RESEARCH PAPER

Clinical Implications of Core and Trunk Centered Exercise in Prediabetes and Type 2 Diabetes Mellitus: Current Evidence and Potential Mechanisms

Pompy Mahato[1] and Manabendra Nayak[2*]

[1]*Research Scholar, Faculty of Paramedical Sciences, Assam Down Town University, Guwahati, Assam, India*
[2]*HOD, Department of Medicine, Down Town Hospital, Guwahati, Assam, India*
[1]*pompy.maha@gmail.com and* [2]*dr.mnayak@yahoo.co.in*
Corresponding author: [Name, e-mail]

Received: 25th June 2026; **Revised:** 28th July 2026; **Accepted:** 10th October 2026; **Available Online:** 15th October 2026

ABSTRACT
Prediabetes and Type 2 diabetes mellitus (T2DM) are characterized by impaired glucose regulation, insulin resistance and progressive metabolic dysfunction. Although aerobic and conventional resistance exercise has been extensively investigated, comparatively less attention has been directed toward core- and trunk-focused strengthening. The purpose of this narrative review was to synthesize the current evidence on core- and trunk-focused exercise in prediabetes and T2DM andexamines theemerging evidence for core muscle strengthening in prediabetes and T2DM, with particular emphasis on its potential metabolic and functional mechanisms and its possible integration into comprehensive exercise management. A structured literature search was conducted in PubMed/MEDLINE, Google Scholar, Scopus, Web of Science, and PEDro for studies published from January 2015 through 2026. Studies involving core-, abdominal-, trunk-focused exercise in adults with prediabetes or T2DM were considered, with Pilates-based interventions included as supporting evidence when they incorporated a meaningful core component. Core exercise involves repeated activation of the abdominal, paraspinal and lumbopelvic musculature and may provide both muscular and metabolic benefits. Recent evidence suggests that core- and trunk-focused exercise may improve glycemic control, insulin resistance, body composition and physical function in individuals with prediabetes and T2DM. Supporting Pilates-based studies have additionally reported favourable effects on HbA1c, physical performance, balance and selected metabolic variables. However, substantial heterogeneity exists in intervention design, exercise content, duration and frequency, and Pilates interventions incorporate several components beyond isolated core strengthening. The current evidence therefore supports core- and trunk-focused strengthening as a promising approach, while the specific contribution of isolated trunk-muscle loading to systemic metabolic improvement requires further investigation. Further adequately powered randomized trials using standardized core-strengthening protocols and clinically relevant metabolic outcomes are needed.

Keywords: core strengthening, core stability, core training, trunk strengthening, trunk stabilisation, abdominal strengthening, prediabetes, Type 2 diabetes mellitus, Pilates.
How to cite this article: [Author surnames and initials]. Clinical Implications of Core and Trunk Centered Exercise in Prediabetes and Type 2 Diabetes Mellitus: Current Evidence and Potential Mechanisms. Int J Drug Deliv Technol. 2026;16(89s): 2028-2039; DOI: 10.25258/ijddt.16.89s.190
Source of support: Nil
Conflict of interest: None

INTRODUCTION

Prediabetes and type 2 diabetes mellitus (T2DM) are major metabolic disorders characterized by abnormalities in glucose regulation.[1] Prediabetes is defined by glucose levels above the normal range but below the diagnostic threshold for diabetes and represents an important stage at which lifestyle intervention may help prevent or delay progression to T2DM.[1] T2DM is characterized by progressive loss of adequate pancreatic β-cell insulin secretion, frequently occurring in the setting of insulin resistance, and results in chronic hyperglycemia with an increased risk of vascular and other complications.[1,2]

The International Diabetes Federation (IDF) estimates that approximately 589 million adults aged 20–79 years were living with diabetes globally in 2024, equivalent to approximately one in nine adults, with this number projected to increase to 853 million by 2050.[3] Intermediate hyperglycemia is even more prevalent; in 2024, an estimated 634.8 million adults (12.0%) had impaired glucose tolerance, while approximately 487.7 million adults (9.2%) had impaired fasting glucose.[3] These figures highlight the importance of interventions capable not only of managing established diabetes but also of preventing or delaying disease progression in individuals with prediabetes.

Physical activity and structured exercise are established components of diabetes management, with current guidelines recommending 150 min or more of moderate- to vigorous-intensity aerobic activity per week, spread over at least 3 days, together with resistance exercise on 2–3 nonconsecutive days per week.[4]Flexibility and balance activities are additionally recommended, particularly for older adults, while prolonged sedentary behavior should be interrupted regularly.[1,4] High-intensity interval training (HIIT) represents another exercise strategy that can

Author for Correspondence: [corresponding author's e-mail]

improve cardiorespiratory fitness and glycemic outcomes in appropriately selected individuals.[1,4] In addition, reducing sedentary time and interrupting prolonged sitting with brief periods of physical activity have increasingly been recognized as important components of diabetes management.[1,4] Thus, contemporary exercise recommendations emphasize a multimodal approach combining aerobic activity, muscle strengthening, flexibility, balance, functional movement, and reduction of sedentary behavior rather than reliance on a single form of exercise.

Conventional exercise recommendations for individuals with prediabetes and T2DM emphasize aerobic activity together with muscle-strengthening exercise.[1,4] Resistance exercise increases the demand placed on skeletal muscle and may improve glucose disposal, insulin sensitivity and body composition. However, most exercise research in diabetes has focused on large-muscle-group or whole-body exercise, whereas the potential contribution of specifically targeted trunk and abdominal musculature has received considerably less attention.

The core musculature provides central stability for movement and includes the abdominal and paraspinal muscles that contribute to control of the trunk and lumbopelvic region.[5–8] Core-strengthening exercise therefore represents a form of muscular exercise directed toward improving the strength and control of this central musculature. Although core exercise has traditionally been studied for its effects on posture, balance, spinal stability and functional movement, increasing attention has recently been given to its potential metabolic relevance.

Despite the established metabolic benefits of general exercise, evidence specifically addressing core-muscle strengthening in prediabetes and T2DM remains limited. Recent intervention studies have begun to investigate abdominal strengthening, core-strengthening programmes and Pilates-based core exercise, with encouraging findings for glycemic and physical outcomes.[13–27] These studies provide a basis for examining the potential role of targeted core strengthening in individuals with abnormal glucose regulation.

The purpose of this narrative review is therefore to examine the available evidence concerning the role of core- and trunk-focused strengthening exercise in prediabetes and T2DM and their potential effects on glycemic control, insulin resistance, body composition and physical function.

METHODOLOGY

Study Design

This study was designed as a structured narrative review aiming to synthesize the available evidence on core- and trunk-focused exercise in individuals with prediabetes and T2DM. A structured search and predefined eligibility criteria were used to enhance transparency and reproducibility. Quantitative pooling was not performed because the available studies differed substantially in participant characteristics, intervention content, exercise dose, and outcome assessment.

Literature Search Strategy

A comprehensive literature search was conducted in PubMed/MEDLINE, Google Scholar, Scopus, Web of Science, and PEDro for studies published from January 2015 through 2026. For PubMed/MEDLINE, a combination of MeSH and free-text keywords relating to prediabetes, T2DM, exercise, core strengthening, core stability, abdominal strengthening, trunk strengthening, trunk stabilization and Pilates were combined using Boolean operators. Equivalent search strategies were adapted for the other databases. The initial search was intentionally broad and did not require specific outcome terms or an RCT filter, thereby allowing potentially relevant observational, interventional and randomized studies to be identified. Reference lists of relevant articles were also screened.

Study Selection and Eligibility Criteria

Studies were considered eligible when they involved human participants with prediabetes or T2DM and evaluated an exercise intervention with a meaningful core-, abdominal-, or trunk-focused component and reported relevant metabolic, cardiorespiratory, muscular or functional outcomes. Direct core-focused studies were considered irrespective of study design when they met the population and intervention criteria. For the supporting Pilates evidence, only randomized controlled trials involving mat- or body-weight Pilates without Pilates apparatus or specialized equipment were included, provided that the intervention incorporated a meaningful core/trunk strengthening component. Reviews, meta-analyses, editorials, letters, abstracts, duplicate publications and studies with an inappropriate population, intervention or outcome were excluded.

Out of the 43 studies considered, 22 were excluded following application of the predefined eligibility criteria. The excluded studies comprised two direct-core studies that did not meet the final intervention or outcome criteria and 20 Pilates studies that did not meet the predefined criteria for the supporting Pilates evidence, including studies with inappropriate populations, interventions, study designs, use of Pilates apparatus or specialized equipment, or insufficient relevance to the core/trunk-focused outcomes of interest. The final evidence base comprised 21 studies, including seven studies evaluating direct core strengthening interventions and 14 randomized controlled trials evaluating Pilates as supporting evidence representing 1,136participants.The overall study-selection process and the final composition of the evidence base are summarized in Figure 1.

Data Extraction and Narrative Synthesis

Information extracted from eligible studies included study design, participant characteristics, diagnosis, intervention content, exercise frequency and duration, outcome measures and principal findings. Evidence was synthesized descriptively and organized into direct core-focused evidence and supporting equipment-free Pilates evidence. Outcomes were considered across four broad domains: glycemic and metabolic outcomes, body-composition

outcomes, muscular and cardiorespiratory outcomes, and functional outcomes including balance, gait, proprioception and quality of life.

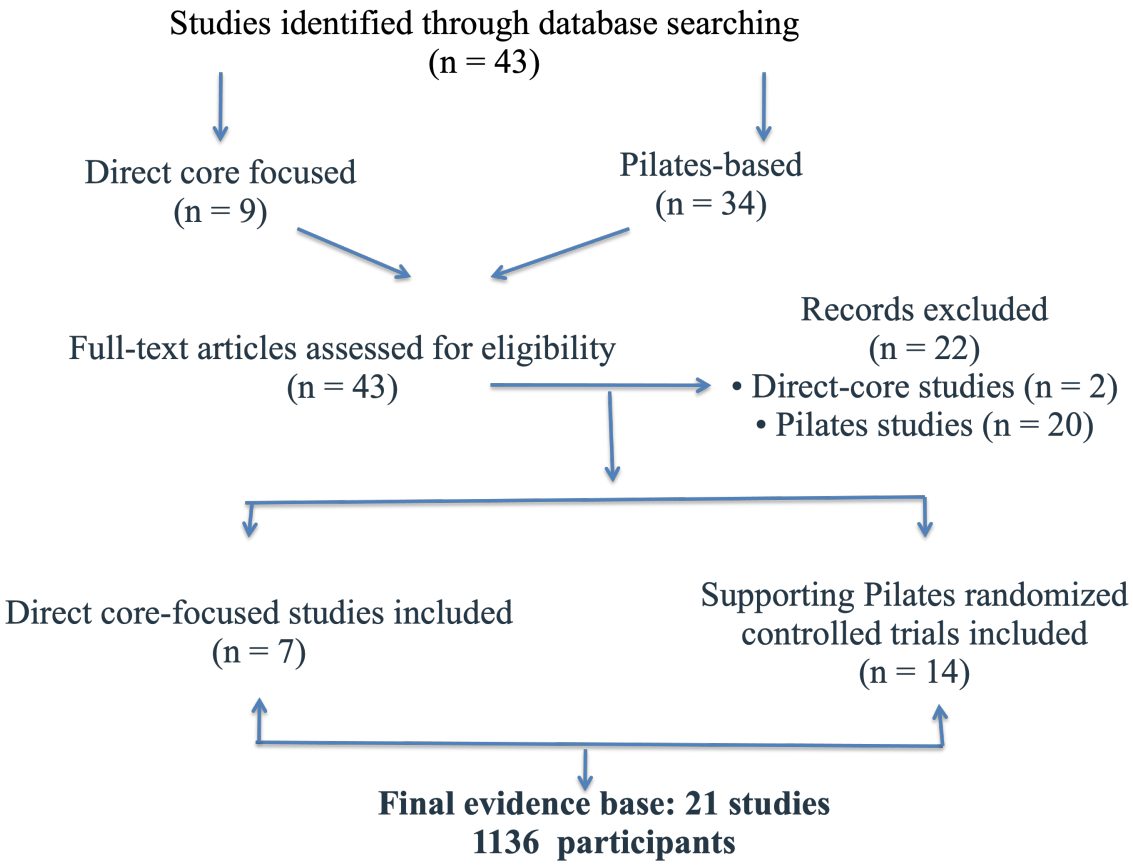


Figure 1: Schematic study-selection flow for the narrative review. This diagram summarizes the final screening decisions based on the predefined inclusion and exclusion criteria.

SKELETAL MUSCLE AND GLUCOSE REGULATION

Skeletal muscle is the principal tissue responsible for insulin-stimulated glucose disposal and therefore plays an important role in maintaining glucose homeostasis. In insulin-resistant states, the ability of skeletal muscle to respond appropriately to insulin is reduced, contributing to impaired glucose disposal and elevated blood glucose concentrations.[2]

Repeated exercise produces longer-term adaptations within skeletal muscle. Regular physical activity can improve insulin sensitivity, glucose transport and mitochondrial function while increasing the capacity of muscle to utilize glucose.[3],[4],[5] Resistance exercise may additionally preserve or increase skeletal-muscle mass, thereby increasing the metabolically active tissue available for glucose disposal. These mechanisms provide the physiological foundation for examining different forms of muscular exercise in prediabetes and T2DM.

Among the different forms of muscular exercise, core- and trunk-focused strengthening provides a distinct approach by specifically targeting the abdominal, paraspinal and lumbopelvic musculature. Repeated activation of these muscles increases local energy demand thereby stimulating contraction-mediated glucose uptake, while also contributing to trunk stability, balance and functional movement. These characteristics provide a physiological basis for investigating whether targeted core-muscle strengthening may contribute to metabolic and functional outcomes in individuals with prediabetes and T2DM. The anatomical characteristics and functional role of the core musculature are therefore considered in the following section.

CORE MUSCULATURE AND CORE STRENGTHENING

Core muscles represent a substantial component of the skeletal-muscle system and participate repeatedly in both structured exercise and activities of daily living.Terminology describing trunk-focused exercise is inconsistent across the literature, and terms such as core strengthening, core stability, core training, abdominal strengthening and trunk strengthening are often used interchangeably despite representing different constructs.[5–9] Core strengthening has been described as encompassing lumbar stabilization, motor-control training and other exercise approaches involving muscular control around the

lumbar spine to maintain functional stability.[7] Core stability emphasizes the ability to control the position and movement of the trunk over the pelvis during functional activities, with both muscular capacity and neuromuscular control contributing to this function.[6,8] The term core itself has been broadly described to include abdominal, paraspinal, gluteal, hip-girdle and other muscles contributing to spinal and trunk stability.[6] More recent literature has also highlighted that core training does not consistently specify the anatomical location or depth of the muscles being targeted, resulting in considerable variation in the exercises classified under this term.[16] Similarly, trunk-strengthening interventions may target trunk flexor and extensor musculature and may therefore overlap with exercises described as core strengthening.[15] For the purposes of the present review, studies were classified according to the principal characteristics of their interventions while retaining the terminology used by the original investigators.

Core muscle strengthening can be achieved through a variety of exercise strategies. Traditional exercises may include abdominal curls, trunk flexion or extension exercises, bridges, planks, side planks, and resisted trunk movements. More integrated approaches incorporate free-weight or functional movements such as squats, deadlifts, loaded carries, and unilateral resistance exercises, which require substantial trunk muscle activation while simultaneously training other muscle groups.[5–10] For the purposes of the present review, core muscle strengthening refers primarily to progressive exercise intended to increase the force-generating capacity of the musculature of the trunk and lumbopelvic region**,** rather than interventions designed exclusively to improve endurance or motor control.

An important practical characteristic of core strengthening is that exercises can be performed using body weight or simple mat-based movements. Examples include abdominal strengthening exercises, bridging, controlled trunk flexion, quadruped exercises and stabilization tasks. This accessibility may be particularly relevant for individuals with prediabetes or type 2 diabetes mellitus, for whom a simple, low-equipment approach may facilitate the incorporation of structured exercise into routine clinical, community or home-based settings. Such interventions may therefore provide a practical option for individuals who have limited access to exercise facilities or equipment, while also allowing exercise to be progressively adapted according to individual functional capacity.

DIRECT EVIDENCE FROM CORE-FOCUSED EXERCISE STUDIES

The final evidence base comprised seven direct core/core-focused studies involving 368 participants. These studies varied in design, population and intervention content, but collectively provide the most direct evidence for evaluating whether targeted trunk exercise is associated with metabolic or functional outcomes in prediabetes and T2DM. The characteristics and principal findings of these direct core-focused studies are summarized in Table 1.

Glycemic and metabolic outcomes

Evidence for glycemic effects from direct core-focused exercise interventions is emerging. In a study of 100 individuals with T2DM, Sudhan et al. investigated an abdominal muscle-strengthening programme. Participants received supervised exercise for 30 minutes, three times weekly, over 12 weeks, and the experimental group performed the ABON abdominal exercise programme incorporating leg raises, abdominal tucks, quadruped abdominal exercises, breathing and abdominal grading. The abdominal-strengthening group demonstrated significantly greater improvements in random blood glucose and HbA1c than the control group.[13]

More recently, evidence in prediabetes has extended these findings to broader metabolic outcomes. Yiğiter et al. conducted a randomized controlled trial specifically investigating core exercise in women with prediabetes. Eighteen women aged 20–55 years were randomized to core exercise or control, with nine participants in each group, and the intervention group completed 24 supervised sessions over eight weeks. Significant improvements were reported in fasting and postprandial glucose, HbA1c, insulin, HOMA-IR, body weight, BMI, fat percentage, selected circumferences and lipid-related measures.[14] The small sample and restriction to women require confirmation in larger and more diverse populations

Muscular, cardiorespiratory and functional outcomes

Functional outcomes have also been examined, particularly in individuals with diabetes-related peripheral neuropathy. Core stability exercises combined with desensitisation therapy were associated with improvement in limit of stability in the study by Battesha et al.[15] Pavana et al. compared core-stability exercise with proprioception exercise and found significant within-group improvements in balance in both groups, without a significant between-group difference.[16] These findings support the functional relevance of trunk-focused exercise for balance and postural control, but do not establish superiority over other active rehabilitation strategies.

Evidence for improvements in cardiorespiratory and muscular fitness is provided by a progressive intervention reported by Arkate et al. The study investigated a progressive core-strengthening programme in people with T2DM and reported improvements in VO_2max, vital capacity and core strength after four weeks. The programme progressed from deep segmental activation to more demanding abdominal, bridging, plank, side-plank and rotational exercises.[17] The findings provide preliminary evidence that progressive core exercise may influence muscular and cardiorespiratory fitness, although the small sample and short intervention limit generalizability.

The available Pilates-based evidence provides additional information on both exercise dose and physical outcomes. Kaur et al. examined different durations and frequencies of Pilates-based core strengthening in 40 individuals with T2DM. All groups received the intervention, so the study primarily informs exercise dose rather than comparative efficacy. Six weeks of 20- or 30-minute sessions performed two or three times weekly improved HbA1c, balance, gait

and proprioception, with 30 minutes three times weekly reported as the most favourable protocol among those tested.[18] Ebrahimi et al. similarly reported that eight weeks of selected Pilates exercises improved HbA1c, muscle strength and static balance in women with T2DM, whereas dynamic balance did not change significantly.[19] Because these interventions remained multimodal, their findings cannot be interpreted as a pure test of isolated trunk-muscle loading.

SUPPORTING EVIDENCE FROM PILATES-BASED CORE STRENGTHENING STUDIES

The supporting Pilates literature is larger than the direct core literature. Fourteen randomized controlled trials meeting the present criteria used mat- or body-weight Pilates without specialized Pilates apparatus. Several trials reported favourable glycemic outcomes, including reductions in HbA1c and/or fasting glucose. Zolfaghari et al., Khormizi and Azarniveh, Yucel and Uysal, Ruiz et al, Batar et al., Cui et al., Abd El-Monim et al. and Melo et al. collectively provide evidence that mat-based Pilates may improve selected metabolic outcomes in people with diabetes.[20–27] A systematic review and meta-analysis of Pilates randomized trials similarly reported an overall reduction in HbA1c, although heterogeneity was substantial.[28]

The supporting studies also reported effects beyond glycemic control. Mir and Fathi reported changes in insulin resistance, visfatin, VO_2max and body composition.[29] Sharma et al. found improvements in quality of life, sleep quality and satisfaction with life, whereas Hassani et al. did not observe a significant quality-of-life improvement.[30],[31] Gouveia et al. examined metabolic control and oxidative stress, providing additional evidence that Pilates may influence broader physiological outcomes.[32]

More recent trials further illustrate the variability of findings. Karaman and Angın found that 16 weeks of Clinical Pilates in women with prediabetes improved HbA1c, fasting glucose, insulin, HOMA-IR, lipid parameters and several physical-fitness measures.[33] Uçgul et al., in contrast, reported no significant between-group differences in metabolic or body-composition outcomes following Pilates combined with physical-activity counselling, although physical activity, functional capacity, balance and step counts improved.[34] This contrasting result demonstrates that favourable metabolic effects should not be assumed for every Pilates-based programme.

Taken together, these studies provide useful supporting evidence for the potential role of trunk-focused exercise.

Table 1: Study characteristics and principal findings

Study	Participant characteristics	Diagnosis	Sample and group allocation	Intervention	Dosage	Outcome measures	Principal findings	Interpretation
Sudhan et al. (2018)	Adults with T2DM	T2DM	n=100; intervention n=50, control n=50	**Intervention:** ABON abdominal muscle strengthening. **Control:** no abdominal training; breathing exercises, general stretching, walking encouraged, usual lifestyle continued	30 min/session, 3×/week, 12 weeks	Random blood glucose; HbA1c	Intervention group showed significantly greater improvement in RBG and HbA1c than control	Direct evidence supporting a potential glycemic effect of abdominal strengthening
Battesha et al. (2018)	Adults with diabetic peripheral neuropathy	T2DM with diabetic peripheral neuropathy	**n=60; randomly assigned to four groups(n=15) each**	Group A: selected physical therapy; Group B: core stability;Group C: desensitisationtherapyGroup D: core stability with desensitisation therapy	3×/week, 6 weeks	Limit of stability/postural control	Improvement in limit of stability	Supports functional/postural benefits; metabolic effects were not assessed

Study	Participant characteristics	Diagnosis	Sample and group allocation	Intervention	Dosage	Outcome measures	Principal findings	Interpretation
Pavana et al. (2021)	40–60 years; diabetic peripheral neuropathy	T2DM with diabetic peripheral neuropathy	**n=80; proprioception n=40, core stability n=40**	**Group A:** proprioception exercise (n=40). **Group B:** core stability exercise (n=40)	3×/week, 6 weeks	Berg Balance Scale; Toronto Clinical Scoring System	Both groups significantly improved balance; no significant between-group difference	Core exercise improved balance but was not superior to proprioceptive exercise
Arkate et al. (2024)	Adults with T2DM; demographic details NR	T2DM	**n=40; group allotted randomly in 2 groups.**	Progressive core strengthening, including deep segmental activation, abdominal, bridging, plank, side-plank and rotational exercises	12 sessions, 4 weeks	VO_2max; vital capacity; core strength	Improved VO_2max, vital capacity and core strength	Preliminary evidence for muscular and cardiorespiratory benefits; small sample and short duration limit inference
Kaur et al. (2018)	35–60 years	T2DM	**n=40; four intervention groups, n=10/group; no conventional control group**	Pilates-based core strengthening protocols differing in exercise duration and frequency	20 or 30 min/session; 2 or 3×/week; 6 weeks	HbA1c; balance; gait; proprioception	HbA1c, balance, gait and proprioception improved; 30 min, 3×/week was most favourable among tested protocols	Primarily informs exercise dose rather than comparative efficacy
Ebrahimi et al. (2015)	Women with T2DM;	T2DM	**n=30; Intervention group n=15;control group n=15**	Selected Pilates exercises	8 weeks	HbA1c; muscle strength; static and dynamic balance	HbA1c, muscle strength and static balance improved; dynamic balance did not significantly change	Supporting evidence; multimodal Pilates limits attribution to isolated core training
Yiğiter et al. (2025)	Women aged 20–55 years	Prediabetes	**n=18; intervention n=9, control n=9**	**Intervention:** supervised core exercise. **Control:** control condition	24 supervised sessions, 8 weeks	Fasting glucose; postprandial glucose; HbA1c; insulin; HOMA-IR; body weight; BMI; fat percentage; circumferences; lipid parameter	Significant improvements in glycemic measures, insulin, HOMA-IR, body composition and lipid-related measures	Promising direct metabolic evidence, but very small and female-only sample
Zolfaghari et al. (2015)	Women with T2DM;	T2DM	**n=24; intervention n=12, control n=12**	Mat Pilates vs comparator	75 min/session, 3×/week, 8 weeks	Fasting glucose; HbA1c; testosterone; SHBG	Favourable effects on fasting glucose and HbA1c; hormonal outcomes also assessed	Supporting metabolic evidence from Pilates; multimodal intervention
Khormizi&Azarniveh (2017)	Obese women with T2DM	T2DM with obesity	**n=30; intervention n=15, control n=15**	Mat Pilates vs Routine intervention	60 min/session, 3×/week, 8 weeks	Glycemic control; body weight	Favourable effects on glycemic control and weight loss	Suggests potential metabolic and weight-related benefit
Yucel & Uysal (2016)	Women with T2DM	T2DM	**n=45; intervention n=24, control n=21**	Pilates-based mat exercises vs comparator	45-70 min 3 times/day, 12 weeks	HbA1c; FBS, quality-of-life parameter	HbA1c improvement reported; quality-of-life parameters also assessed	Supports possible glycemic and functional/quality-of-life benefits
Ruiz et al (2025)	Elderly patients with diabetes;	Diabetes mellitus/T2DM	**n=104; intervention n=52, control n=52**	Mat Pilates vs comparator	60 min twice/day, 12 weeks	Nutritional status & HRQOL	Improvements in Nutritional status & HRQOL	Effects can be attributed to Pilates alone

Study	Participant characteristics	Diagnosis	Sample and group allocation	Intervention	Dosage	Outcome measures	Principal findings	Interpretation
Batar et al. (2020)	Women with T2DM;	T2DM	**n=120 randomized ;** intervention 4 groups n= 30 each	Mat Pilates combined with either low-carbohydrate or high-complex-carbohydrate diabetic diet	60 min/session, 3×/week, 12 weeks	Body composition; glucose; HbA1c; insulin; lipid parameter	Changes in body composition, glucose, HbA1c, insulin and lipid parameters	Metabolic/body-composition findings are confounded by dietary intervention
Cui et al. (2020)	Elderly patients with T2DM;	T2DM	**n=90 randomized ;** intervention n=44, control n=46	Mat Pilates combined with diet management	90-150 min/session, 7×/week, 12 weeks	Fasting glucose; postprandial glucose; HbA1c; debilitating status	Improvements in fasting/postprandial glucose and HbA1c	Supporting evidence, but effects cannot be separated from dietary management
Abd El-Monim et al. (2019)	Women with T2DM	T2DM	**n=60 randomized ;** intervention n=30, control n=30	Mat Pilates vs DASH Diet &nedication	60 min/session, 3×/week, 12 weeks	HbA1c; lipid/cardiometabolic parameter	Favourable changes in HbA1c and lipid parameters	Supports potential cardiometabolic effects of Pilates
Melo et al. (2020)	Older women with T2DM;	T2DM	**n=22**randomized assigned to 2 groups	Pilates method training vs comparator	60 min/session, 3×/week, 12 weeks	Functional capacity; blood-glucose-related outcomes	Improvements in functional capacity and blood-glucose-related outcomes	Supports metabolic and functional effects in older women
Gouveia et al. (2021)	Adults with T2DM;	T2DM	**n=44;** intervention n=22, control n=22	Pilates vs comparator	2×/week, 8 weeks	Metabolic control; oxidative-stress-related outcomes	Effects reported on metabolic control and oxidative-stress-related outcomes	Provides supporting metabolic evidence
Hassani et al. (2018)	Elderly women with T2DM	T2DM	**n=40;** intervention n=20, control n=20	Pilates vs comparator	8 weeks	Quality of life	No significant improvement in quality of life	Functional/psychosocial benefits were not consistently demonstrated
Mir & Fathi (2018)	Obese women with T2DM	T2DM with obesity	**n=20;** intervention n=10, control n=10	Pilates vs comparator	60 min/session, 3×/week, 8 weeks	Glucose; insulin resistance; visfatin; VO_2max; body composition	Changes reported in glucose, insulin resistance, visfatin, VO_2max and body composition	Suggests broader metabolic and fitness effects, but sample was small
Sharma et al. (2018)	Adults with T2DM;	T2DM	**n=30;** intervention n=20, control n=10	Mat Pilates vs comparator	20–30 min/session, 3×/week, 4 weeks	Quality of life; sleep quality; satisfaction with life	Improvements in quality of life, sleep quality and satisfaction with life	Suggests potential quality-of-life benefits despite short intervention
Karaman &Angın (2026)	Women with prediabetes;	Prediabetes	**n=49 randomized ; n=42 completed;** intervention n=21, control n=21	Clinical Pilates vs comparator	3×/week, 16 weeks	HbA1c; fasting glucose; insulin; HOMA-IR; lipids; core endurance; strength; balance; physical fitness	Improved HbA1c, fasting glucose, insulin, HOMA-IR, lipids, core endurance, strength, balance and fitness	Recent supportive evidence with metabolic and functional outcomes; still represents multimodal Pilates
Uçgul et al. (2026)	Women with prediabetes and T2DM	Prediabetes/T2DM	**n=90; group 1 (n=30) group 2 (n=30) group 3 (n=30)**	Pilates combined with physical-activity vs counselling vs comparator	12 weeks	Metabolic/body-composition measures; physical activity; functional capacity; balance; step counts	No significant between-group metabolic/body-composition differences; physical activity, functional capacity, balance and step counts improved	Provides important contrasting evidence; functional/activity benefits were more consistent than metabolic effects

POTENTIAL MECHANISMS LINKING CORE STRENGTHENING TO METABOLIC HEALTH

Several physiological pathways may explain the metabolic effects observed following core- and trunk-focused exercise. Skeletal-muscle contraction provides one of the most direct links between exercise and glucose regulation. Muscle contraction stimulates glucose uptake through translocation of glucose transporter type 4 (GLUT4) to the cell membrane via pathways that are partly independent of insulin. Repeated activation of the abdominal, paraspinal and other trunk-stabilizing muscles during core exercise may consequently increase local glucose utilization during exercise. Although the total muscle mass activated during isolated trunk exercise is smaller than that involved in activities such as walking or cycling, repeated muscular contraction may still contribute to overall glucose disposal.

Improved insulin sensitivity and glucose regulation may represent another pathway. Regular exercise can enhance skeletal-muscle glucose transport, mitochondrial function and insulin responsiveness. In the core-focused studies included in this review, improvements in fasting glucose, insulin and HOMA-IR have been reported following structured training, including the study by Yiğiter et al. These findings are consistent with improved metabolic regulation; however, they cannot establish that the response resulted specifically from trunk-muscle activation, since improvements in insulin sensitivity are well-recognized effects of exercise more broadly.[11,12]

Body composition and central adiposity may also influence the relationship between core-focused exercise and metabolic health. Central or abdominal adiposity is closely associated with insulin resistance and adverse metabolic profiles. Several core-focused interventions have reported reductions in body weight, BMI, body-fat measures or abdominal circumferences alongside improvements in metabolic outcomes. Nevertheless, these findings do not establish that core exercise selectively reduces visceral or abdominal fat, and changes in body composition may also reflect increased overall physical activity and energy expenditure.[2]

From a functional perspective, the trunk provides a stable foundation for movement of the extremities.Core-focused training has been associated with improvements in trunk strength and endurance, balance, gait, proprioception,functional performance and, in some studies, cardiorespiratory fitness. Such adaptations may be clinically relevant for individuals with prediabetes or T2DM, particularly when reduced physical capacity limits participation in regular exercise. Better trunk control and physical function may facilitate everyday movement and improve the ability to participate in other forms of structured physical activity.[15–19]

An additional indirect pathway may arise through increased overall physical activity. Improvements in trunk stability, balance and exercise tolerance could make movement more comfortable and physically manageable, potentially encouraging greater participation in daily and structured activities. Consequently, some of the metabolic benefits observed after core-focused programmes may reflect not only the direct effects of muscular contraction but also increases in total physical activity and exercise adherence.

These pathways provide a plausible physiological framework linking core-focused exercise with metabolic health. These mechanisms should not be presented as mechanisms uniquely established for core strengthening. The current evidence supports their biological plausibility, but direct mechanistic studies examining how isolated core exercise alters glucose metabolism remain limited.

CLINICAL IMPLICATIONS AND EXERCISE PRESCRIPTION

The current evidence suggests that core- and trunk-focused strengthening may be considered a complementary exercise strategy for individuals with prediabetes and T2DM rather than a replacement for established aerobic and whole-body resistance exercise. One practical advantage is accessibility: many core exercises can be performed with body weight or minimal equipment and may therefore be implemented in physiotherapy departments, community programmes and home-based settings. The ABON programme investigated by Sudhan et al. was specifically designed as a simple abdominal-strengthening approach.[13]

The findings of the available core-focused studies also provide preliminary guidance regarding practical exercise prescription. Across the included studies, supervised exercise performed approximately three times per week appears to be the most consistently supported frequency. Intervention duration ranged from 6 to 12 weeks, with approximately 20–30 minutes of dedicated core exercise per session appearing feasible when core strengthening was the primary intervention. In studies in which core exercises were incorporated into a broader rehabilitation programme, such as the study by Pavana et al., total session duration was longer because additional components were included.These findings provide a reasonable basis for clinical implementation, although they do not establish an optimal training dose.[13,14,17,18]

The exercise programmes also demonstrate the importance of progressive overload and controlled execution rather than relying solely on increasing exercise volume. Sudhan et al. progressively increased abdominal exercise repetitions from an initial three sets of 10 repetitions.[13] Yiğiter et al. progressively modified exercise duration, sets, repetitions and rest intervals.[14] Similarly, Arkate et al. progressively increased exercise difficulty and workload.[17] Kaur et al. found that a 30-minute programme performed three times per week for six weeks was more favourable than the lower-frequency or shorter-duration alternatives investigated.[18] Collectively, these findings support beginning with activation and stabilization exercises and progressively advancing towards bridging, controlled limb movements, planks and side planks, dynamic trunk exercises and more functionally demanding movements.Exercise difficulty can be increased gradually through changes in repetitions, duration, sets, lever length, movement complexity or external resistance according to the individual's ability

From a clinical perspective, as depicted in Table 2, an evidence-informed approach would therefore be to

prescribe core-focused exercise two to three times per week, progressing towards three supervised sessions per week, with approximately 20–30 minutes of dedicated core training per session for at least 6–8 weeks and potentially up to 12 weeks. Exercise selection should emphasize activation of the deep trunk musculature, maintenance of lumbopelvic control and gradual progression towards exercises requiring greater trunk stabilization and functional integration. Such an approach may be particularly useful as an adjunct to established aerobic and resistance exercise rather than as a replacement for them. This proposed progression represents an evidence-informed clinical framework derived from the available studies and should not be interpreted as a validated optimal protocol.

Progression should be individualized and clinically monitored, particularly in individuals who are previously sedentary or have reduced physical capacity. Proper technique and controlled movement should be prioritized over high exercise volume.

From evidence perspective, the potential benefits of core-focused exercise extend beyond glycemic outcomes. Improvements in trunk endurance, balance, gait, proprioception and functional capacity may help individuals perform daily activities more effectively and may facilitate continued participation in physical activity. These functional benefits could be particularly valuable in people whose physical limitations reduce their ability to engage consistently in conventional exercise programmes.[15–19]

Table 2: Evidence-Informed Core Exercise Dosage, Progression, and Expected Outcomes

Component	Evidence-informed approach
Frequency	2–3 sessions/week, progressing toward 3
Duration	20–30 min
Programme duration	6–8 weeks initially to 12
Initial focus	Activation/stabilization/breathing/control
Progression	Repetitions, duration, sets, complexity, lever length or resistance
Exercises	Bridging, controlled limb movements, planks, side planks, trunk stabilization, functional movements
Integration	Aerobic exercise and whole-body resistance training
Monitoring	Technique, perceived exertion, functional tolerance, adherence and clinical status
Expected outcomes	Potential glycemic, muscular endurance, balance, function and capacity improvements

This framework should be interpreted as an evidence-informed clinical approach rather than a validated optimal prescription. The heterogeneity of existing studies prevents the establishment of a definitive frequency, intensity or duration for core-focused exercise in prediabetes or T2DM. Future controlled trials using standardized core-training protocols are needed to determine the dose and progression most likely to produce clinically meaningful metabolic and functional benefits.

Table 3: Evidence-derived progression of core exercise

Training phase	Main objective	Exercise emphasis	Suggested progression
Phase 1 – Activation	Establish trunk muscle activation and lumbopelvic control	Abdominal activation, controlled abdominal contractions, basic stabilization	Begin with low repetitions and short-duration holds; emphasize technique
Phase 2 – Stabilization	Improve trunk endurance and postural control	Bridging, controlled limb movements, modified plank	Increase repetitions and hold duration gradually
Phase 3 – Advanced stabilization	Increase demand on trunk musculature	Plank, side plank, reverse bridge, dynamic stabilization	Progress exercise difficulty, sets and hold duration
Phase 4 – Dynamic control	Develop trunk control during movement	Trunk rotation, dynamic abdominal exercises, coordinated limb–trunk movements	Increase movement complexity and reduce rest intervals
Phase 5 – Functional integration	Transfer trunk control to functional movement	Whole-body exercises requiring sustained trunk stabilization	Progress according to individual capacity, fatigue and movement quality

CURRENT LIMITATIONS AND RESEARCH GAPS

Although the emerging findings are encouraging, the evidence base remains relatively small and heterogeneous. Studies differ substantially in participant characteristics, intervention content, exercise duration, frequency, supervision and outcome assessment.[13,14,16,17,18,19] These differences make direct comparison difficult and limit confidence in any specific dose-response relationship.

A particularly important distinction is between direct core or abdominal strengthening and broader Pilates interventions. Sudhan et al. investigated a specific abdominal-strengthening programme,[13] while Yiğiter et al. investigated a structured core-exercise programme.[14] In contrast, Pilates-based interventions may involve multiple physical components beyond core strengthening.[18,19,33] Consequently, Pilates evidence should be considered closely related supporting evidence rather than proof of an isolated core-muscle effect.

The small sample sizes and relatively narrow study populations in several investigations also limit generalizability. Some studies have focused on specific populations, including predominantly women with prediabetes, making it difficult to determine whether the findings apply consistently across different ages, sexes, disease stages and baseline fitness levels.There is a lack of larger randomized controlled trials with diverse populations to examine whether responses differ according to age, sex, obesity status, diabetes duration and baseline glycemic control.

Exercise dose remains incompletely established. Although Kaur et al. identified a favourable 30-minute, three-times-weekly protocol within their study,[18] there is insufficient evidence to establish the optimal intensity, duration, frequency or progression of core strengthening for metabolic outcomes. The absence of long-term follow-up is an additional limitation because most available interventions have lasted several weeks to a few months.[13,14,16,18,19,33] It remains unclear whether improvements in HbA1c, insulin resistance and body composition can be maintained after supervised training ends.

Recent evidence also demonstrates that not all Pilates-based interventions produce significant metabolic improvements. Uçgul et al. studied 90 women with prediabetes and T2DM randomized to Pilates plus physical-activity counselling, physical-activity counselling alone or standard treatment. After 12 weeks, no significant between-group differences were observed in metabolic or body-composition outcomes, although improvements were found in physical activity, functional capacity, balance and step counts.[34] This contrasting finding is important because it demonstrates that positive metabolic effects should not be assumed for every Pilates-based programme.

FUTURE DIRECTIONS

Future research should establish whether core strengthening produces metabolic benefits that are independent of, or additive to, those achieved through conventional aerobic and resistance exercise. Well-designed randomized controlled trials should compare standardized core-strengthening programmes with usual care, conventional resistance training and combined exercise programmes. Such comparisons would help determine whether core strengthening provides a unique metabolic stimulus or primarily represents another accessible form of resistance exercise.

Intervention protocols should clearly describe exercise selection, intensity, number of repetitions or duration, progression, frequency and total programme duration. This would allow replication and facilitate comparison between studies.

Longer follow-up is necessary to establish whether improvements in glycemic control are sustained. Future studies should additionally investigate adherence, feasibility and patient acceptability because the clinical value of an exercise intervention depends not only on efficacy but also on its ability to be maintained over time. Studies combining metabolic outcomes with measures of muscle activation, insulin sensitivity, body composition and physical activity could help determine how core-focused exercise influences systemic metabolism.

CONCLUSION

Core- and trunk-focused exercise represents a promising adjunctive strategy within exercise programmes for individuals with prediabetes and type 2 diabetes mellitus (T2DM). The available evidence suggests that core exercise may contribute to improvements in glycemic regulation, insulin sensitivity, body composition, muscular fitness and physical function. These effects are physiologically plausible through pathways involving skeletal-muscle glucose uptake, insulin sensitivity and improvements in physical capacity.

However, the evidence should be interpreted with appropriate caution. Small samples, heterogeneous exercise protocols, limited follow-up and the multimodal nature of many interventions emphasize the need for larger and longer-term randomized controlled trials using standardized core-focused protocols and appropriate controls.

Until stronger evidence is available, core-focused exercise may reasonably be considered a practical and accessible component of comprehensive exercise management for prediabetes and T2DM, with exercise prescription individualized according to functional capacity, tolerance and clinical needs.

REFERENCES

1. American Diabetes Association Professional Practice Committee. 5. Facilitating positive health behaviors and well-being to improve health outcomes: Standards of Care in Diabetes—2026. Diabetes Care. 2026;49(Suppl 1):S89-S131. doi:10.2337/dc26-S005.Full article / PMC | DOI
2. DeFronzo RA, Tripathy D. Skeletal muscle insulin resistance is the primary defect in type 2 diabetes. Diabetes Care. 2009;32(Suppl 2):S157-S163. doi:10.2337/dc09-S302.PubMed | DOI
3. International Diabetes Federation. IDF Diabetes Atlas. 11th ed. Brussels: International Diabetes Federation; 2025.IDF Diabetes Atlas – 11th edition | NCBI Bookshelf edition
4. Colberg SR, Sigal RJ, Yardley JE, Riddell MC, Dunstan DW, Dempsey PC, et al. Physical Activity/Exercise and Diabetes: A Position Statement of the American Diabetes Association. Diabetes Care. 2016;39(11):2065-2079. doi:10.2337/dc16-1728.PubMed | Full text / PMC | DOI
5. Akuthota V, Ferreiro A, Moore T, Fredericson M. Core stability exercise principles. Curr Sports Med Rep. 2008;7(1):39-44. doi:10.1097/01.CSMR.0000308663.13278.69.DOI / article
6. Akuthota V, Nadler SF. Core strengthening. Arch Phys Med Rehabil. 2004;85(3 Suppl 1):S86-S92. doi:10.1053/j.apmr.2003.12.005.ScienceDirect article
7. Kibler WB, Press J, Sciascia A. The role of core stability in athletic function. Sports Med. 2006;36(3):189-198. doi:10.2165/00007256-200636030-00001.PubMed | DOI
8. Standaert CJ, Herring SA. Expert opinion and controversies in musculoskeletal and sports medicine: core stabilization as a treatment for low back pain. Arch Phys Med Rehabil. 2007;88(12):1734-1736. doi:10.1016/j.apmr.2007.10.002.PubMed | DOI
9. Willson JD, Dougherty CP, Ireland ML, Davis IM. Core stability and its relationship to lower extremity function and injury. J Am Acad Orthop Surg. 2005;13(5):316-325. doi:10.5435/00124635-200509000-00005.PubMed | DOI / article

10. Bruno P. The use of “stabilization exercises” to affect neuromuscular control in the lumbopelvic region: a narrative review. J Can Chiropr Assoc. 2014;58(2):119-130. PMID:24932016.PubMed
11. Holloszy JO. Exercise-induced increase in muscle insulin sensitivity. J Appl Physiol (1985). 2005;99(1):338-343. doi:10.1152/japplphysiol.00123.2005.PubMed | DOI / article
12. Sylow L, Kleinert M, Richter EA, Jensen TE. Exercise-stimulated glucose uptake—regulation and implications for glycaemic control. Nat Rev Endocrinol. 2017;13(3):133-148. doi:10.1038/nrendo.2016.162.DOI / article
13. Sudhan SG, Haripriya S, Arun B, Jency JM, Sivakumar C. Effect of an Abdominal Muscle Strengthening Program on Blood Glucose Levels in Persons with Type II Diabetes Mellitus. J Clin Diagn Res. 2018;12(8):YC01-YC04. doi:10.7860/JCDR/2018/29943.11852.DOI / article
14. Yiğiter N, Akçınar F, Yasul Y, Çınar V, Akbulut T, Migliaccio GM. Core Exercise as Non-Pharmacological Strategy for Improving Metabolic Health in Prediabetic Women. Medicina (Kaunas). 2025;61(5):942. doi:10.3390/medicina61050942.Full article | DOI
15. Battesha HNM, Ahmed GM, Amer HA, El Gohary AM, Ragab WM. Effect of core stability exercises and desensitisation therapy on limit of stability in diabetic peripheral neuropathy patients. Int J Ther Rehabil. 2018;25(3):128-134. doi:10.12968/ijtr.2018.25.3.128.DOI / article
16. Pavana, Nair Anjali Premrajan, Ghosh A. Effectiveness of Core Stability Exercise and Proprioception Exercise on Balance in Subjects with Diabetic Neuropathy—A Randomized Controlled Trial. Indian J PhysiotherOccup Ther. 2021;15(3):81-89. doi:10.37506/ijpot.v15i3.16166.Publisher article | DOI
17. Arkate S, Parulekar P, Fernandes O. Effects of Core Strengthening Exercises on Cardiorespiratory Fitness in Type 2 Diabetics. Int J Sci Res. 2024. doi:10.36106/ijsr/2303194.DOI / article
18. Kaur J, Singh SK, Vij JS. Optimization of Efficacy of Core Strengthening Exercise Protocols on Patients Suffering from Diabetes Mellitus. Rom J Diabetes NutrMetab Dis. 2018;25(1):23-36. doi:10.2478/rjdnmd-2018-0003.Publisher article | DOI
19. Ebrahimi F, Mahdavinejad R, Jalily HR. The Effects of Selected Pilates Exercises on Muscle Strength, Balance and HbA1c in Female Patients with Diabetes Type 2. Sport Sciences and Health Research. 2015;7(2):251-265. doi:10.22059/jsmed.2015.56563.DOI / article
20. Zolfaghari N, Faramarzi M, Afkhami-Ardekani M, Jazi AA, Afkhami-Ardekani A, Ashkezari SJ. The Effect of Eight Weeks Pilates Exercise on Testosterone and Sex Hormone Binding Globulin (SHBG) in Women with Type 2 Diabetes. Iran J Diabetes Obes. 2015;7(2):45-49.Article record
21. Khormizi SAT, Azarniveh MS. The effect of Pilates exercise on glycemic control and weight loss in obese women with type 2 diabetes. Kinesiology. 2017;10:68-73.
22. Yucel H, Uysal O. Pilates-Based Mat Exercises and Parameters of Quality of Life in Women With Type 2 Diabetes. Iran Red Crescent Med J. 2016;18(3):e21919. doi:10.5812/ircmj.21919.Article / DOI
23. Ruiz-Ariza B, Aibar-Almazán A, Hita-Contreras F, Castellote-Caballero Y, Carcelén-Fraile MDC. Pilates-Based Exercise and Its Impact on Nutritional Status and Health-Related Quality of Life in Older Adults with Type 2 Diabetes: A Randomized Controlled Trial. Diagnostics (Basel). 2025 Nov 18;15(22):2913. doi: 10.3390/diagnostics15222913. PMID: 41300937; PMCID: PMC12651460.
24. Batar N, Kermen S, Sevdin S, Ersin A, San S, Genco Erdem M, Pulat Demir H, Guclu D. Effect of Pilates on Body Composition and Some Biochemical Parameters of Women with Type 2 Diabetes on a Low-Carbohydrate or High-Complex-Carbohydrate Diabetic Diet. Iranian Red Crescent Medical Journal (IRCMJ). 2020;22(6):e188880.
25. Cui P, Wang B, Chang L. The effect of Pilates training combined with diet management on the debilitating state and blood sugar of elderly patients with type 2 diabetes. Chin J Geriatr Care. 2020;18(5):14-16.
26. Abd El-Monim YM, El-Nahas NG, Hakem SA. Effect of Pilates Exercise on Cardio Metabolic Risk Factors in Women with Type 2 Diabetes. Med J Cairo Univ. 2019;87(1):851-857. doi:10.21608/mjcu.2019.52630.DOI / article
27. Melo KCB, Araújo FS, Cordeiro Júnior CCM, Andrade KTP, Moreira SR. Pilates Method Training: Functional and Blood Glucose Responses of Older Women With Type 2 Diabetes. J Strength Cond Res. 2020;34(4):1001-1007. doi:10.1519/JSC.0000000000002704.PubMed | DOI
28. Chen Z, Ye X, Xia Y, Song H, Wang Y, Guan Y, Shen Z, Chen W, Jiang T, Wu H, Xu X. Effect of Pilates on Glucose and Lipids: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Front Physiol. 2021;12:641968. doi:10.3389/fphys.2021.641968.Full article | PubMed | DOI
29. Mir E, Fathi M. Changes in Plasma Visfatin and Insulin Resistance Index in Obese Women with Type 2 Diabetes after Pilates Exercise. J Health Care. 2018;20(1):30-39. doi:10.29252/jhc.20.1.30.DOI / article
30. Sharma D, Kaur J, Rani M, Bansal A, Malik M, Kulandaivelan S. Efficacy of Pilates Based Mat Exercise on Quality of Life, Quality of Sleep and Satisfaction with Life in Type 2 Diabetes Mellitus.

Rom J Diabetes NutrMetab Dis. 2018;25(2):149-156. doi:10.2478/rjdnmd-2018-0017.DOI / article

31. Hassani N, Heravi-Karimooi M, Rejeh N, Danesh Ashtiani MH, Sharifnia H, Ghanbari M, MohammadiNejad M. The effect of Pilates exercise on quality of life of elderly women with type 2 diabetes. Payesh. 2018;17(5):531.PEDro article record
32. Vasconcelos Gouveia SS, Pertinni de Morais Gouveia G, Souza LM, Cunha da Costa B, Iles B, Pinho VA, Vasconcelos SS, Rolim Medeiros JV, Lago da Silva R, Porto Pinheiro LG. The effect of pilates on metabolic control and oxidative stress of diabetics type 2 - A randomized controlled clinical trial. J Bodyw Mov Ther. 2021 Jul;27:60-66. doi: 10.1016/j.jbmt.2021.01.004. Epub 2021 Jan 21. PMID: 34391294.
33. Karaman A, Angın E. Effects of clinical Pilates exercises on glycemic control, blood lipids, and physical fitness parameters in women with prediabetes: a randomized controlled trial. Physiother Theory Pract. 2026;42(4):528-541. doi:10.1080/09593985.2025.2591158.PubMed | Full article – Taylor & Francis | DOI
34. Uçgul MŞ, Tarakcı E, Kus G, Shalaby NB. Effectiveness of physical activity counseling and PILATES exercises in women with prediabetes and type 2 diabetes: a randomized controlled trial. Physiother Theory Pract. 2026; online ahead of print:1-15. doi:10.1080/09593985.2026.2654807.PubMed | Full article – Taylor & Francis | DOI