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EFFECTIVENESS OF A SELF-STRETCHING EXERCISE PROGRAM ON DAYTIME SLEEPINESS IN ADULTS WITH RESTLESS LEG SYMPTOMS IN TYPE 2 DIABETES MELLITUS: A PRE-POST INTERVENTIONAL STUDY

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Abstract

Background: *Daytime sleepiness negatively affects daily functioning and overall health especially in Type 2 Diabetes Mellites with restless leg syndrome. While physical activity is known to influence sleep regulation, limited evidence exists regarding the effect of stretching exercises on daytime sleepiness.*

Objective: *To assess the effectiveness of a stretching exercise program in reducing daytime sleepiness in type 2 diabetes mellites patients with restless leg symptoms measured by the Epworth Sleepiness Scale (ESS).*

Methods: *This experimental study included 200 adults of type 2 diabetes mellites presenting with daytime sleepiness who suffered from restless leg symptoms. Participants completed a structured stretching program over a four week period. Daytime sleepiness was evaluated using the Epworth Sleepiness Scale before and after the intervention. Statistical analysis was performed using SPSS version 25.0, and pre–post differences were analyzed with significance set at $p < 0.05$.*

Results: *Epworth Sleepiness Scale scores showed a statistically significant reduction following the stretching intervention (12.30 ± 6.60 to 7.81 ± 4.90; $p<0.001$), indicating improvement in daytime alertness. A noticeable reduction in the number of participants categorized with moderate to severe daytime sleepiness was observed post-intervention.*

Conclusion:

Stretching exercises were effective in reducing daytime sleepiness in diabetes mellites type 2 patients suffering from restless leg symptoms. Given their simplicity and accessibility, stretching exercises may be incorporated as a non-pharmacological approach to improve daytime alertness and well-being.

INTRODUCTION

Excessive daytime sleepiness (EDS) is a frequent complaint among adults with type 2 diabetes mellitus (T2DM) suffering from restless leg symptoms and can meaningfully affect safety, productivity, and quality of life. Beyond subjective tiredness, EDS reflects reduced daytime alertness that can impair attention, increase risk of road-traffic incidents, and reduce adherence to lifestyle behaviors fundamental to

diabetes self-management. Epidemiologic and clinic-based studies indicate that a substantial proportion of people with T2DM report clinically relevant sleepiness, and that sleepiness often co-occurs with poor sleep quality and short or fragmented sleep usually due to restless leg symptoms. (Medeiros et al., 2013; Yusuf et al., 2022, Mehmood et al., 2025).

The etiology of EDS in T2DM is typically multifactorial. Obesity and sleep-disordered breathing are major contributors; in particular, untreated obstructive sleep apnea (OSA) can worsen glucose regulation and promote fatigue through intermittent hypoxia and sleep fragmentation. In addition to OSA, sleepiness in T2DM may be influenced by nocturnal symptoms, autonomic imbalance, depression or stress, medication effects, restless leg symptoms, and co-existing pain conditions. Recent work has highlighted that specific aspects of sleep, especially sleep efficiency and sleep continuity, are strongly associated with glycemic outcomes, suggesting that interventions that improve consolidated sleep could have downstream benefits on daytime function (Aronsohn et al., 2010; Brouwer et al., 2020; Bloomgarden, 2023, Mehmood et al., 2025).

Standardized measurement is essential when evaluating EDS because self-perceived fatigue and sleepiness may overlap but are not identical. The Epworth Sleepiness Scale (ESS) is a commonly used patient-reported measure that quantifies the likelihood of dozing across everyday situations, generating a total score from 0 to 24. Contemporary psychometric evidence supports the ESS as a predominantly one-dimensional measure of sleepiness, and reliability-generalization findings indicate that internal consistency is generally acceptable across settings. Moreover, test–retest investigations in intervention contexts suggest that the ESS is sufficiently stable to detect clinically meaningful change over time, supporting its use as an outcome in behavioral programs that aim to improve sleep and daytime alertness. (Gonçalves et al., 2023; Lapin et al., 2018; Rosenberg et al., 2022).

Non-pharmacological approaches are attractive in T2DM because they can be delivered alongside routine care, have favorable safety profiles, and support broader cardiometabolic goals. Lifestyle guidance for T2DM includes physical activity and exercise prescriptions, which may improve sleep and reduce daytime sleepiness through a combination of circadian, neuroendocrine, and psychological pathways. Importantly, exercise may not only reduce EDS indirectly via weight and cardiometabolic improvements, but also directly by improving sleep continuity and lowering hyperarousal. Recent review-level evidence in sleep medicine further supports a positive impact of regular physical activity on sleep quality and symptoms of sleep disorders. (Colberg et al., 2016; Korkutata et al., 2025).

Stretching-based programs deserve attention because they are low-impact, inexpensive, and feasible as home-based self-management strategies for middle-aged adults with chronic disease. Stretching may promote relaxation and reduce somatic tension before bedtime, potentially improving sleep initiation and reducing nocturnal awakenings. Telehealth-delivered stretching trials in chronic pain conditions and pragmatic exercise programs delivered with simple protocols in local settings have demonstrated feasibility and benefits on patient-reported outcomes, supporting the practicality of stretching interventions in resource-constrained contexts. (Andrade et al., 2023; Munir et al., 2023; Ahmed et al., 2024).

Despite growing international evidence on the sleep–diabetes relationship specifically with respect to restless leg symptoms, local data from South Punjab on whether a structured self-stretching program can reduce ESS-measured daytime sleepiness in adults with T2DM remain scarce. Accordingly, this study evaluated the effectiveness of a 4-week home-based self-stretching exercise program on daytime sleepiness severity in diabetes type 2 with restless leg symptoms as measured by the ESS in a hospital-based T2DM sample. We hypothesized that participants would demonstrate a significant reduction in ESS total score after completing the

stretching program, reflecting improved daytime alertness and functional capacity. (Tan & Benedict, 2020; Yang et al., 2021).

Methods

Study design and setting: An experimental, single-group pre–post interventional design was applied. The study was conducted at District Headquarter Hospital Lodhran and Bahawal Victoria Hospital (BVH), Bahawalpur, Pakistan. Data collection was completed within approximately three months after ethical clearance, encompassing recruitment, baseline assessment, delivery of the stretching program, and post-intervention reassessment.

Sampling and sample size. A convenience, non-probability sampling technique was used. The target sample size, calculated using G*Power 3.0 software, was 200 adults with T2DM attending outpatient services. Recruitment continued until the intended sample was achieved within the study timeframe.

Eligibility criteria. Participants were eligible if they were 40–59 years of age, had confirmed type 2 diabetes mellitus, HbA1c > 6.5%, and provided informed consent. Participants were excluded if they had type 1 diabetes, nephropathy, clinically significant heart disease, a recent history of trauma, major musculoskeletal conditions limiting safe stretching, or diabetic neuropathy. Exclusions were applied to reduce clinical confounding and to improve safety during home-based exercise.

Intervention procedure. After consent, baseline assessments were completed and the Epworth Sleepiness Scale (ESS) was administered as the primary outcome. Participants then received a standardized home-based self-stretching exercise program demonstrated by a physiotherapist. The routine targeted lower-limb and lumbopelvic muscle groups (e.g., gastrocnemius–soleus, hamstrings, quadriceps, hip flexors) using slow, controlled stretches within a comfortable range. Each session required approximately 15–20 minutes and was performed on most days of the week (typically 5 days/week) for four weeks. Participants were instructed to breathe normally, avoid ballistic movements, and stop the routine if unusual pain or adverse symptoms occurred. Adherence was supported through brief follow-up contacts and a simple self-report log, consistent with pragmatic home-exercise delivery models. (Colberg et al., 2016; Munir et al., 2023).

Outcome measure: Daytime sleepiness severity was measured with the Epworth Sleepiness Scale (ESS), scored from 0 to 24. The ESS was selected because it is widely used and demonstrates acceptable psychometric properties, including a predominantly one-factor structure and stable measurement properties suitable for detecting change over time in intervention settings. For descriptive reporting, ESS scores were also categorized into commonly used clinical severity bands; however, hypothesis testing focused on change in total score. (Gonçalves et al., 2023; Lapin et al., 2018; Rosenberg et al., 2022).

Statistical analysis: Analyses were performed using SPSS version 25.0. Continuous variables were summarized using mean ± standard deviation, and categorical variables using frequencies and percentages. The primary analysis evaluated within-participant change in ESS total score from baseline to post-intervention using a paired-samples t-test with a two-tailed significance threshold of $p < 0.05$ and 95% confidence intervals for the mean difference. Where appropriate, paired-samples effect size (Cohen's d) was calculated. Changes in categorical ESS severity distribution were explored using chi-square-based procedures appropriate for paired categorical outcomes.

Ethical considerations: Ethical approval was obtained from the relevant institutional and hospital review committees prior to data collection. Participants provided written informed consent. Data were anonymized and stored securely to protect confidentiality. Exercise instruction was delivered in a gender-sensitive manner where feasible to maximize participant comfort and privacy.

Results

Participant characteristics

A total of 200 adults with type 2 diabetes mellitus facing restless leg symptoms were analyzed for changes in daytime sleepiness following the self-stretching exercise program. The sample included 97 males (48.5%) and 103 females (51.5%). The mean age was 50.76 ± 5.54 years, with participant ages ranging from 40 to 59 years. There were no missing cases in the ESS analyses, and all paired comparisons were performed on complete pre- and post-intervention observations (N = 200).

Table 1. Baseline characteristics (N = 200)

Variable	Value
Male, n (%)	97 (48.5)
Female, n (%)	103 (51.5)
Age (years), mean ± SD	50.76 ± 5.54
Age range (years)	40–59

Change in overall Epworth Sleepiness Scale (ESS) score

The primary outcome was the change in total Epworth Sleepiness Scale (ESS) score. Mean ESS decreased from 12.30 ± 6.60 at baseline to 7.81 ± 4.90 at follow-up, reflecting an absolute reduction of 4.49 points and an approximate 36.5% decrease in average daytime sleepiness. The paired-samples t-test demonstrated that this reduction was statistically significant ($t(199) = 10.804$, $p < .001$), with a 95% confidence interval for the mean change ranging from 3.67 to 5.31 points. Using the paired-samples standardized mean change (Cohen's dz), the magnitude of improvement was moderate to large ($dz = 0.76$), indicating a clinically meaningful shift in daytime sleepiness levels at the group level.

Pre- and post-intervention ESS scores were moderately correlated ($r = 0.511$, $p < .001$), suggesting that participants who reported higher sleepiness at baseline tended to remain relatively higher compared with peers after the intervention, even though most participants exhibited improvement.

Table 2. Paired comparison of ESS total score (N = 200)

Outcome	Pre (Mean)	Pre (SD)	Post (Mean)	Post (SD)	Mean difference	95% CI	t (df), p
Total ESS score	12.30	6.604	7.81	4.901	4.490	3.670 to 5.310	10.804 (199), $p < .001$

Change in ESS sleepiness severity categories

To provide clinically interpretable findings, total ESS scores were also categorized into severity levels (Normal, Mild, Moderate, and Severe sleepiness). At baseline, 78 participants (39.0%) were classified as Normal, while 122 participants (61.0%) fell into non-normal categories (mild/moderate/severe). Following the intervention, 137 participants (68.5%) were classified as Normal and 63 (31.5%) remained in non-normal categories, indicating a substantial overall shift toward lower daytime sleepiness severity.

Notably, the Severe sleepiness category decreased from 54 participants (27.0%) at baseline to 4 participants (2.0%) at follow-up, representing a marked reduction in the most symptomatic category. The overall pre-post category distribution changed significantly (Pearson $\chi^2 = 46.314$, $df = 9$, $p < .001$), supporting that the

intervention was associated with movement to lower severity classifications.

Table 3. ESS severity categories before and after intervention

ESS category	Pre, n (%)	Post, n (%)
Normal	78 (39.0)	137 (68.5)
Mild sleepiness	51 (25.5)	44 (22.0)
Moderate sleepiness	17 (8.5)	15 (7.5)
Severe sleepiness	54 (27.0)	4 (2.0)

Table 4. Transition of ESS severity categories from baseline to follow-up (counts)

Pre category	Post: Normal	Post: Mild	Post: Moderate	Post: Severe
Normal	68	9	1	0
Mild sleepiness	26	22	3	0
Moderate sleepiness	8	6	3	0
Severe sleepiness	35	7	8	4

The transition matrix (Table 4) demonstrates that improvements occurred across all baseline severity strata. Among participants classified as Severe at baseline (n = 54), 35 individuals (64.8%) moved into the Normal category at follow-up, while only 4 (7.4%) remained Severe. Participants categorized as Mild at baseline (n = 51) also frequently shifted to Normal at follow-up (n = 26, 51.0%). Even those with Moderate sleepiness at baseline (n = 17) showed movement toward lower severity categories, with nearly half reclassified as Normal (n = 8, 47.1%).

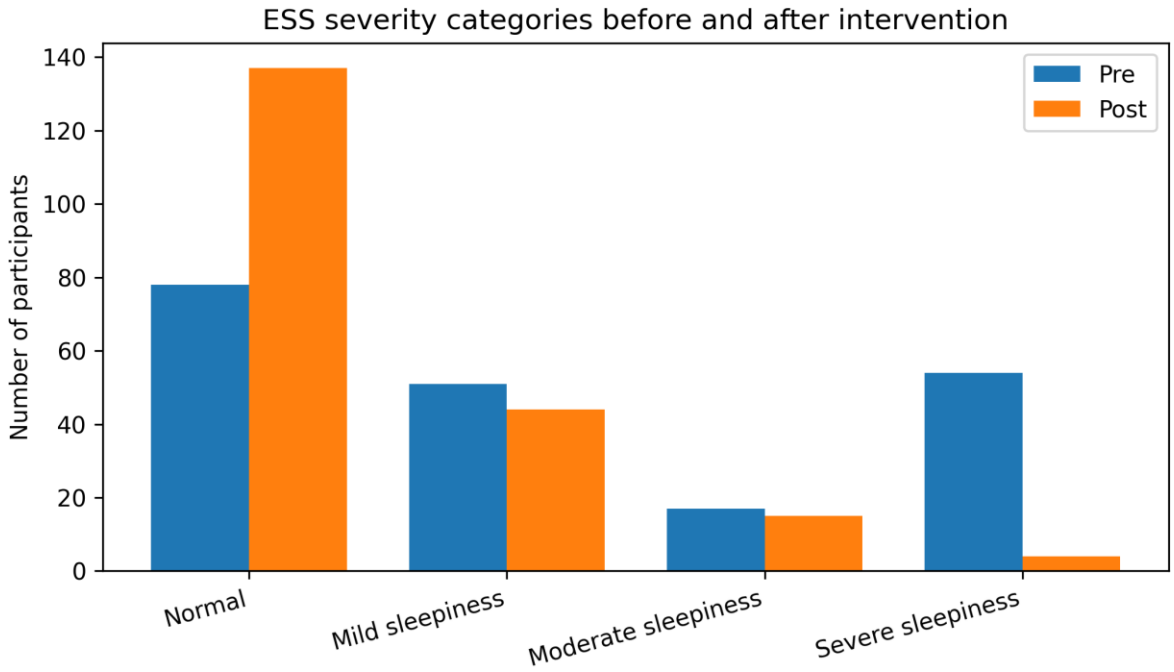

Figure 1. Distribution of ESS severity categories before and after the intervention.

Item-wise changes across ESS situations

Beyond total ESS score, item-level analyses examined whether the likelihood of dozing changed across the eight daily situations assessed by the ESS. For each situation, response distributions (Never, Slight, Moderate, High chance of dozing) differed significantly between baseline and follow-up, indicating that the observed improvement extended across multiple contexts of everyday life rather than being confined to a single sedentary activity (Table 5).

Table 5. Item-wise pre–post differences (Pearson χ^2 tests)

ESS situation	χ^2	p-value
Sitting and reading	60.222	< .001
Watching TV	73.224	< .001
Sitting inactive in a public place	67.094	< .001
Passenger in a car for an hour	63.474	< .001
Lying down to rest in the afternoon	54.756	< .001
Sitting and talking to someone	41.021	< .001
Sitting quietly after lunch (no alcohol)	64.095	< .001
In a car, stopped in traffic	30.430	< .001

Across situations, the largest χ^2 values were observed for watching TV and sitting quietly after lunch, reflecting robust redistribution of responses away from higher dozing probability categories at follow-up. Even for the least extreme shift (stopped in traffic), the pattern remained statistically significant, suggesting consistent improvement across the ESS item set.

Table 6. Direction of change by ESS situation (percent of participants)

ESS situation	"Never doze" Pre → Post (%)	"High chance of dozing" Pre → Post (%)
Sitting and reading	22.0 → 38.5	32.5 → 5.5
Watching TV	23.0 → 32.0	31.5 → 7.5
Sitting inactive in a public place	22.5 → 30.0	31.5 → 9.5
Passenger in a car for an hour	18.5 → 36.0	30.5 → 13.0
Lying down to rest in the afternoon	16.5 → 32.5	32.5 → 13.5
Sitting and talking to someone	28.5 → 39.5	25.5 → 10.0
Sitting quietly after lunch (no alcohol)	34.0 → 46.0	23.0 → 9.5
In a car, stopped in traffic	40.5 → 60.0	17.0 → 3.0

As shown in Table 6, the most notable reductions in the "high chance of dozing" response were observed for sitting and reading (32.5% to 5.5%) and watching TV (31.5% to 7.5%). Meanwhile, "never doze" responses increased most prominently for being stopped in traffic (40.5% to 60.0%) and being a passenger in a car for an hour (18.5% to 36.0%). Collectively, these item-level patterns align with the decrease in the ESS total score and the shift toward Normal classification.

Discussion

This pre–post study evaluated whether a structured self-stretching exercise program could reduce excessive daytime sleepiness (EDS) in adults with type 2 diabetes mellitus (T2DM) facing restless leg symptoms, using the Epworth Sleepiness Scale (ESS) as the primary patient-reported outcome. The results showed a clear improvement in subjective sleepiness after the stretching program. Mean ESS decreased from 12.30 (SD 5.62) at baseline to 7.81 (SD 4.18) post-intervention, yielding a mean reduction of 4.49 points. The paired-samples test indicated this change was statistically significant ($t = 10.804$, $df = 199$, $p < .001$) and the magnitude of improvement is consistent with a moderate-to-large within-subject effect.Beyond the mean score reduction, the categorical findings provide clinically meaningful context. At baseline, a substantial proportion of participants fell into moderate (23%) and severe (27%) sleepiness categories. Post-intervention, the distribution shifted toward healthier levels: normal sleepiness increased from 53% to 63%, moderate sleepiness decreased from 23% to 18%, and severe sleepiness decreased markedly from 27% to 2%. In practical terms, these shifts suggest that many participants moved from a level of daytime impairment likely to affect daily functioning and safety (e.g., dozing risk during sedentary activities) to a more functional range.

EDS in T2DM is common and multifactorial, reflecting the combined influence of sleep restriction/fragmentation, restless leg symptoms, metabolic dysregulation, obesity, medication effects, mood symptoms, and unrecognized sleep disorders; particularly obstructive sleep apnea (OSA). Population-based analyses show that diabetes is associated with higher likelihood of EDS at the community level, highlighting its relevance as a functional problem rather than merely a symptom report (Yusuf et al., 2022). In clinical samples, OSA and restless leg symptoms are especially important because it is highly prevalent in T2DM and is linked to poor glycemic control; importantly, OSA also contributes strongly to EDS through sleep fragmentation and intermittent hypoxemia (Aronsohn et al., 2010; Mehmood et al., 2025). A key implication, therefore, is that improvements in ESS following stretching may reflect a beneficial change in sleep continuity and perceived restoration, but ESS changes should still be interpreted with an awareness that untreated OSA and other comorbid sleep conditions could remain present.

Stretching is a low-cost, low-barrier intervention that can plausibly influence sleepiness through several pathways. First, gentle stretching may reduce musculoskeletal discomfort, nocturnal restlessness, or tension that contributes to difficulty initiating/maintaining sleep, thereby improving sleep continuity and next-day alertness. Second, regular stretching can contribute to autonomic down-regulation, improved relaxation, and stress reduction; factors that are often implicated in sleep onset latency and perceived sleep quality. Third, stretching can function as a form of light physical activity, supporting sleep homeostasis and circadian alignment. A broader mechanistic framework linking sleep/circadian disruption with metabolic regulation supports the idea that improving sleep quality and stability can have downstream benefits for daytime function in diabetes (Reutrakul & Van Cauter, 2014).

Although the stretching literature is still emerging, a recent scoping review mapping chronic stretch training and sleep outcomes concluded that the evidence base remains limited and mixed, with only a subset of included studies showing statistically significant sleep improvements; nonetheless, the overall direction across studies trends toward potential benefits and suggests plausible physiologic mechanisms (Alimoradi Mohammad et al., 2024). The present findings add clinically relevant support to that "possible benefit" signal, specifically for reducing daytime sleepiness, in a metabolic population where sleep disturbances are common and consequential.

The ESS is widely used in both clinical and research settings to quantify subjective daytime sleepiness, and its measurement properties have

been examined across populations and contexts. A systematic review focusing on the measurement properties of the ESS highlighted its broad applicability while emphasizing the importance of context (population, comorbidities, and purpose of screening vs. outcome evaluation) when interpreting scores (Kendzerska et al., 2014). More recent psychometric synthesis work has also evaluated reliability patterns across diverse validations, supporting the continued use of ESS while acknowledging heterogeneity across studies (Gonçalves et al., 2023). In that context, the pre–post improvement observed here is unlikely to be explained purely by measurement noise, particularly given the consistent direction of change and the large shift away from severe sleepiness in the categorical distribution.

Clinical implications

From a practical standpoint, a structured self-stretching program may represent a feasible adjunct strategy for diabetes care settings, especially where access to specialist sleep medicine services is limited. Because EDS can impair adherence, productivity, and quality of life, even moderate improvements may be meaningful at the patient level. However, these findings should not be interpreted as evidence that stretching "treats" the underlying causes of EDS in all individuals with T2DM. Instead, stretching may operate as a supportive behavioral strategy that improves comfort, relaxation, and sleep continuity, thereby reducing next-day sleepiness, while comprehensive assessment for common contributors to EDS (especially OSA) remains important (Aronsohn et al., 2010; Reutrakul & Van Cauter, 2014).

Conclusion

A self-stretching exercise program was associated with a statistically significant and clinically meaningful reduction in daytime sleepiness among adults with T2DM facing restless leg symptoms, evidenced by a marked decrease in mean ESS and a substantial shift from severe sleepiness toward normal sleepiness categories. Stretching may offer a low-cost, scalable supportive intervention to improve daytime functioning in T2DM, particularly in resource-limited settings, while broader sleep disorder screening and metabolic optimization should continue in parallel.

Limitations

This study used a pre–post design without a concurrent control group, so improvements could partially reflect non-specific effects (e.g., attention, expectation, regression to the mean) or concurrent changes in lifestyle/health. Daytime sleepiness was measured using a self-report scale; objective sleep measures (e.g., actigraphy, polysomnography) were not available to verify changes in sleep continuity or to identify untreated sleep disorders such as OSA. Additionally, potential confounders strongly linked to ESS, BMI/obesity, depression/anxiety symptoms, sedating medications, and OSA risk, may not have been fully controlled, which limits causal inference.

Recommendations

Clinically, self-stretching can be considered as an adjunct component of diabetes lifestyle counseling to support sleep-related functioning, particularly for patients reporting tension, discomfort, or sedentary routines. For research, future studies should use randomized controlled designs, include objective sleep indices and OSA screening, measure adherence to the stretching protocol, and examine whether ESS improvements track with metabolic endpoints (e.g., HbA1c) and quality-of-life outcomes over longer follow-up. Stratified analyses (e.g., by obesity, neuropathy symptoms, or baseline ESS severity) may help identify which subgroups benefit most.

Conflict of interest

The authors declare no conflicts of interest.

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