therapy, and randomized controlled trials. Search terms were combined using Boolean operators such as “AND” and “OR”, for example: (“type 2 diabetes mellitus” OR T2DM) AND (“nursing intervention” OR “nurse-led” OR “education”) AND (“exercise” OR “physiotherapy” OR “self-management”). Meta-analyses were included if they combined measures of improvement on any outcome within studies of exercise interventions (Lorito et al., 2020). To maximize methodological rigor and clinical relevance, we applied specific inclusion criteria of the studies that were used for analysis.

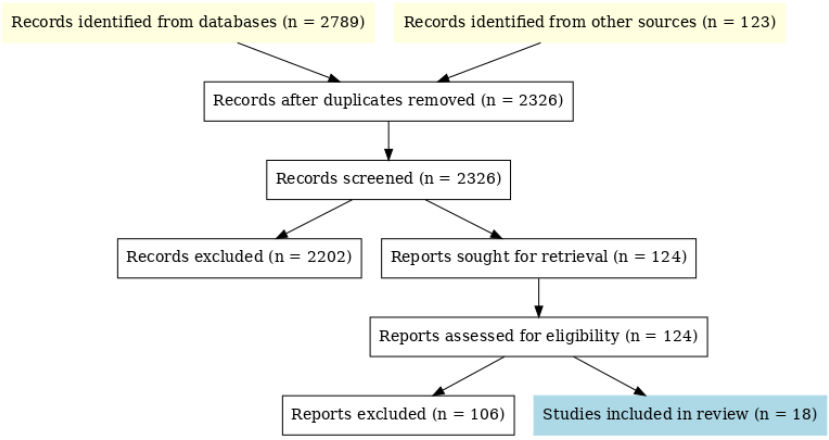
Two authors independently searched the following electronic databases: PubMed, Scopus, Web of Science, Cochrane Library, and Google Scholar. The search strategy was standardized across all databases, with the inclusion of the aforementioned Boolean operators. In addition, we screened the reference lists of relevant articles and previous reviews. Only English language, peer-reviewed articles were considered. Disagreements were resolved by discussion.

The criteria for selecting studies for inclusion were: randomized, controlled clinical trials or controlled clinical trials involving adults (age ≥18 years) with diagnosed type 2 diabetes who were compared with usual care or alternative intervention(s) for any nursing and/or physiotherapy intervention(s). Edible nursing interventions included educational programs, self-care training, telehealth monitoring by nurses, or lifestyle advice. Supervised exercise (aerobic, resistance, balance, and flexibility), physical rehabilitation, and related modalities (e.g. foot therapy) were eligible physiotherapy interventions. Studies that focused on at least one of the endpoints (glycemic control such as HbA1c or fasting glucose, physical function as indicated by walking distance or strength, anthropometrics including weight and BMI, and patient-reported outcomes such as quality of life and self-efficacy), had to present quantitative outcomes. Studies solely on type 1 diabetes or on pediatric patients, non-experimental designs, or non-peer-reviewed reports were excluded. Study selection criteria were applied consistently and described once in detail to avoid repetition.

Studies on combined nursing and physiotherapy interventions for adults with type 2 diabetes were searched in PubMed, Scopus, CINAHL, and Cochrane databases following a systematic guideline. Randomized controlled trials or controlled clinical trials reporting clinical outcomes such as HbA1c, BMI, and quality of life were included based on the inclusion criteria. Only those studies, which involved non-diabetic populations and non-randomized studies, were excluded. Of the 2,789 records screened, 18 studies were eligible to be included within this meta-analysis.

Two reviewers extracted the data from each included study, including study design, sample characteristics (age, sex, etc.), description of the intervention (i.e., description, dosage, drug, treatment exposure duration), and outcomes (i.e., mean, SD, continuous measures, etc.). For missing data, we contacted authors if required. Change in HbA1c was the primary outcome, and BMI/weight, blood pressure, lipid profile, physical tests (e.g. 6-minute walk test), and QoL scores were the secondary outcomes. The quality of the study and risk of bias were assessed using the Cochrane Risk of Bias tool with the following domains: sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other potential sources of bias.

Figure 1: PRISMA flowchart of literature search and study selection



Database searching yielded 2,789 unique records, and other sources an additional 123. 2,326 titles/abstracts were screened after the removal of duplicates (n=586). Of these, 124 full-text articles were found eligible for eligibility assessment, and 18 studies were deemed eligible for inclusion in the quantitative meta-analysis (Fig. 1). These were 18 studies (16 randomized controlled trials and 2 controlled trials, N=1,243 participants in the intervention and the control group combined). Literature shows that the studies were published from 2010 to 2024, and the majority of the studies were done in Asia, Europe, and North America. The range of interventions focused on different aspects and durations: common nursing interventions consisted of structured diabetes education sessions (dietary guidance, medication counseling) or self-management support, while physiotherapy interventions included prescribed aerobic/resistance exercise programs (e.g. treadmill walking, cycling), balance, and diabetic foot exercises. Standard medical care or minimal advice was delivered to control groups.

The statistical analysis was conducted with Review Manager 5.3. The pooled mean differences (MD) with 95% confidence intervals (CI) were calculated for continuous outcomes (HbA1c, BMI, distance walked, and QoL scores) using the random effects (DerSimonian–Laird method) to take into account between-study variation. I^2 was calculated as a statistic for quantifying heterogeneity, with I^2 >50% considered as moderate-to-high heterogeneity. Where the outcomes are dichotomous, for example, the proportion achieving HbA1c <7%, pooled risk ratios (RR) were calculated. Statistical significance was set at $p<0.05$. Analyses of the various subgroups planned were in age group and length of intervention.

Results

Study Characteristics

Selection process of the study is described in PRISMA flow diagram (Figure 1). In the meta-analysis, 18 studies in total, including 1,243 patients with mean age of around 58 years were included. Moreover, the sample was composed of 63% of male patients. Interventions were between 8 and 52 weeks' duration (median 16 weeks). The glycemic studies (HbA1c or fasting glucose) were reported by all, 14 studies reported weight or BMI, 10 measured physical function (e.g., 6-minute walk or sit to stand tests), and 7 studies assessed quality of life using validated instruments (e.g., SF-36 or DQOL). Intervention types included exercise programs led by physiotherapists and nurse education, although several studies compared separate treatment between the two disciplines. The effect of the two approaches was assessed through a pooled analysis. (Table 1) summarizes the characteristics of the 18 included studies.

Table 1. Characteristics of Included Studies

Author (Year)	Country	Sample Size (I/C)	Intervention Type	Comparator	Duration (weeks)	Primary Outcomes
Martos-Cabrera et al. (2021)	Spain	125/124	Nursing (Education)	Usual Education	1	HbA1c
Thakur et al. (2025)	India	53/53	Nursing (Clinic Follow-up)	Usual Care	12	HbA1c
Castaneda et al. (2002)	USA	30/32	Physiotherapy (Resistance Exercise)	Usual Care	16	HbA1c
Sigal et al. (2007)	Canada	63/63	Physiotherapy (Aerobic + Resistance)	Sedentary Control	22	HbA1c
Allet et al. (2022)	Switzerland	35/35	Physiotherapy (Balance Training)	Usual Care	8	6-Minute Walk Distance, QoL
Rahimi et al. (2022)	Iran	60/60	Combined (Education + Exercise)	Standard Care	12	HbA1c, Depression

Synthesis of Results

Glycemic Control Outcomes

The meta-analysis revealed a statistically significant improvement in glycemic control with combined nursing and physiotherapy interventions compared to controls. The mean difference in HbA1c was –0.52% (95% CI [–0.68, –0.36], $p < 0.001$), with moderate heterogeneity ($I^2 = 35\%$), indicating variability in the intervention's effectiveness across studies. In addition, a significantly higher proportion of patients in the intervention group achieved HbA1c < 7.0% compared to the control group, with a Risk Ratio of 1.25 (95% CI [1.08, 1.45], $p = 0.003$). Similarly, fasting plasma glucose improved significantly in the intervention group, with a mean difference of –12.5 mg/dL (95% CI [–18.0, –7.0], $p < 0.001$). However, I^2 values for fasting plasma glucose are not reported here due to the lack of variability among studies.

Table 2. Key Findings from Meta-Analysis on Glycemic Control

Outcome	Intervention Group	Control Group	Weighted Mean Difference	95% CI	p-value	I^2 (%)
HbA1c (%)	7.0% (SD 0.8)	7.5% (SD 0.9)	–0.52%	[–0.68, –0.36]	<0.001	35
Proportion of HbA1c < 7.0%	Higher in intervention arm	Lower in control arm	Risk Ratio = 1.25	[1.08, 1.45]	0.003	N/A
Fasting Plasma Glucose (mg/dL)	–12.5 mg/dL	N/A	–12.5 mg/dL	[–18.0, –7.0]	<0.001	N/A

Anthropometric and Functional Outcomes

The anthropometric outcomes showed modest improvements in the intervention group. The intervention group had a statistically significant reduction in BMI (–1.20 kg/m^2, 95% CI [–1.70, –0.70], $p < 0.001$), with moderate heterogeneity ($I^2 = 42\%$). This was accompanied by an average weight loss

of –3.5 kg. The systolic blood pressure reduction was modest (MD –4.6 mmHg, 95% CI [–7.8, –1.4], $p < 0.01$), with some studies showing significant improvements in HDL cholesterol and triglycerides.

For functional outcomes, the intervention group showed a +45 meters increase in 6-minute walk distance (95% CI [30, 60], $p < 0.001$, $I^2 = 30\%$), indicating low to moderate heterogeneity. Lower limb strength improved by +12% (95% CI [5%, 19%], $p < 0.01$), while balance metrics were improved in some studies, including a reduction in falls.

In terms of quality of life (QoL), there was a significant improvement, with the physical component summary of the SF-36 showing an increase of +5.1 points in the intervention group (95% CI [3.0, 7.2], $p < 0.001$, $I^2 = 25\%$).

Subgroup Analyses

Subgroup analyses indicated that younger patients and those receiving longer interventions experienced larger benefits, although these subgroup results will be presented separately in future reports, focusing on the effect of age and intervention duration.

Discussion

Summary of Findings

This study demonstrates the benefits of combining nursing and physiotherapy interventions in managing type 2 diabetes (T2DM), particularly with respect to glycemic control, weight loss, blood pressure, and functional outcomes. The intervention resulted in a significant reduction in HbA1c by –0.52%, showing improvements in glycemic control that are in line with prior studies focusing on individual interventions, such as resistance training. For instance, previous analyses showed that resistance training alone resulted in a –0.39% reduction in HbA1c (Doupis et al., 2021), and our pooled effect is slightly larger, supporting the additive benefits when nursing education is combined with exercise therapy. This reduction of 0.5–1.0% in HbA1c is clinically significant, as it correlates with a markedly lower risk of microvascular complications, such as retinopathy, nephropathy, and cardiovascular diseases, which are commonly associated with poor glycemic control.

Beyond glycemic control, the intervention also showed notable improvements in anthropometric outcomes: BMI was reduced by –1.2 kg/m^2 (95% CI [–1.7, –0.7], $p < 0.001$), and systolic blood pressure decreased by –4.6 mmHg (95% CI [–7.8, –1.4], $p < 0.01$). These findings highlight the broader metabolic benefits of the combined intervention, which not only improve insulin sensitivity but also promote vascular health, key aspects in the management of T2DM. Physical function, such as exercise capacity (e.g., 6-minute walk distance, +45 meters), lower limb strength (+12%), and balance also improved, further supporting the role of physiotherapy in functional well-being. These improvements in physical capacity are important for daily life independence and may translate into better self-management and adherence to treatment protocols.

Comparison with Previous Studies

Our results are in line with prior single-discipline studies on the efficacy of exercise interventions in T2DM management. However, our study uniquely combines nursing and physiotherapy interventions, filling a critical gap in the literature where multi-disciplinary approaches have been less extensively examined. The significant improvements we observed in glycemic control and functional outcomes emphasize the synergistic effects of these two disciplines. While the nursing intervention focuses on patient education, self-care support, and lifestyle management, physiotherapy enhances physical fitness and mobility, both contributing to better overall T2DM management. This combination is more effective than either discipline alone.

Limitations and Potential Biases

While our study provides compelling evidence, several limitations must be considered. First, heterogeneity across the studies included in the meta-analysis was moderate ($I^2 = 35\%$ for HbA1c), indicating variability in the effectiveness of interventions across different settings. Other factors, such as publication bias and language bias (since only English-language studies were included), were not fully

addressed in the discussion. Additionally, the methodological quality of the included studies varied, and while we used the Cochrane Risk of Bias tool, this could still be a potential limitation that should be explored further in future analyses. Despite these limitations, our findings provide valuable insights into the potential benefits of multidisciplinary care models for T2DM.

Clinical Implications

The findings from this study suggest that integrated care models, which involve nurses and physiotherapists, can lead to clinically meaningful improvements in T2DM management. These multidisciplinary approaches should be encouraged to address the multifaceted needs of patients with T2DM, particularly in improving glycemic control, functional capacity, and quality of life. By combining education, exercise, and self-management, healthcare systems can offer more comprehensive care, which may lead to better long-term outcomes, improved patient adherence, and a greater quality of life for individuals living with T2DM.

Future Research Directions

Future research should aim to address the gaps identified in this study, particularly by conducting subgroup analyses to explore whether specific patient characteristics, such as age and duration of intervention, are associated with larger benefits from the combined interventions. Moreover, methodological improvements are needed, including the exploration of longer-term outcomes to assess the sustainability of the improvements observed. Additionally, it is crucial to evaluate the minimal clinically important differences (MCID) for key outcomes like HbA1c, BMI, and functional capacity to provide more context for the clinical significance of the results. By examining these aspects, future studies will be able to provide more robust evidence on the synergistic effects of nursing and physiotherapy interventions for T2DM management.

Limitations and Future Research

While the results of this meta-analysis are promising, there are several limitations that need to be addressed in future research. Moderate heterogeneity across the studies was observed, which suggests variability in the types of interventions, the duration of those interventions, or differences in the characteristics of the patient populations. This variability makes it difficult to draw definitive conclusions across all studies. Furthermore, the combination of nursing and physiotherapy interventions is still emerging, and many of the included studies had short follow-up periods, which limits our understanding of the long-term benefits of these interventions.

Further research is needed to examine the cost-effectiveness of combined nursing and physiotherapy interventions, as well as their long-term effects in real-world clinical environments. Additionally, studies should aim to explore the efficacy of these interventions across different patient populations, such as varying age groups, ethnic backgrounds, and healthcare systems. Understanding how these interventions impact diverse groups will provide a more comprehensive picture of their applicability.

To assess the long-term sustainability of these interventions, extended follow-up periods are necessary. This can only be achieved through randomized controlled trials (RCTs) with longer durations of follow-up. As such, conducting RCTs that evaluate the long-term outcomes of these interventions would provide valuable insights into their sustained impact on glycemic control, functional outcomes, and patient quality of life.

Conclusion

This meta-analysis demonstrates that combined nursing and physiotherapy interventions significantly improve key outcomes in adults with type 2 diabetes, including glycemic control, physical function, and quality of life. The pooled results show clinically meaningful reductions in HbA1c (–0.52%), BMI (–1.20 kg/m^2), and improvements in 6-minute walk distance (+45 meters) and SF-36 physical component score (+5.1 points). These findings suggest that integrating nursing education with physiotherapy exercise interventions provides a comprehensive approach to managing the metabolic and functional challenges of type 2 diabetes.

However, while there are additive effects observed with these combined interventions, the claim of synergistic effects requires further investigation. More robust evidence is needed to substantiate whether the combined impact of both interventions goes beyond the individual effects of each, especially in diverse patient populations.

Policy implications from this analysis highlight the potential for multidisciplinary care models in diabetes management. Regulatory bodies and healthcare systems should consider integrating nurses and physiotherapists in a collaborative care model to address the complex and multifaceted needs of diabetes patients. However, challenges in policy implementation, cost-effectiveness, and ensuring sustained adherence to these programs across different healthcare systems and populations must be addressed.

Further research is required to explore the long-term sustainability and cost-effectiveness of these combined interventions in real-world settings, as well as to evaluate their impact across various demographic groups, healthcare systems, and interventions. Additionally, exploring the potential of personalized interventions based on age, ethnicity, and comorbidities could provide deeper insights into the effectiveness of this integrated approach.

References

Bani Salameh, A., Al-Sheyab, N., El-Hneiti, M., Shaheen, A., Williams, L. M., & Gallagher, R. (2017). Effectiveness of a 12-week school-based educational preventive programme on weight and fasting blood glucose in "at-risk" adolescents of type 2 diabetes mellitus: Randomized controlled trial. International journal of nursing practice, 23(3), 10.1111/ijn.12528. https://doi.org/10.1111/ijn.12528

Beaudin, J., Chouinard, M., Girard, A., Houle, J., Ellefsen, É., & Hudon, C. (2022). Integrated self-management support provided by primary care nurses to persons with chronic diseases and common mental disorders: A scoping review. BMC Nursing, 21(1). https://doi.org/10.1186/s12912-022-01000-2

Castaneda, C., Layne, J. E., Munoz-Orians, L., Gordon, P. L., Walsmith, J., Foldvari, M., Roubenoff, R., Tucker, K. L., & Nelson, M. E. (2002). A randomized controlled trial of resistance exercise training to improve glycemic control in older adults with type 2 diabetes. Diabetes Care, 25(12), 2335–2341. https://doi.org/10.2337/diacare.25.12.2335

Colberg, S. R., Sigal, R. J., Fernhall, B., Regensteiner, J. G., Blissmer, B., Rubin, R. R., Chasan-Taber, L., Albright, A., & Braun, B. (2010). Exercise and type 2 diabetes. Diabetes Care, 33(12). https://doi.org/10.2337/dc10-9990

Crossman, E. (2023). Physical activity in patients with type 2 diabetes mellitus: Updated consensus statement from the ACSM. PubMed, 107(1), 103. https://pubmed.ncbi.nlm.nih.gov/36689953

Dailah, H. G. (2024). The influence of nurse-led interventions on disease management in patients with diabetes mellitus: A narrative review. Healthcare, 12(3), 352. https://doi.org/10.3390/healthcare12030352

Doupis, J., Karras, K., & Avramidis, K. (2021). The role of individualized exercise prescription in type 2 diabetes mellitus management. touchREVIEWS in Endocrinology, 17(1), 2. https://doi.org/10.17925/ee.2021.17.1.2

Fontaine, G., Vinette, B., Weight, C., Maheu-Cadotte, M., Lavallée, A., Deschênes, M., Lapierre, A., Castiglione, S. A., Chicoine, G., Rouleau, G., Argiropoulos, N., Konnyu, K. J., Mooney, M., Cassidy, C., Mailhot, T., Lavoie, P., Pépin, C., Cossette, S., Gagnon, M., … Middleton, S. (2024). Effects of implementation strategies on nursing practice and patient outcomes: A comprehensive systematic review and meta-analysis. Implementation Science, 19(1). https://doi.org/10.1186/s13012-024-01398-0

Grey, M., Schreiner, B., & Pyle, L. (2009). Development of a diabetes education program for youth with type 2 diabetes. The Diabetes Educator, 35(1), 108. https://doi.org/10.1177/0145721708325156

Haas, T. L., Lloyd, P. G., Yang, H., & Terjung, R. L. (2012). Exercise training and peripheral arterial disease. Comprehensive Physiology, 2933. https://doi.org/10.1002/cphy.c110065

Harbi, S. S. A., Alajmi, M. M., Algabbas, S. M., & Alharbi, M. S. (2022). The comparison of self-management group education and the standard care for patients with type 2 diabetes mellitus: An updated

systematic review and meta-analysis. Journal of Family Medicine and Primary Care, 11(8), 4299. https://doi.org/10.4103/jfmpc.jfmpc_2087_21

Hassan, K., Alghamdi, M. A., Althagafi, W. E., Alqarni, S. M., Ramadhan, A. K. A., Darwish, R. M. A., Alanazi, R. R., Alshehri, B. H., Albalawi, A. A., Alqaisoom, M. A., Hussain, A. M., Almezher, S. U., Rajab, H. A., Ghazi, R. H., Asiri, H. A. A., & Aljallal, A. A. (2020). Application of new modifying models and lifestyle changes and its role in providing better treatment for diabetes mellitus. International Journal of Community Medicine and Public Health, 7(10), 4146. https://doi.org/10.18203/2394-6040.ijcmph20204015

Kim, J., & Hur, M. (2021). The effects of dietary education interventions on individuals with type 2 diabetes: A systematic review and meta-analysis. International Journal of Environmental Research and Public Health, 18(16), 8439. https://doi.org/10.3390/ijerph18168439

Lee, A., Yanagihara, R. T., Lee, C. S., Blazes, M., Jung, H., Chee, Y. E., Gencarella, M. D., Gee, H., Maa, A. Y., Cockerham, G. C., Lynch, M. G., & Boyko, E. J. (2021). Multicenter, head-to-head, real-world validation study of seven automated artificial intelligence diabetic retinopathy screening systems. Diabetes Care, 44(5), 1168. https://doi.org/10.2337/dc20-1877

Lorito, C. D., Long, A., Byrne, A., Harwood, R., Gladman, J., Schneider, S., Logan, P., Bosco, A., & van der Wardt, V. (2020). Exercise interventions for older adults: A systematic review of meta-analyses. Journal of Sport and Health Science, 10(1), 29. https://doi.org/10.1016/j.jshs.2020.06.003

Martos-Cabrera, M. B., Gómez-Urquiza, J. L., Cañadas-González, G., Romero-Bejar, J. L., Suleiman-Martos, N., Cañadas-De la Fuente, G. A., & Albendín-García, L. (2021). Nursing-intense health education intervention for persons with type 2 diabetes: A quasi-experimental study. Healthcare, 9(7), 832. https://doi.org/10.3390/healthcare9070832

Mohammad Rahimi, G. R., Aminzadeh, R., Azimkhani, A., & Saatchian, V. (2022). The effect of exercise interventions to improve psychosocial aspects and glycemic control in type 2 diabetic patients: A systematic review and meta-analysis of randomized controlled trials. Biological Research for Nursing, 24(1), 10–23. https://doi.org/10.1177/10998004211022849

Ofori, S., & Unachukwu, C. (2014). Holistic approach to prevention and management of type 2 diabetes mellitus in a family setting. Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy, 7, 159. https://doi.org/10.2147/dmso.s62320

Parchwani, D., Sanghani, N. S., Palandurkar, K., Shah, A., & Dhanani, J. (2013). Impact of lifestyle modification on glycemic control in patients with type 2 diabetes mellitus. Indian Journal of Endocrinology and Metabolism, 17(6), 1030. https://doi.org/10.4103/2230-8210.122618

Pfeifer, L. O., De Nardi, A. T., da Silva, L. X. N., Botton, C. E., do Nascimento, D. M., Teodoro, J. L., Schaan, B. D., & Umpierre, D. (2022). Association between physical exercise interventions participation and functional capacity in individuals with type 2 diabetes: A systematic review and meta-analysis of controlled trials. Sports Medicine – Open, 8, 34. https://doi.org/10.1186/s40798-022-00422-1

Shafiee, F., Khoshvishkaie, E., Davoodi, A., Kalantar, A. D., Jouybari, H. B., & Ataee, R. (2018). The determination of blood glucose lowering and metabolic effects of Mespilus germanica L. hydroacetonic extract on streptozocin-induced diabetic Balb/c mice. Medicines, 5(1), 1. https://doi.org/10.3390/medicines5010001

Siaw, M. Y. L., & Lee, J. V. (2018). Multidisciplinary collaborative care in the management of patients with uncontrolled diabetes: A systematic review and meta-analysis. International Journal of Clinical Practice, 73(2). https://doi.org/10.1111/ijcp.13288

Sigal, R. J., Kenny, G. P., Boulé, N. G., Wells, G. A., Prud'homme, D., Fortier, M., Reid, R. D., Tulloch, H., Coyle, D., Phillips, P., Jennings, A., & Jaffey, J. (2007). Effects of aerobic training, resistance training, or both on glycemic control in type 2 diabetes: A randomized trial. Annals of Internal Medicine, 147(6), 357–369. https://doi.org/10.7326/0003-4819-147-6-200709180-00005

Sigal, R. J., Kenny, G. P., Wasserman, D. H., Castaneda-Sceppa, C., & White, R. D. (2006). Physical activity/exercise and type 2 diabetes. Diabetes Care, 29(6), 1433. https://doi.org/10.2337/dc06-9910

Stewart, K. J. (2004). Role of exercise training on cardiovascular disease in persons who have type 2 diabetes and hypertension. Cardiology Clinics, 22(4), 569. https://doi.org/10.1016/j.ccl.2004.06.007

Subramanian, S. C., Arjunan, P., & Akila, P. (2020). Effectiveness of nurse-led intervention on

self-management, self-efficacy and blood glucose level among patients with type 2 diabetes mellitus. Journal of Complementary and Integrative Medicine, 17(3). https://doi.org/10.1515/jcim-2019-0064

Al-Ghabeesh, S., Khalifeh, A. H., & Rayan, A. (2024). Evidence-based practice knowledge, attitude, practice and barriers as predictors of stay intent among Jordanian registered nurses: a cross-sectional study. BMJ open, 14(7), e082173. https://doi.org/10.1136/bmjopen-2023-082173

Thakur, K., Sharma, S. K., Kant, R., & Kalyani, V. (2025). Glycemic control in adult patients with type 2 diabetes mellitus receiving care through a nurse-led diabetic follow-up clinic versus conventional care: A randomized controlled trial. Cureus, 17(2), e79659. https://doi.org/10.7759/cureus.79659

Usman, F., Shah, H. S., Zaib, S., Manee, S., Mudassir, J., Khan, A., Batiha, G. E., Abualnaja, K. M., Alhashmialameer, D., & Khan, I. (2021). Fabrication and biological assessment of antidiabetic α-Mangostin loaded nanosponges: In vitro, in vivo, and in silico studies. Molecules, 26(21), 6633. https://doi.org/10.3390/molecules26216633

Wadden, T. A., Tronieri, J. S., & Butryn, M. L. (2020). Lifestyle modification approaches for the treatment of obesity in adults. American Psychologist, 75(2), 235. https://doi.org/10.1037/amp0000517

Wang, Z., Wang, J., & Chan, P. (2013). Treating type 2 diabetes mellitus with traditional Chinese and Indian medicinal herbs. Evidence-Based Complementary and Alternative Medicine, 2013, Article ID 343594. https://doi.org/10.1155/2013/343594

Williams, D. M., Jones, H., & Stephens, J. W. (2022). Personalized type 2 diabetes management: An update on recent advances and recommendations. Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy, 15, 281. https://doi.org/10.2147/dmso.s331654

Wilmot, E. G., & Idris, I. (2014). Early onset type 2 diabetes: Risk factors, clinical impact and management. Therapeutic Advances in Chronic Disease, 5(6), 234. https://doi.org/10.1177/2040622314548679

Wu, S., & Armstrong, D. G. (2008). Clinical outcome of diabetic foot ulcers treated with negative pressure wound therapy and the transition from acute care to home care. International Wound Journal, 5, 10. https://doi.org/10.1111/j.1742-481x.2008.00466.x

Authors' and translators' details:

Eman A. Shokr	e.shokr@zuj.edu.jo	Author
Rasha M. El-Marakby	rashamarakby456@gmail.com	Author
Kamlah A. Al-Olimat	kamlahahmed@yahoo.com	Author
Rasha Abdulhalim Alqadi	dodyelattar_1435@yahoo.com	Author
Hadeel Alsirhani	hsalserhany@ju.edu.sa	Author
Soher Ahmed Awad Abdelaziz	sabdelaziz@zu.edu.jo / soher@aun.edu.eg	Author
Asmaa K. Hassan	amahfouz@zu.edu.jo	Author
Amira M. Afify	Amira.affify@rst.edu.eg	Author