



Exploring the Relationship between Mild Cognitive Impairment, Physical Functioning and Sleep Quality in Middle-Aged Diabetic Women

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Abstract

Background: Diabetes mellitus is known to impact multiple aspects of health, including cognition, sleep, and physical function. Middle-aged women with diabetes may be at particular risk for mild cognitive impairment (MCI), poor sleep quality, and reduced physical activity. This study aimed to identify the relationship between mild cognitive impairment, physical functioning and sleep quality in middle-aged Type 2 diabetic women.

Methods: A cross-sectional survey was conducted among 44 middle-aged diabetic women. Participants were assessed using the Mini-Mental State Examination (MMSE) for cognitive function, the International Physical Activity Questionnaire (IPAQ) for physical activity, and the Pittsburgh Sleep Quality Index (PSQI) for sleep quality. Data were analysed using descriptive statistics, chi-square tests, and independent t-tests to examine relationships between variables.

Results: The study revealed that half of the participants (n=22) were identified with MCI based on MMSE scores (21–24), while the remaining half had normal cognition (25–30). Results showed poor sleep quality was prevalent in 70.5% of participants, with no significant difference in sleep quality between those with normal cognition and those with mild cognitive impairment ($p = 1.000$). Regarding physical activity, most participants (63.6%) exhibited moderate levels of physical functioning, and there was no significant difference in physical activity levels between the two cognitive groups ($p = 0.807$). The findings indicated that poor sleep and low physical activity were common across the sample, but no significant associations were found between cognitive status, sleep quality, or physical functioning.

Conclusion: The study concludes that poor sleep quality and suboptimal physical activity are widespread among middle-aged diabetic women, although no significant relationships were found between cognitive status, sleep quality, and physical functioning. The high prevalence of poor sleep and limited physical activity highlights the need for health interventions in this population.

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Keywords: Diabetes, Mild Cognitive Impairment, Sleep Quality, Physical Activity, Middle-aged Women

1. Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder characterised by elevated blood glucose levels, either due to insulin resistance (Type 2 diabetes mellitus, T2DM) or absolute insulin deficiency (Type 1 diabetes mellitus, T1DM) (WHO, 2023). Among the global population, T2DM is the most prevalent, accounting for approximately 90–95% of all diabetes cases (ADA, 2022). Diabetes is associated with a range of complications, including cardiovascular disease, nephropathy, neuropathy, and

cognitive dysfunction, which significantly affect the health and quality of life of individuals, particularly in middle-aged and older adults (Di Pede, C., *et al.* 2020).^[7] It is now recognised that women with diabetes are particularly vulnerable to these complications, which may be compounded by hormonal changes during menopause and the ageing process (Eleni, D., & Kafatos, A. 2021).^[9] Mild Cognitive Impairment (MCI) represents an intermediate stage between normal cognitive ageing and dementia, with individuals experiencing noticeable cognitive decline without significant disruption to daily activities (Petersen, R. C., *et al.* 2018)^[12]. Recent studies have highlighted a connection between diabetes and MCI, with diabetes-related hyperglycemia, insulin resistance, and vascular damage negatively impacting brain function (Janson, J. 2019)^[10]. Furthermore, cognitive decline in diabetic individuals is often accompanied by impaired physical functioning and poor sleep quality, which can collectively lead to a diminished quality of life (Stenholm, S., *et al.* 2020)^[14]. Despite this, there is a limited body of research that explores the combined effects of MCI, physical functioning, and sleep quality, particularly in middle-aged diabetic women.

This study aimed to investigate the relationships between MCI, physical functioning, and sleep quality among middle-aged women with diabetes, a group that is underrepresented in clinical research. Understanding how these factors interact can inform strategies to mitigate the adverse impacts on health in this population.

Methodology

The study design was a cross-sectional, survey-based study which was conducted among 44 middle-aged diabetic women aged 40 to 55 years, all of whom were diagnosed with Type 2 diabetes in Delhi-NCR. Participants were included if they met the inclusion criteria, such as women aged between 40 and 55 years who were diagnosed with T2DM and had no severe mental or physical impairments. Exclusion criteria included any history of major neurological disorders or psychiatric conditions. Participants were selected using convenience sampling. Cognitive functioning was assessed using the Mini-Mental State Examination (MMSE), a widely used tool to screen for cognitive impairment. Participants were categorised into two groups based on MMSE scores: those scoring between 25 and 30 were considered cognitively normal, while those scoring between 21 and 24 were classified as having mild cognitive impairment (MCI) (Borsini, A., *et al.* 2021).^[4] Physical activity levels were assessed using the International Physical Activity

Questionnaire (IPAQ). Participants were classified into three levels of physical functioning: low, moderate, and high, based on the frequency and intensity of physical activity reported over the past week (Choi, M., *et al.* 2019)^[5]. Sleep Quality: Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), which evaluates sleep duration, sleep efficiency, disturbances, and daytime dysfunction. Participants were classified as having either fair (PSQI score ≤ 5) or poor (PSQI score > 5) sleep quality (Cook, I. 2018)^[6]. Consent and Personal data were collected in physical presence after explaining the nature and purpose of the study. The collected data were entered into a Microsoft Excel spreadsheet and analysed using IBM SPSS Statistics version 21.0. The Descriptive analysis, chi-square test and t-test were used to summarise demographic characteristics, cognitive function, physical activity, and sleep quality. The relationship between cognitive status, physical activity levels, and sleep quality was analysed using chi-square tests for categorical variables and independent t-tests for continuous variables.

Results

The findings of the study that investigates the interplay between mild cognitive impairment (MCI), physical functioning, and sleep quality among middle-aged diabetic women. A total of 44 women participated in the research, with data collected using the Mini-Mental State Examination (MMSE) to assess cognitive function, the International Physical Activity Questionnaire (IPAQ) to evaluate physical activity levels, and the Pittsburgh Sleep Quality Index (PSQI) to measure sleep quality. The results aim to elucidate the relationships between these variables, providing insights into their impact on the health and well-being of diabetic women aged 40 to 55 years.

Demographic Characteristics

The study sample consisted of 44 middle-aged diabetic women, aged between 40 and 55 years. The participants were categorized into three age groups: 40–45 years, 46–50 years, and 51–55 years. The largest age group was women aged 46–50 years, comprising 52.3% of the sample ($n=23$), followed by women aged 51–55 years, representing 27.3% ($n=12$). Women aged 40–45 years accounted for 20.5% of the participants ($n=9$). This distribution reflects a diverse representation of middle-aged diabetic women, enabling a comprehensive analysis of the variables under investigation. Table 1 and Figure 1 provide a breakdown of the number of women in each age group.

Table 1: Distribution of Participants by Age Group

Age Groups	Number of Women	Percentage (%)
40-45	9	20.5%
46-50	23	52.3%
51-55	12	27.3%
Total	44	100%

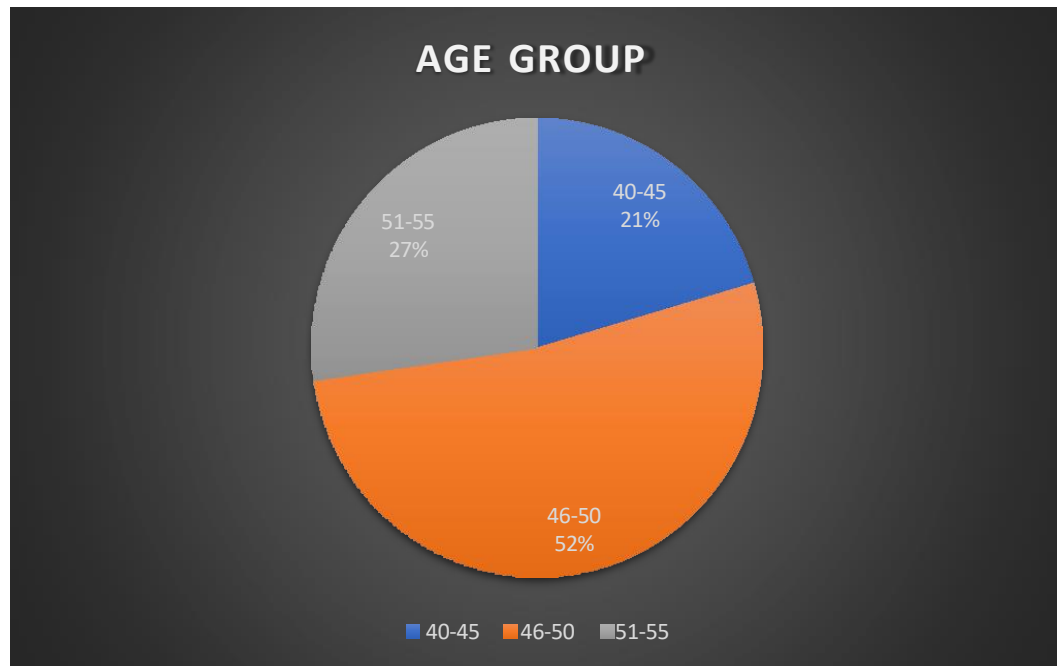


Fig 1: Distribution of participants by age group

Cognitive Functioning (MMSE Scores)

Cognitive functioning among the 44 participants was assessed using the MMSE. The results revealed an equal distribution between the two cognitive status categories.

Specifically, 22 women (50%) scored within the normal cognitive range (25–30), and 22 women (50%) fell within the mild cognitive impairment range (21–24). These findings are summarised in Table 2 and Figure 2.

Table 2: Distribution of Participants Based on MMSE Scores

Cognitive Status	MMSE Score Range	Number of Women	Percentage (%)
Normal Cognition	25–30	22	50%
Mild Cognitive Impairment	21–24	22	50%
Total		44	100%

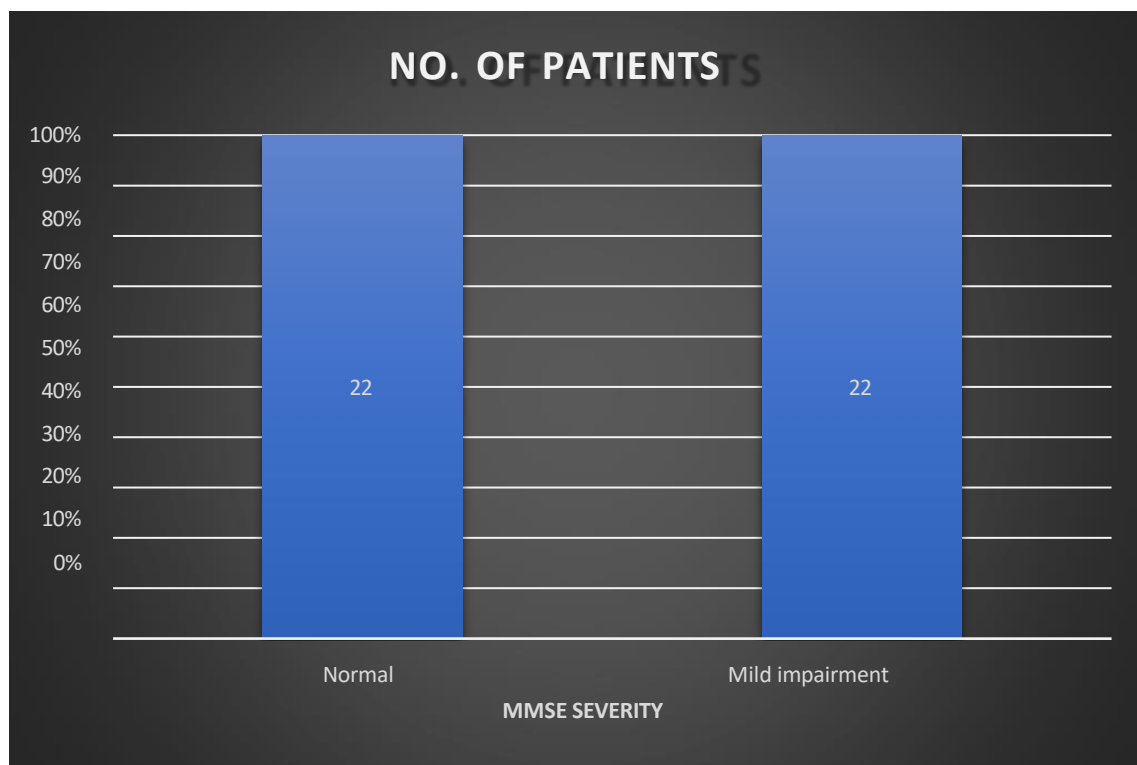


Fig 2: Distribution of Participants Based on MMSE Scores

Physical Functioning (IPAQ Scores)

The physical activity levels of participants were assessed using IPAQ. Based on IPAQ classification, participants were categorized into three levels of physical functioning: low, moderate, and high. Among the 44 diabetic women surveyed,

14 (31.8%) demonstrated low physical functioning, 28 (63.6%) had moderate physical functioning, and only 2 (4.6%) reported high levels of physical activity. The distribution of participants across these categories is summarized in Table 3 and Figure 3.

Table 3: Distribution of Participants Based on Physical Functioning (IPAQ Scores)

Physical Functioning Level	Number of Participants	Percentage (%)
Low	14	31.8%
Moderate	28	63.6%
High	2	4.6%
Total	44	100%

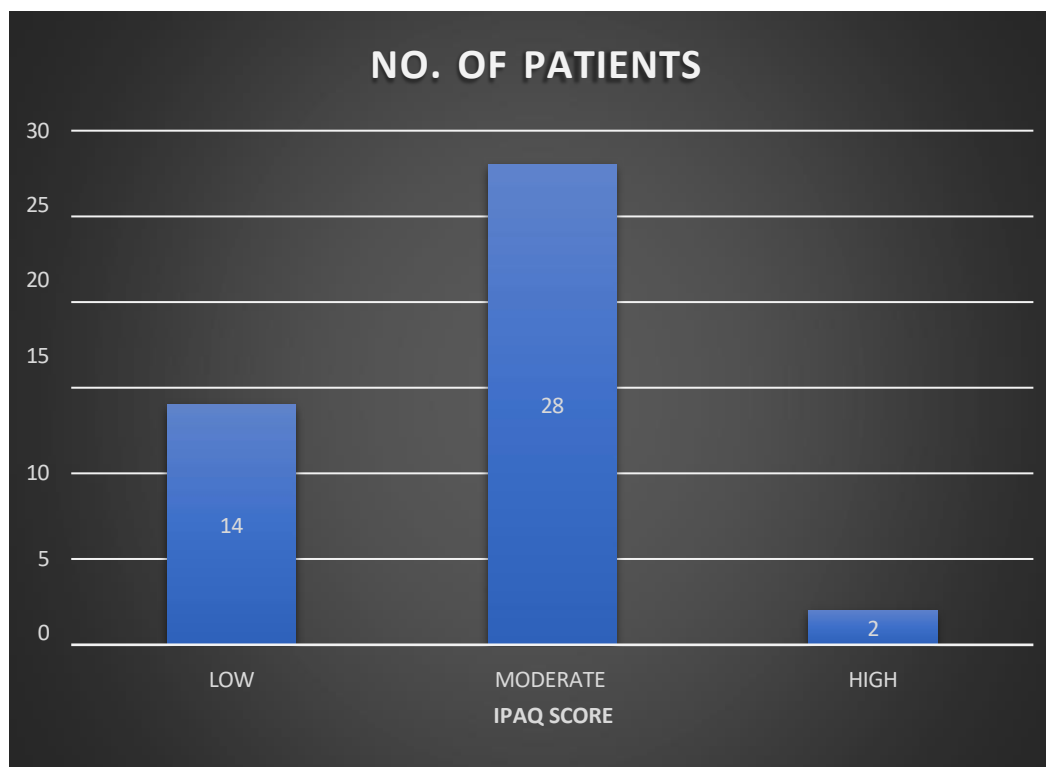


Fig 3: Distribution of Participants Based on Physical Functioning (IPAQ Scores)

Sleep Quality (PSQI Scores)

Sleep quality among the participants was evaluated using the PSQI. According to standard PSQI interpretation, scores ranging from 0 to 5 indicate fair (good) sleep quality, while scores greater than 5 reflect poor sleep quality. Out of the 44

women surveyed, 13 women (29.5%) had fair sleep quality, whereas 31 women (70.5%) were found to have poor sleep quality. These results suggest that a significant proportion of the participants experienced inadequate sleep. The distribution is detailed in Table 4 and Figure 4.

Table 4: Distribution of Participants Based on Sleep Quality (PSQI Scores)

PSQI Score Range	Sleep Quality	Number of Participants	Percentage (%)
0-5	Fair	13	29.5%
>5	Poor	31	70.5%
Total		44	100%

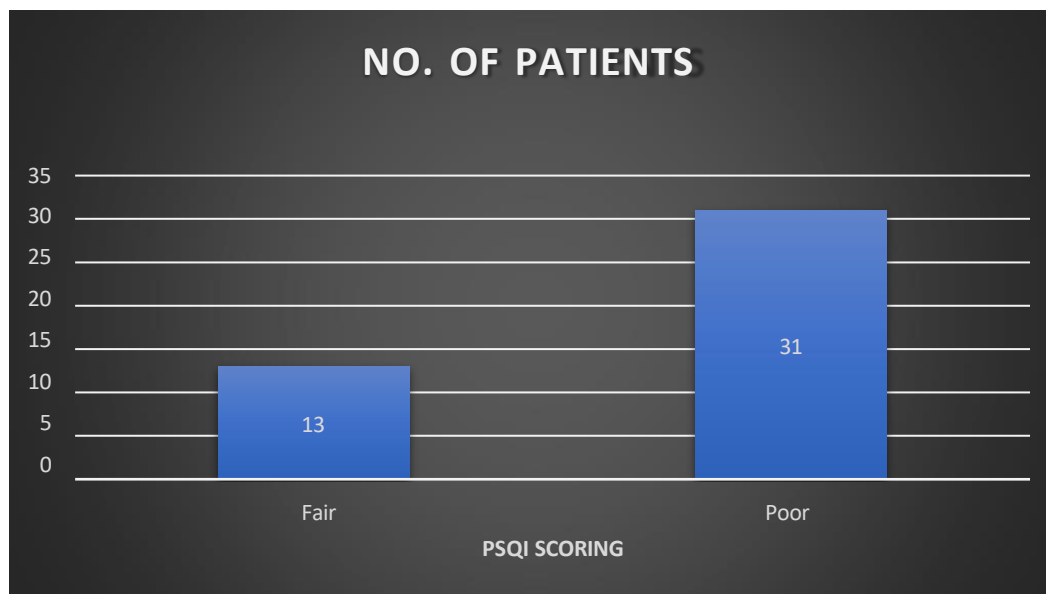


Fig 4: Distribution of Participants Based on Sleep Quality (PSQI Scores)

Sleep Quality Among Women with Mild Cognitive Impairment

To further explore the interconnection between cognitive function and sleep quality, the sleep patterns of women with mild cognitive impairment (MCI), as identified through MMSE scores (21–24), were analyzed using PSQI results. Among the 22 women classified as having mild cognitive impairment, 15 women (68.2%) exhibited poor sleep quality,

indicated by PSQI scores greater than 5, while 7 women (31.8%) demonstrated fair sleep quality, with PSQI scores ranging from 0 to 5. This pattern suggests that poor sleep quality is more prevalent among those with mild cognitive impairment, indicating a potential relationship between sleep disturbances and cognitive decline. The data are summarised in Table 5.

Table 5: Sleep Quality Among Women with Mild Cognitive Impairment (n = 22)

Sleep Quality (PSQI Score)	Number of Participants	Percentage (%)
Poor (>5)	15	68.181818
Fair (0–5)	7	31.818182
Total	22	100%

Sleep Quality Among Women with Normal Cognitive Functioning

In addition to examining sleep quality among those with mild cognitive impairment, the sleep profiles of women with normal cognitive functioning, defined by MMSE scores between 25 and 30, were also analyzed using PSQI scores. Among the 22 women identified as having normal cognition, 16 women (72.7%) exhibited poor sleep quality with PSQI

scores greater than 5, while 6 women (27.3%) demonstrated fair sleep quality with PSQI scores ranging from 0 to 5. These results suggest that even among women with normal cognitive functioning, poor sleep quality is highly prevalent. This finding indicates that poor sleep may serve as an early factor in cognitive decline or may be independently associated with diabetes-related health outcomes. The data are summarized in Table 6.

Table 6: Sleep Quality Among Women with Normal Cognitive Function (n = 22)

Sleep Quality (PSQI Score)	Number of Participants	Percentage (%)
Poor (>5)	16	72.72727
Fair (0–5)	6	27.27273
Total	22	100%

Physical Functioning Among Women with Mild Cognitive Impairment

To explore the association between cognitive status and physical activity, the physical functioning levels of women identified with mild cognitive impairment (MMSE scores 21–24) were examined using the International Physical Activity Questionnaire (IPAQ). Among the 22 women with mild cognitive impairment, 8 women (36.4%) exhibited low

physical functioning, 13 women (59.1%) demonstrated moderate physical functioning, and 1 woman (4.5%) reported high physical functioning. These findings suggest that most women with mild cognitive impairment fall into the moderate activity level, with a considerable proportion showing low levels of physical activity. The details are presented in Table 7.

Table 7: Physical Functioning Among Women with Mild Cognitive Impairment (n = 22)

Physical Functioning Level	Number of Participants	Percentage (%)
Low	8	36.36363636
Moderate	13	59.09090909
High	1	4.545454545
Total	22	100%

Physical Functioning Among Women with Normal Cognitive Function

In addition to women with mild cognitive impairment, physical activity levels were also analyzed in participants with normal cognitive function (MMSE scores 25–30) using the International Physical Activity Questionnaire (IPAQ). Among the 22 women with normal cognitive function, 6 women (27.3%) had low physical functioning, 15 women

(68.2%) demonstrated moderate physical functioning, and 1 woman (4.5%) showed high physical functioning. These findings indicate that the majority of cognitively normal women had moderate levels of physical activity. A relatively smaller portion reported low physical functioning, which may reflect better overall health status compared to those with cognitive impairment. The results are summarized in Table 8.

Table 8: Physical Functioning Among Women with Normal Cognitive Function (n = 22)

Physical Functioning Level	Number of Participants	Percentage (%)
Low	6	27.27273
Moderate	15	68.18182
High	1	4.545455
Total	22	100%

Descriptive Statistics and Inferential Analysis

The following table summarises the mean and standard deviation of proxy scores for sleep quality and physical

activity in both the Mild Cognitive Impairment (MCI) group and the Normal Cognitive Function group. The details are presented in Table 9 and Figure 9.

Table 9: Descriptive Statistics of Sleep Quality and Physical Activity by Cognitive Status

Measure	MCI Group (Mean ± SD)	Normal Group (Mean ± SD)
Sleep Score (Proxy)	2.68 ± 0.48	2.73 ± 0.46
Physical Activity (Proxy)	1.68 ± 0.57	1.77 ± 0.53

The mean sleep score for the MCI group was slightly lower (M = 2.68, SD = 0.48) compared to the normal group (M = 2.73, SD = 0.46), suggesting marginally lower perceived sleep quality in the MCI group. Similarly, physical activity

proxy scores were slightly lower in the MCI group (M = 1.68, SD = 0.57) than in the normal cognition group (M = 1.77, SD = 0.53). However, these differences were not statistically significant.

Chi-Square Test of Independence

1. Sleep Quality and Cognitive Status

Table 10: Chi-Square Test for sleep quality and cognitive status

Sleep Quality	MCI Group (n = 22)	Normal Group (n = 22)
Poor	15	16
Fair	7	6

Chi-square (χ^2) = 0.00, p = 1.000

There was no statistically significant association between cognitive status and sleep quality among participants.

2. Physical Activity and Cognitive Status

Table 11: Chi-Square Test for Physical Activity and Cognitive Status

Physical Functioning	MCI Group (n = 22)	Normal Group (n = 22)
Low	8	6
Moderate	13	15
High	1	1

Chi-square (χ^2) = 0.43, p = 0.807

Similarly, no significant association was found between physical activity level and cognitive status.

Independent t-Test Analysis

To further assess the relationship between cognitive status and other variables, independent t- tests were conducted comparing sleep quality and physical activity scores between women with MCI and those with normal cognitive function.

1. Sleep Quality Scores

The independent t-test revealed no statistically significant difference in sleep scores between the MCI group and the normal cognitive function group. This suggests that the sleep quality, as measured by ordinal proxies derived from the Pittsburgh Sleep Quality Index (PSQI), did not significantly differ based on cognitive status ($t = -0.32$, $p = 0.748$). As shown in figure 5.

2. Physical Activity Scores

The independent t-test for physical activity scores showed no significant difference between the two groups. The physical functioning levels, measured by ordinal proxies based on the International Physical Activity Questionnaire (IPAQ), were not significantly different between women with MCI and those with normal cognition ($t = -0.55$, $p = 0.585$).

These findings suggest that neither sleep quality nor physical activity, when assessed using ordinal proxies, differ significantly between middle-aged diabetic women with mild cognitive impairment and those with normal cognitive functioning. As shown in figure 6.

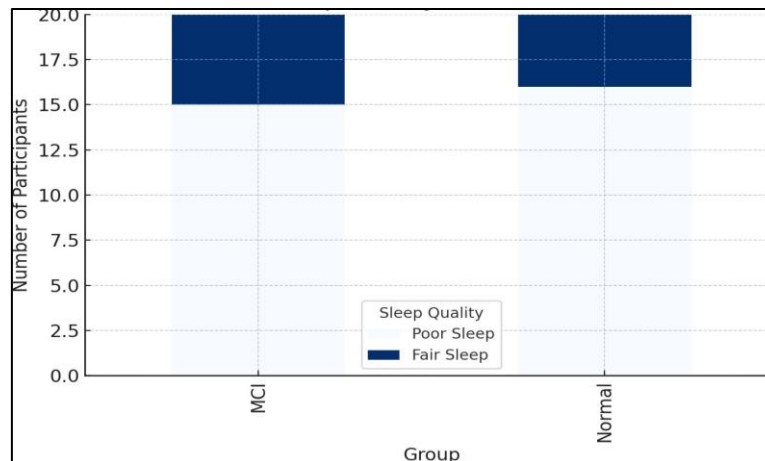


Fig 5: Independent T-Test for Sleep Quality Scores

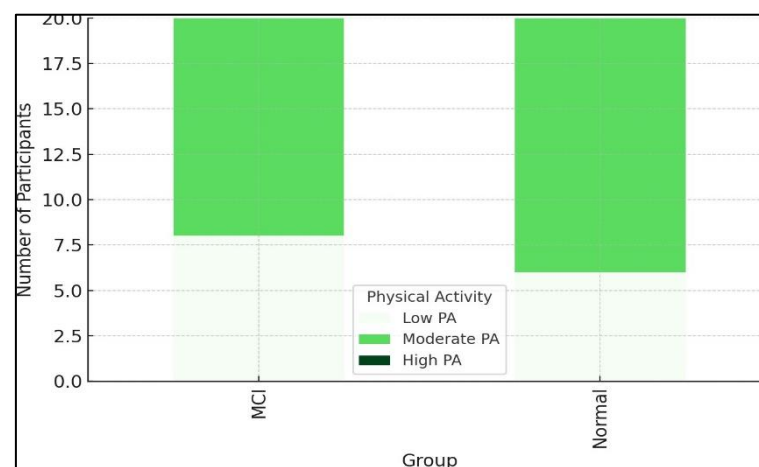


Fig 6: Independent T-Test for Physical Activity Scores

Discussion

This study was conducted to explore the relationship between mild cognitive impairment (MCI), physical functioning, and sleep quality among middle-aged diabetic women aged between 40 and 55 years. By using three well-established tools — the Mini-Mental State Examination (MMSE) for cognitive assessment, the International Physical Activity Questionnaire (IPAQ) for measuring physical activity, and the Pittsburgh Sleep Quality Index (PSQI) for assessing sleep quality — the study aimed to provide a comprehensive understanding of how these factors interact within this vulnerable population. A total of 44 diabetic women participated, with an even split between those categorised as cognitively normal and those classified as having mild cognitive impairment. The sample was diverse across the age

groups, allowing for a more nuanced view of middle-aged diabetic women's health.

The study found that poor sleep quality was highly prevalent among participants, with 70.5% of the women exhibiting poor sleep quality as indicated by a Pittsburgh Sleep Quality Index (PSQI) score greater than 5. When broken down by cognitive status, 68.2% of women with mild cognitive impairment (MCI) had poor sleep, while 72.7% of women with normal cognitive function also experienced poor sleep. Although descriptively, there appeared to be slightly better sleep quality among women with MCI compared to those with normal cognitive function, statistical analysis did not support a significant difference. A chi-square test revealed no significant association between cognitive status and sleep quality (Chi square = 0.00, $p = 1.000$), and an independent t-

test comparing sleep scores between the two groups similarly showed no significant difference ($t = -0.32$, $p = 0.748$). These findings suggest that although sleep disturbances are common in middle-aged diabetic women, the presence of cognitive impairment does not significantly worsen sleep quality. Instead, it appears that poor sleep is a pervasive issue likely influenced more by diabetes itself or other common factors such as stress, pain, or metabolic dysfunction rather than by cognitive status.

Physical activity levels among participants showed that 31.8% had low physical functioning, 63.6% had moderate functioning, and only 4.6% had high physical functioning. Among women with mild cognitive impairment (MCI), 36.4% had low physical activity, 59.1% had moderate activity, and 4.5% had high activity. In contrast, among women with normal cognition, 27.3% had low physical activity, 68.2% had moderate activity, and 4.5% had high activity. Despite a slight trend indicating that women with MCI had a higher proportion of low physical activity compared to cognitively normal women, no significant association was found between cognitive status and physical activity levels ($\chi^2 = 0.43$, $p = 0.807$). Similarly, independent t-test results showed no significant difference between the two groups in terms of their physical activity scores ($t = -0.55$, $p = 0.585$). This indicates that, much like sleep quality, physical activity levels were not significantly different between diabetic women with or without cognitive impairment. Both groups predominantly exhibited moderate levels of physical activity, suggesting a relatively uniform pattern of physical functioning in this population.

Although descriptively trends were suggesting worse sleep and slightly lower physical activity among those with MCI, statistical analyses confirmed no significant differences between the MCI and normal cognition groups across sleep quality and physical functioning measures. Several important conclusions can be drawn such as, Poor sleep quality is extremely common in middle-aged diabetic women, regardless of their cognitive status. This widespread sleep disturbance could itself be an independent health concern that needs addressing in clinical care. Physical activity levels are generally moderate in this population, but a substantial portion still exhibits low activity levels, which could contribute to worsening health outcomes over time. Cognitive impairment did not appear to be directly associated with either poorer sleep or lower physical activity in this sample. This suggests that in middle-aged diabetic women, the presence of MCI may not yet be strongly reflected in functional measures like sleep and physical activity, or that other diabetes-related factors may mask or influence these relationships.

Several studies have previously reported associations between poor sleep quality and cognitive decline. For example, Blackwell *et al.* (2006) [3] demonstrated that lower sleep efficiency was associated with worse cognitive performance in older women (Blackwell, T., *et al.*, 2006) [3]. Similarly, Yaffe *et al.* (2011). [16] found that disrupted sleep was a predictor of future cognitive decline in elderly women (Yaffe, K., *et al.* 2014) [16]. However, the current study did not replicate these findings, potentially due to the sample's relatively younger age range (45–55 years) or differences in diabetes management. Regarding physical activity, literature consistently supports its neuroprotective effects (Yaffe, K., *et*

al. 2014) [16]. Lautenschlager *et al.* (2008). [11] showed that a 6-month physical activity intervention significantly improved cognitive function in older adults at risk for Alzheimer's disease (Lautenschlager, N. T., *et al.*, 2008). [11] Yet, the lack of a significant relationship in our findings aligns with those of Doi *et al.* (2017) [8], who reported that physical activity alone may not predict cognitive performance among diabetic patients unless accompanied by adequate glycemic control (Doi T., *et al.*, (2017) [8]). Moreover, a study by Reutrakul and Van Cauter (2014). [13] emphasized the bidirectional link between diabetes and poor sleep, suggesting that metabolic dysregulation in diabetes may override the cognitive benefits normally attributed to physical activity and good sleep hygiene (Reutrakul, S., & Van Cauter, E. 2014). [13] This may explain why our participants, despite engaging in moderate activity and reporting fair sleep quality, did not show differential cognitive outcomes (Reutrakul, S., & Van Cauter, E. 2014). [13]

Limitations of the study

Several limitations must be acknowledged. The sample size was relatively small ($n = 44$), which may limit the power to detect significant associations. The cross-sectional design prevents any inference of causality. Moreover, the study relied on self-reported questionnaires for physical activity and sleep, which may introduce bias or inaccuracies. Objective measures such as actigraphy or polysomnography and more detailed neuropsychological assessments could provide deeper insights.

Clinical and practical implications

These findings emphasize the importance of holistic care approaches for diabetic women in midlife. Even though no statistically significant associations were found, the high prevalence of poor sleep and low physical activity levels highlight potential areas for intervention. Sleep hygiene education and structured physical activity programs may still be valuable in improving overall quality of life and potentially supporting long-term cognitive health.

Scope for future research

Future studies should aim for larger, more diverse samples and consider longitudinal designs to examine causal pathways. It would also be beneficial to investigate the role of other variables such as glycemic control, depressive symptoms, menopausal status, and medication adherence, which may mediate the relationships among cognitive function, sleep, and physical activity.

Conclusion

This study provides valuable insights into the relationships between MCI, physical functioning, and sleep quality in middle-aged women with diabetes. Although no significant associations were found between cognitive status and either physical functioning or sleep quality, the high prevalence of poor sleep and suboptimal physical activity levels warrants further attention. Interventions designed to improve these factors could help mitigate the adverse effects of diabetes and improve overall health outcomes in middle-aged diabetic women. Future research with larger, longitudinal samples is needed to further explore these relationships and identify effective interventions.

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