

Original Article

Psychometric properties of the multidimensional fatigue inventory in people with type 2 diabetes mellitus

Sarah Parveen¹, Muhammad Azharuddin², Chhavi Arora Sehgal¹, Maria Usmani¹, Majumi Mohamad Noohu^{1*}

¹ Centre for Physiotherapy and Rehabilitation Sciences, Jamia Millia Islamia, New Delhi, India

² Department of Physiotherapy, Regional Institute of Paramedical and Nursing Sciences, Aizawl, Mizoram, India

* Correspondence to: Majumi Mohamad Noohu, Centre for Physiotherapy and Rehabilitation Sciences, Jamia Millia Islamia, New Delhi 110025, India. E-mail: mnoohu@jmi.ac.in

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Abstract

The purpose of this study was to examine the test-retest reliability and discriminant validity of the Multidimensional Fatigue Inventory (MFI) in people with type 2 diabetes mellitus (T2DM). The study recruited 30 people with T2DM. Test-retest reliability of the MFI was examined by re-administration of the MFI after an interval of one day. Cronbach's α , intraclass correlation (ICC), standard error of measurement (SEM), and smallest detectable change (SDC) were calculated. Bland-Altman limits of agreement (LoA) were determined. Discriminant validity was assessed using Spearman's test. Internal consistency values were adequate for the MFI-total score and five MFI subscales, with Cronbach's α ranging from 0.97 to 0.99. ICCs ranged from 0.97 to 0.99. The Bland-Altman analysis revealed high stability and low variation of MFI. High discriminant validity was observed for MFI ($r=0.33$, $p=0.08$). In order to measure the different aspects of fatigue in people with T2DM, MFI can be considered a comprehensive instrument.

Keywords: fatigue, type 2 diabetes mellitus, reliability, validity, depression

Introduction

Fatigue is a common multifaceted feeling with elements related to the body, mind, and environment [1]. The awareness of a reduced capability for physical and/or mental function resulting from the discrepancy in the availability, utilization, and/or restoration of resources required to conduct an activity is known as fatigue [1]. Approximately 9.75% to 33% of the general population experience fatigue [2], which mainly results from an illness, or it might be related to lifestyle factors, like disturbed sleep or stress [3]. According to the current understanding of the pathophysiology of fatigue, the body's central & peripheral processes both contribute to and regulate the physical manifestation of fatigue. After receiving signals from higher centers, the neuromuscular system fails to respond, which results in peripheral fatigue. The central nervous system

(CNS) plays a role in central fatigue, which is characterized by an impaired transmission of motor impulses or an inability to carry out voluntary activities [4].

Diabetes mellitus (DM) is a metabolic disorder characterized by hyperglycemia resulting from impairment in insulin secretion, insulin action, or both [5]. Type 2 diabetes mellitus (T2DM), which accounts for approximately 90% of all diabetes worldwide [6], presents with a number of complications and affects the physical and mental health of the individual [7]. Fatigue is a common complaint among individuals with T2DM [8] and has a negative impact on the quality of life of these patients [9]. The prevalence of fatigue in people with T2DM ranges from 50% [10] to 61% [11]. According to Sudore & colleagues, fatigue is one of the most prevalent symptoms of T2DM [12]. Fatigue compromises the capability of T2DM patients to carry out daily tasks [13]. It is considered a barrier to the self-management of



DM [14]. Some of the short & long-term complications of T2DM were reported to be associated with increased fatigue [8].

Individuals with T2DM may experience fatigue from a variety of sources, including physiological, psychological, and lifestyle factors. Physiological factors, such as hyperglycemia & hypoglycemia [2, 15], psychological factors, including diabetes-related distress & depression [2, 15], epidemiological [16] and lifestyle factors, such as increased body mass index (BMI) [17] have been associated with fatigue in people with T2DM.

There are various unidimensional & multidimensional instruments designed to assess fatigue in various populations [18], such as Fatigue Severity Scale (FSS) [8], Fatigue Assessment Scale (FAS) [8], Visual Analogue Fatigue Scale (VAFS) [8], Iowa Fatigue Scale (IFS) [19], Diabetes Symptom Checklist-Revised (DSC-R) [7], Illness Perceptions Questionnaire-Revised (IPQ-R) [20], and Multidimensional Fatigue Inventory (MFI). Among the scales assessing fatigue in people with T2DM, the psychometric properties of the FACIT-F scale have been examined [21]. However, the FACIT-F scale seems to be a unidimensional scale [22], and fatigue is multidimensional in nature [9]. Therefore, instruments assessing the multidimensional aspects of fatigue were the most suitable. Considering this fact, MFI, being a multidimensional questionnaire, can be used to assess fatigue in people with T2DM. According to a recent systematic review [23], which included 9 studies examining fatigue in T2DM, the majority of the included trials used MFI to assess fatigue. The MFI is a 20-item self-reported questionnaire, designed by Smets and colleagues in 1995. It is a multidimensional questionnaire assessing general, physical, and mental fatigue, along with reduced activity & motivation. It has been considered an important tool in the assessment of fatigue in patients with cancer [24], fibromyalgia [25], post-polio syndrome [26], chronic fatigue syndrome [27], and patients with brain injury [28].

Attempts were made to measure the psychometric properties of MFI in other populations [29, 30] and only one study by Romadlon and colleagues [31] measured the psychometric properties of the Indonesian version of MFI in people with T2DM. However, no study was done to investigate the psychometric properties of the original MFI in individuals with T2DM. The psychometric studies on MFI in T2DM people will be of great importance, as it facilitates assessing the efficacy of the interventions and applying research evidence in a clinical setting with assurance. Therefore, the present study aims to examine the psychometric properties

of MFI in individuals with T2DM. Improved fatigue assessment can lead to more targeted and effective interventions, ultimately enhancing patients' quality of life, adherence to diabetes management plans, and overall health outcomes. Furthermore, understanding fatigue's impact on T2DM can inform clinical guidelines and promote a holistic approach to patient care, ensuring that fatigue is addressed alongside other diabetes-related challenges.

Material and methods

Participants

The study included 30 people with a medical diagnosis of T2DM who were aged 39 years or older. Participants with at least 5 years of diagnosed T2DM according to the American Diabetes Association criteria and possessing at least a high school degree were recruited in the study. Participants with uncontrolled hypertension, the presence of cardiovascular or pulmonary disease & those with the inability to follow directions were excluded from the study. The sample size of 30 participants was calculated for two observations per patient, with an alpha value of 0.05 & power of 0.80, to test the null hypothesis intraclass correlation coefficient (ICC) of 0.3 & alternative hypothesis ICC of 0.7. The study was approved by the Institutional Ethics Committee (IEC), Jamia Millia Islamia (Approval ID: 24/5/319/JMI/IEC/2021). All the participants provided written informed consent.

Procedure

The study participants were recruited from the Centre for Physiotherapy and Rehabilitation Sciences and M. A. Ansari Health Centre, JMI, New Delhi. At the first visit, after the initial screening of the participants for eligibility, general demographics & clinical characteristics were recorded. For the evaluation of fatigue, MFI was used. This was followed by assessing depression using the Beck Depression Inventory (BDI). For the assessment of inter-day test-retest reliability, the participants completed the MFI on their first visit & then 24 hours later (second visit). Test-retest reliability, the standard error of measurement (SEM), and smallest detectable change (SDC) were determined. Bland-Altman (BA) analysis was performed. This was followed by the evaluation of discriminant validity.

Measures

Multidimensional fatigue inventory

To examine the multidimensional feature of fatigue, MFI was developed by Dutch researchers in the year 1995 [32]. MFI consists of 20 items and five domains (general fatigue, physical fatigue, reduced activity, mental fatigue, & reduced motivation). Each domain includes 4 items, where two items indicate fatigue (e.g. "I tire easily") & two items contradict fatigue (e.g. "I feel fit"). The participants rate their responses on a 5-point Likert scale ranging from 1 (strongly agree) to 5 (strongly disagree). Reverse scoring was done for items that indicate fatigue (items: 2, 5, 9, 10, 13, 14, 16, 17, 18, 19). For each dimension, a single score is produced by adding the individual item scores. The score ranges from 4 to 20 for each dimension. The greater the score, more will be the fatigue [32].

Beck depression inventory

The BDI was created by Dr Aaron T. Beck in 1961. It is a 21-item, self-administered questionnaire assessing depression. Its items include questions related to feelings of helplessness, feelings of restlessness, depressed mood etc. The items are rated on a 4-point scale from 0 to 3. The scores of individual items are summed together to produce a global score. A higher score indicates more severe depression [33].

Statistical analysis

All statistical analyses were performed using IBM® SPSS® version 26 (IBM Corp.). The general demographics, clinical characteristics, fatigue, and depression of the participants were examined using mean, standard deviation (SD), frequency, and percentage. The normality of the data was examined using the Shapiro-Wilk test. Spearman correlation coefficient was performed to determine the relationship with contributing factors like duration of diabetes, glycemic control, and depression. The internal consistency of MFI was examined with Cronbach's alpha (α). Internal consistency examines the degree to which all items are assessing the same attribute, and its value ranges from 0.7 to 0.95 [34, 35]. The inter-day test-retest reliability of MFI was examined by ICC using a 2-way mixed-effect model with an absolute agreement definition. Values of ≥ 0.70 were considered adequate for ICC [34]. Absolute reliability was observed using SEM, calculated by $SD \times \sqrt{(1 - ICC)}$. SEM is used to calculate the SDC, which is the minimum amount of change that a measurement

must demonstrate to be larger than the within-subject variability and measurement error. The formula used for SDC is $SEM \times 1.96 \times \sqrt{2}$ [36]. Spearman's test was used to assess the discriminative validity by correlating the scores of MFI and BDI.

Results

Of the 30 participants, 19 were men and 11 were women. They were aged between 45 and 59 years, with a mean duration of diabetes of 10.40 ± 5.16 years (Table 1). A significant correlation was observed between fatigue and disease duration ($r=0.43$; $p=0.02$), fasting plasma glucose (FPG) ($r=0.42$, $p=0.02$), post-prandial plasma glucose ($r=0.46$; $p=0.01$), and BDI ($r=0.33$; $p=0.08$) whereas no significant correlation was found between MFI-total and HbA1c ($r=0.24$; $p=0.21$). For discriminative analysis, the MFI-total demonstrated a non-significant correlation with BDI ($r=0.33$; $p=0.08$) (Table 2). The subscales of the MFI showed adequate internal consistency, expressed as Cronbach's α . The internal consistency of the MFI-total and each of the five subscales was: total MFI (0.99), general fatigue (0.98), physical fatigue (0.98), mental fatigue (0.99), reduced activity (0.97), and reduced motivation (0.98) (Table 3).

Discussion

To the best of our knowledge, this is the first study that investigates the inter-day test-retest reliability of MFI for assessing fatigue in people with T2DM. The present study shows that MFI possesses good test-retest reliability and adequate internal consistency. The general fatigue score observed in the participants of this study was similar to fatigue scores reported in previously done studies [9, 15].

Duration of diabetes of the participants in the present study was found to be associated with fatigue. A similar correlation was observed in a previously done study [37]. Assessment of glycemic control in people with T2DM can be done by measuring HbA1c, FPG, and PPG [38]. The present study observed no relationship between fatigue and HbA1c. This was in line with previously done studies where no relationship was reported between HbA1c and fatigue [9, 39]. HbA1c measures the three-month average blood glucose level. It provides an average of blood glucose because of which it cannot measure fluctuations between high and low blood glucose [9]. A relationship was found

Table 1: Participants' demographic and clinical characteristics.

Characteristics	Mean (SD)
Age (years)	53.60±4.94
Sex (male/female)*	19/11
Body mass index (kg/m ²)	26.39±2.76
Duration of diabetes (years)	10.40±5.16
Presence of comorbidities (yes/no)*	14/16
Systolic plasma pressure (mmHg)	126.73±14.23
Diastolic plasma pressure (mmHg)	79.93±6.75
Fasting blood glucose (mg/dl)	137.67±28.42
Postprandial blood glucose (mg/dl)	193.93±40.06
Glycosylated hemoglobin (%)	7.05±0.71
Any medications for diabetes (yes/no)*	29/1
Beck Depression Inventory score	12.43±1.17

Note: * – frequency; kg – kilogram; m – meters; mmHg – millimeters of mercury; mg/dl – milligrams per deciliter; % – percentage.

Table 2: Correlation of MFI with duration of diabetes, glycemic control, and BDI.

	MFI-total	
	r	p
Duration of diabetes (years)	0.43	0.02
Glycated hemoglobin (%)	0.24	0.21
Fasting plasma glucose (mg/dl)	0.42	0.02
Postprandial plasma glucose (mg/dl)	0.46	0.01
Beck Depression Inventory score	0.33	0.08

Note: MFI – Multidimensional Fatigue Inventory; mg/dl – milligrams per deciliter; % – percentage.

Table 3: Description of statistical analysis for test-retest reliability of MFI.

Subscales of MFI	Day 1 Mean±SD	Day 2 Mean±SD	P-value	Internal consistency (Cronbach's α)	ICC (95% CI)	SEM	SDC
General fatigue	12.83±3.05	12.97±2.85	0.32	0.98	0.98 (0.96–0.99)	0.10	0.29
Physical fatigue	12.50±2.92	12.37±3.02	0.29	0.98	0.98 (0.97–0.99)	0.10	0.27
Reduced activity	12.10±2.80	11.83±2.72	0.12	0.97	0.97 (0.93–0.98)	0.16	0.44
Reduced motivation	10.33±2.25	10.13±2.21	0.08	0.98	0.98 (0.95–0.99)	0.09	0.24
Mental fatigue	11.00±3.44	10.83±3.47	0.09	0.99	0.99 (0.98–0.99)	0.05	0.15
MFI-total	58.77±10.68	58.13±10.22	0.09	0.99	0.99 (0.97–0.99)	0.20	0.55

Note: MFI – multidimensional fatigue inventory; ICC – intraclass correlation; SEM – standard error of measurement; SDC – smallest detectable change.

between fatigue and other measures of blood glucose (FPG & PPG), as these measures of blood glucose assess the fluctuations in blood glucose. Similar findings were found in one study where fatigue was found to be significantly associated with FPG & PPG in T2DM patients. The alteration in blood glucose levels results in fatigue [40]. The discriminant validity of MFI was found to be good by the no correlation between the scores of MFI and BDI.

Reliability reflects the agreement between the measurements [41]. Test-retest reliability is the consistency of test results when assessing a constant individual attribute over time [42]. ICC is a relative index to assess the levels of agreement between the test-retest measurements [43]. Reporting of SEM and BA plot is used to quantify the absolute reliability [44]. In the BA method, there is presentation of individual differences of two administrations against their average [45]. Unlike the ICC, it is independent of the true variability of the observations, and it can potentially alert the researcher to systematic differences in scores [45]. In this study, the MFI-total and subscales showed high test-retest reliability over a 24-hour interval, with ICC ranging from 0.99 to 0.97 for MFI-total and subscales. These

findings were consistent with previously done studies where MFI showed high test-retest reliability [30, 46]. Limits of agreement (LoA) offer a range of error of 95% for two measurements [45]. For the analysis of LoA, the mean difference determined was small, and no data point was outside the LoA plot, indicating agreement between the two measurements and no systematic errors (Figure 1).

One of the limitations of the present study was the small sample size and the absence of a control group. The presence of a control group could have provided a better understanding of how different measures of T2DM influence fatigue in this population. Polypharmacy is common in patients with T2DM, which may result in a number of complications including fatigue. Intake of metformin disturbs the gastrointestinal system and increases the concentration of homocysteine [47], which leads to chronic fatigue [48]. Administration of insulin treatment in T2DM might result in hypoglycemia [49] and weight gain [50]. The present study failed to report the medications used by the participants and their effect on fatigue. Therefore, the relationship between the type of medications and the level of fatigue should be investigated in future studies.

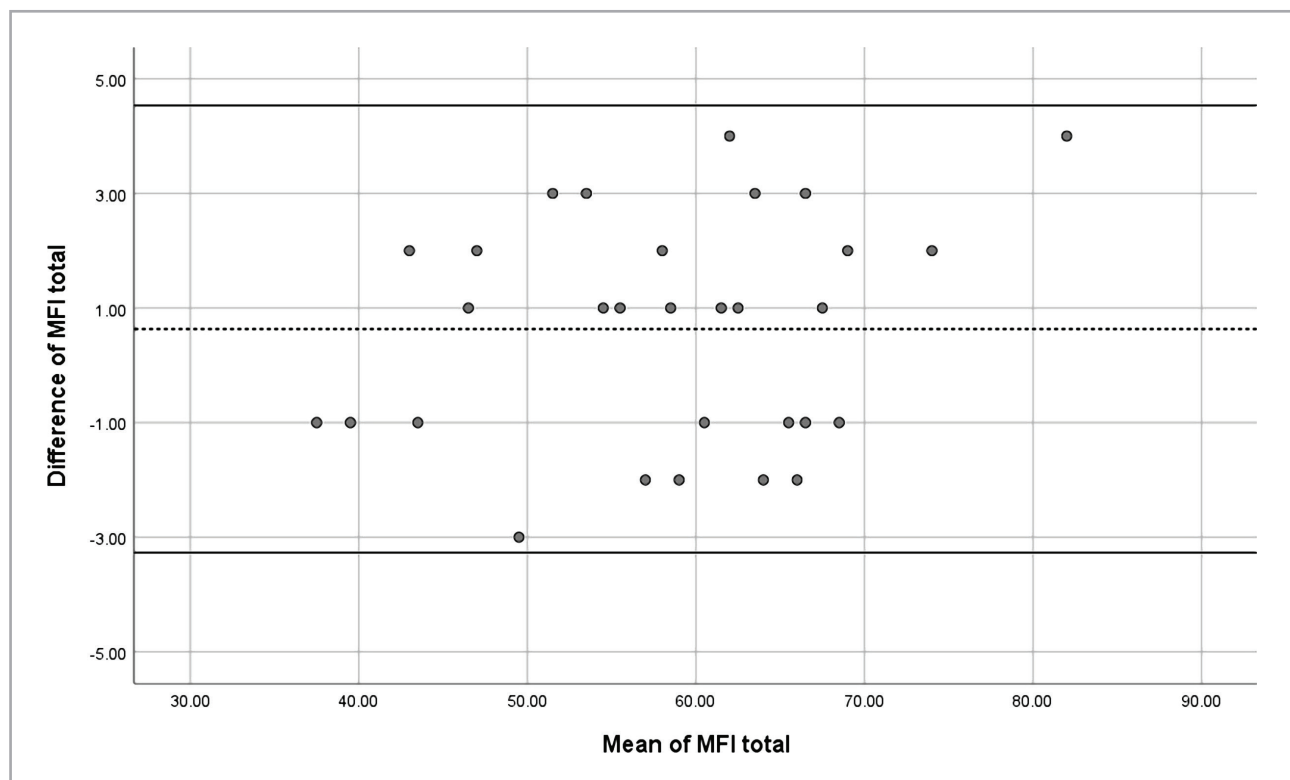


Figure 1: Graphical representation according to the Bland-Altman method for the MFI-total. All the data points are within ± 1.96 SD. In the graph, the mean value of the assessments for each subject was along the x-axis, while the difference between the two assessments was along the y-axis. The broken line is the mean difference between time 1 and time 2, whereas the solid lines show the 95% limits of agreement for the mean difference.

Conclusion

This study represents the first investigation demonstrating that the MFI is an adequate and reliable tool for measuring fatigue in individuals with T2DM. The MFI encompasses various subscales specifically designed to evaluate distinct dimensions of fatigue, including physical, emotional, and cognitive aspects. This multifaceted approach allows for a more comprehensive understanding of how fatigue impacts patients' daily lives. As a robust assessment instrument, the MFI equips clinicians with the means to identify and address the complex nature of fatigue in T2DM patients. By utilizing this tool, healthcare providers can enhance their ability to tailor interventions and improve the overall management of fatigue, ultimately leading to better patient outcomes and quality of life. The findings underscore the importance of incorporating reliable fatigue assessments into standard diabetes care, thereby promoting a more holistic approach to patient health.

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Conflict of interests

The authors declare no conflict of interest.

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