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The psychometric properties of the Persian version of the participation measure-3 domains, 4 dimensions in Iranian patients with multiple sclerosis

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Keywords
Multiple Sclerosis; Participation; Reliability; Validity

Abstract

Background: Multiple sclerosis (MS) profoundly influences individuals' participation across various life domains. This study evaluated the psychometric properties of the Persian version of the Participation Measure-3 Domains, 4 Dimensions (PM-3D4D) in people with MS (PwMS).

Methods: In a cross-sectional design with a nested test-retest sub-study, 230 PwMS were assessed. Construct validity was examined through intercorrelations among PM-3D4D dimensions and associations with the Community Integration Questionnaire (CIQ), Participation Measure for Post-Acute Care (PM-PAC), Satisfaction with Life Scale (SWLS), and Purpose in Life Test-Short Form (PIL-SF). The instrument's discriminative capacity across subgroups with different levels of disability and fatigue was also analyzed.

Results: The PM-3D4D demonstrated excellent test-retest reliability [intraclass correlation coefficient $(ICC)_{(2,1)}$ = 0.81-0.90] and good internal consistency (Cronbach's alpha = 0.79-0.89). Strong correlations emerged between the diversity and frequency dimensions (r_s = 0.70-0.88), alongside moderate to strong correlations with the difficulty dimension (r_s = 0.37-0.82).

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As hypothesized, PM-3D4D scores correlated strongly with CIQ (r_s = 0.71-0.83), and the difficulty dimension was negatively correlated with PM-PAC subscales (r_s = -0.75 to -0.85). Desire for change showed weak negative correlations with SWLS (r_s = -0.16 to -0.29) and moderate negative correlations with PIL-SF (r_s = -0.33 to -0.51). The instrument significantly differentiated participants based on disability and fatigue levels (P < 0.001).

Conclusion: The Persian version of the PM-3D4D is a valid and reliable measure for evaluating participation among PwMS in both clinical and research settings.

Introduction

Multiple sclerosis (MS) is a chronic autoimmune and inflammatory disorder of the central nervous system (CNS) that impairs motor, sensory, and cognitive functions and contributes to fatigue, collectively limiting individuals' participation.[1-3] Participation, as defined by the International Classification of Functioning, Disability and Health (ICF), refers to involvement in life situations, serves as a core indicator of health and well-being,[4] and represents a primary objective in rehabilitation.[2,3] The ICF framework categorizes participation into three main domains: "interpersonal interactions and relationships", "major life areas", and "community, social, and civic life".[5]

Restricted participation in people with MS (PwMS) presents a persistent challenge in rehabilitation.[6] Given that disease onset often occurs during individuals' most active and productive years, participation is significantly disrupted.[7] This disruption highlights the necessity of evaluating participation as a multidimensional construct. Previous studies have underscored limitations in current participation frameworks, including the absence of a comprehensive definition, insufficient consideration of its multidimensional nature, and inadequate assessment across various life domains.[8] Such gaps fail to capture patients' actual performance in diverse aspects of daily living.[9] Accordingly, the complex structure of participation continues to pose challenges for precise measurement.[5,8]

Several tools have been developed to assess participation, including the Craig Handicap Scale, the Impact on Participation and Autonomy (IPA), and the Assessment of Life Habits,[10] along with the Frenchay Activity Index (FAI) and the Community Integration Questionnaire (CIQ).[7] However, these instruments frequently conflate activity, impairment, and participation, thereby overlooking the multidimensional aspects of participation.[10] To address this gap, Chang et al. restructured ICF participation domains. They developed the Participation Measure-3 Domains, 4 Dimensions (PM-3D4D), an instrument designed to comprehensively assess participation across three domains – productivity, social engagement, and community activities – and four dimensions – diversity, frequency, difficulty, and desire for change.[5] This 24-item self-report tool evaluates both subjective and objective components of participation, supporting clinical decision-making and individualized treatment planning across diverse settings.[5] The PM-3D4D has demonstrated strong psychometric properties, with Cronbach's alpha ranging from 0.89 to 0.93[10] and test-retest reliability [intraclass correlation coefficient $(ICC)_{(2,1)}$ = 0.70-0.96].[11]

To ensure cross-cultural and cross-linguistic comparability, translated instruments must measure the same underlying construct as the original versions. Although this process is lengthy, it is essential to achieving conceptual and measurement equivalence.[12] Validation of participation tools in native languages is critical due to linguistic, cultural, and geographic variability.[13] When culturally adapted appropriately, such translations allow meaningful comparisons across populations.[14] Given the absence of a validated Persian version of the PM-3D4D for individuals with MS, this study aimed to evaluate its psychometric properties, including test-retest reliability, internal consistency, and face, content, structural, convergent, and discriminant validity.

It was hypothesized that the Persian version of the PM-3D4D would demonstrate robust psychometric performance. Internal consistency, measured via Cronbach's alpha, was expected to exceed 0.70, and test-retest reliability, evaluated using $ICC_{(2,1)}$, was anticipated to surpass 0.80. Based on prior findings,[5] strong correlations were expected between the diversity and frequency dimensions, moderate-to-strong correlations between these and the difficulty dimension, and weak-to-moderate correlations with the desire for change dimension. In addition, the frequency dimension was hypothesized to show strong positive correlations with the CIQ, reflecting structural and content alignment.[5] Conversely, the difficulty dimension was predicted to demonstrate strong negative correlations with the Participation Measure for Post-Acute Care (PM-PAC). In contrast, the desire for change dimension was expected to show weak to moderate negative correlations with the Satisfaction with Life

Scale (SWLS) and the Purpose in Life Test-Short Form (PIL-SF). Correlation strength was categorized as weak (< 0.30), moderate (0.30-0.70), or strong (> 0.70).[15] Lastly, it was anticipated that PM-3D4D scores would significantly distinguish between individuals with varying levels of disability and fatigue.

Materials and Methods

Participants: This cross-sectional study with a nested test-retest sub-study included 230 PwMS (mean age: 39.34 ± 9.40 years; women: 185, men: 45) recruited consecutively from the Iranian MS Association (and associated centers) using a convenience non-probability sampling method (Figure 1). After providing informed consent, participants completed the paper-based questionnaires in a quiet, standardized environment at the center. Inclusion criteria required participants to have an MS diagnosis confirmed by a neurologist based on the revised 2017 McDonald criteria,[16] be aged 18-65, and have a minimum of six months since diagnosis. Moreover, participants were required to have no significant visual impairments uncorrec with glasses, be proficient in Persian, report no sleep problems, as indicated by the patients or confirmed by their physician, and severe pain [Visual Analogue Scale (VAS) ≥ 6.5],[17] or not experience severe depression [Beck Depression Inventory-Second Edition (BDI-II) score: 29-63],[18] as severe depression affects cognition, motivation,[19,20] and correct questionnaire responses.

Exclusion criteria included disease relapse or corticosteroid use within the preceding four weeks, significant cognitive impairment [Montreal Cognitive Assessment (MoCA) score < 24],[21] due to self-reporting of the questionnaire,[5] and the presence of other neurological or orthopedic disorders, substance abuse, arthritis, diabetes, mood instability, or uncontrolled cardiovascular conditions. The study's ethical approval was granted by the local university (IR.IUMS.REC.1401.185) and the research adhered to the principles of the Declaration of Helsinki.

Translation: Permission to evaluate the tool's psychometric properties was obtained from the original developer.[10] This study used the Persian version of the PM-3D4D, which had previously been translated and cross-culturally adapted for the patient population according to the International Quality of Life Assessment (IQOLA) protocol.[22] Since this version was initially adapted for patients with stroke, we conducted a two-stage evaluation process to ensure the suitability of the Persian translation for PwMS. In the first stage of clarity/pilot testing, a sample of 20 PwMS evaluated the clarity and potential ambiguities of the questionnaire items using a three-point Likert scale: "very clear", "somewhat clear", and "unclear".[23] The demographic information of this pilot sample is presented in table 1.

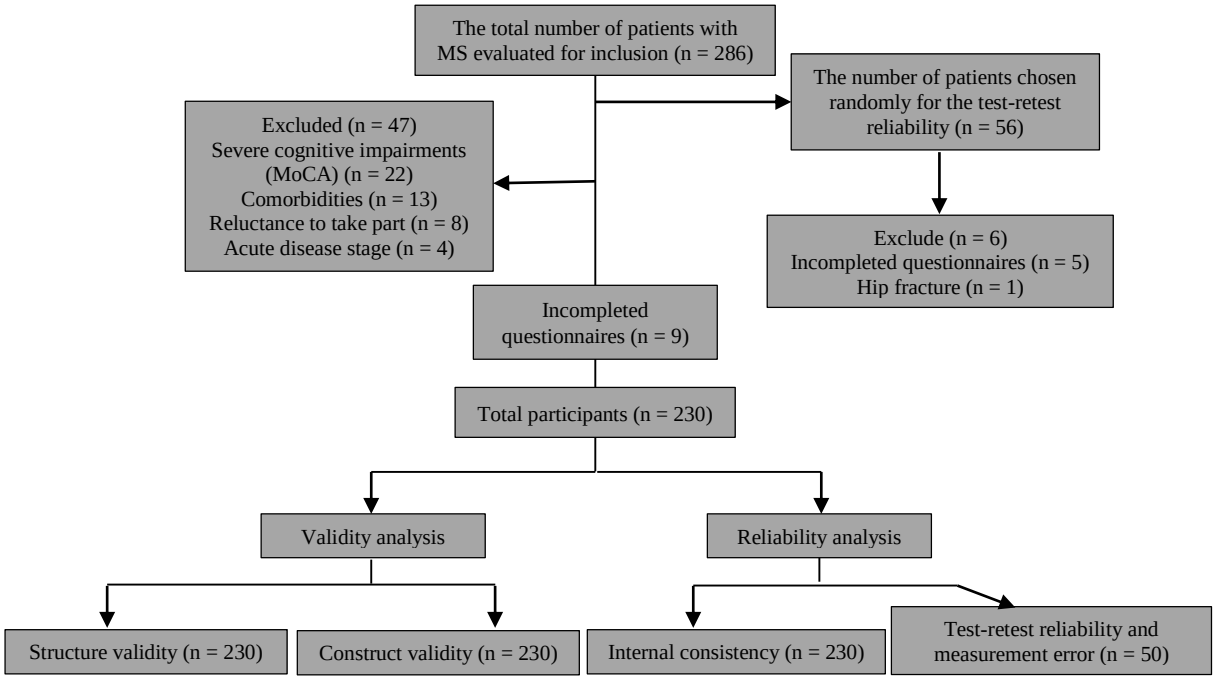

Figure 1. Flow diagram of participants in this study (MS: Multiple sclerosis; MoCA: Montreal Cognitive Assessment)

Table 1. Demographic and clinical characteristics of the participants

Variable		Patients with MS (n = 20) (pre-test phase)	Patients with MS (n = 230) (all participants)
Age (year) (mean ± SD, minimum-maximum)		45.60 ± 7.48 25-58	39.34 ± 9.40 17-65
Gender [n (%)]	Women	11 (55.0)	185 (80.4)
	Men	9 (45.0)	45 (19.6)
Marital status [n (%)]	Single	4 (20.0)	67 (29.1)
	Married	16 (80.0)	163 (70.9)
Education level [n (%)]	Academic	13 (65.0)	132 (57.4)
	Non academic	7 (35.0)	98 (42.6)
Employment status [n (%)]	Employed	6 (30.0)	90 (39.1)
	Unemployed	14 (70.0)	140 (60.9)
EDSS (mean ± SD, minimum-maximum)		2.75 ± 2.03 0-6.5	2.61 ± 2.19 0-7.5
Disease duration (month) (mean ± SD, minimum-maximum)		153.40 ± 109.34 24-484	109.67 ± 77.63 7-484
Type of MS [n (%)]	RR	15 (75.0)	177 (77.0)
	SP	20 (4.0)	39 (17.0)
	PP	1 (5.0)	14 (6.0)
MoCA (mean ± SD, minimum-maximum)		27.10 ± 1.21 25-29	27.50 ± 1.49 25-30
Degree of disability [n (%)]	Mild	12 (60.0)	134 (58.3)
	Moderate	7 (35.0)	69 (30.0)
	Severe	1 (5.0)	27 (11.7)
Pain severity (VAS) (mean ± SD, minimum-maximum)		2.03 ± 1.59 0-4.5	1.64 ± 1.72 0-6

SD: Standard Deviation; EDSS: Expanded Disability Status Scale; VAS: Visual Analuge Scale; MoCA: Montreal Cognitive Assessment; RR: Relapsing remitting; SP: Secondary progressive; PP: Primary progressive; MS: Multiple sclerosis

The results confirmed the appropriateness of the items for this population, allowing progression to the second stage, which involved testing the validity and reliability of the instrument.

Procedures: Participants completed a demographic questionnaire along with the PM-3D4D, CIQ, PM-PAC, SWLS, PIL-SF, and Fatigue Severity Scale (FSS), administered in a randomized order. A neurologist documented each participant's MS subtype and Expanded Disability Status Scale (EDSS) score. To minimize respondent fatigue, structured rest intervals were incorporated during questionnaire administration.

Reliability: In line with COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) guidelines,[24] test-retest reliability of the PM-3D4D was evaluated using a simple random sampling method. 50 PwMS were selected to evaluate test-retest reliability by completing the questionnaire across two sessions held one week apart under standardized time and location conditions. The one-week interval was chosen to reduce the likelihood of clinical change while minimizing recall bias in responses.[9] To ensure stability, all participants were clinically monitored for any significant symptom changes, including medication adjustments, new relapses, or worsened fatigue, during this one-week interval.

Validity: Face and content validity of the PM-3D4D were assessed through structured interviews with two groups: 15 patients (distinct from the 20 participants in the pilot phase) and 15 experts (comprising nine occupational therapists and six physiotherapists), each with 8 to 24 years of experience working with PwMS.

Structural validity was examined using both exploratory and confirmatory factor analyses. Exploratory factor analysis (EFA) with maximum likelihood extraction and varimax rotation was conducted to examine the underlying factor structure of the PM-3D4D. Confirmatory factor analysis (CFA) was performed to assess the model fit. In accordance with COSMIN guidelines (requiring seven participants per item),[24] the study was conducted on a sample of 230 participants.

To evaluate construct validity, 230 PwMS were recruited following COSMIN recommendations of 5-10 participants per item.[24] Construct validity was tested through four predefined hypotheses concerning interdimensional correlations within

the PM-3D4D and their associations with the CIQ, PM-PAC, SWLS, and PIL-SF. These instruments were selected based on conceptual and structural alignment with the PM-3D4D. Based on prior evidence,[5] strong correlations were anticipated between the diversity and frequency dimensions due to their objective nature and structural similarity (Hypothesis 1). Moderate-to-strong correlations were expected between these two dimensions and the difficulty dimension, reflecting structural differences and varying construct relevance (Hypotheses 2, 3). Weak-to-moderate correlations were hypothesized between each of these three dimensions and the desire for change dimension (Hypotheses 4-6).

In line with structural and content overlap, the frequency dimension was expected to correlate strongly with the CIQ (Hypothesis 7), and the difficulty dimension with the PM-PAC (Hypothesis 8). Weak and moderate negative correlations were hypothesized between the desire for change dimension and the SWLS and PIL-SF, respectively (Hypotheses 9, 10), due to the conceptual divergence between life satisfaction and desire for change.[5] Nonetheless, life satisfaction may influence motivational factors that shape individual behavior, supporting the rationale for weak associations.[25]

Known-group validity was assessed by comparing participation scores across subgroups stratified by disability and fatigue severity, as measured by the EDSS and FSS. Previous studies suggest that participation among PwMS is affected by multiple variables, including disability[26] and fatigue.[7] Patients were classified into three disability levels: mild (EDSS: 0-3), moderate (EDSS: 3.5-6), and severe (EDSS ≥ 6.5).[13] Fatigue was assessed using the FSS, categorizing patients as fatigued (FSS ≥ 4) or non-fatigued (FSS < 4).[27] It was hypothesized that participation scores would significantly differ among groups with varying levels of disability and fatigue (Hypotheses 11, 12), as informed by existing research and clinical experience.

Instruments

PM-3D4D: The PM-3D4D is a 24-item self-report questionnaire designed to assess participation over the past three months across three domains: productivity, social engagement, and community activities. It evaluates participation along four dimensions: diversity, frequency, difficulty, and desire for change. Diversity is captured using binary "yes/no" responses, frequency is assessed based on engagement over predefined time intervals, difficulty is rated on a 4-point scale ranging from 1 (very difficult) to 4 (no difficulty), and desire for change is recorded using "yes/no" responses. The PM-3D4D demonstrates strong psychometric performance, with established content validity, high internal consistency (Cronbach's alpha = 0.89-0.93), and robust test-retest reliability ($ICC_{(2,1)} > 0.7$).[10,11]

CIQ: The CIQ is a 15-item instrument that assesses participation across three domains: home (5 items), community (6 items), and productivity (4 items). Total scores range from 0 to 29, with higher scores indicating greater social integration.[28] The validated Persian version has demonstrated acceptable reliability for use in PwMS.[29]

PM-PAC: The PM-PAC assesses self-perceived participation restrictions across productivity, social engagement, and community involvement. It includes 17 items rated on a 5-point scale from 1 (not limited) to 5 (very limited), where higher scores reflect more severe participation limitations.[30] The Persian version has shown strong psychometric performance, supporting its reliability and validity.[31]

SWLS: The SWLS is a 5-item instrument that measures overall life satisfaction using a 7-point Likert scale, from 1 (strongly disagree) to 7 (strongly agree).[32] The Persian version has demonstrated satisfactory reliability and validity in Iranian PwMS.[33]

PIL-SF: The PIL-SF is a 4-item short form derived from the original 20-item instrument, designed to assess life purpose and meaning using a 7-point Likert scale. Total scores range from 4 to 28, with higher scores indicating a greater sense of purpose and meaning.[34] The Persian version has been validated and exhibits acceptable psychometric properties.[35]

FSS: The FSS is a 9-item instrument that measures fatigue severity using a 7-point Likert scale, with scores ranging from 1 (strongly disagree) to 7 (strongly agree). A score of 4 or higher is considered indicative of pathological fatigue.[36] The Persian version has shown acceptable reliability and validity among Iranian PwMS.[37]

BDI-II: The BDI-II is a 21-item scale used to assess depression severity. Cut-off scores are categorized as follows: 0-13 (minimal), 14-19 (mild), 20-28 (moderate), and 29-63 (severe).[18] The Persian version has demonstrated strong reliability.[38]

All analyses were conducted using SPSS software (version 26.0, IBM Corporation, Armonk, NY, USA) and AMOS version 24.0. Following COSMIN guidelines, a minimum of 100 participants was required to ensure adequate evaluation of reliability and validity.[24] The Kolmogorov-Smirnov test indicated non-normal data distribution; therefore, descriptive statistics summarized demographic and clinical characteristics.

Floor and ceiling effects were defined as present if more than 15% of participants scored at the lowest or highest levels on the PM-3D4D.[39] For internal consistency, Cronbach's alpha values > 0.70 were deemed acceptable, and McDonald's omega values ≥ 0.80 were considered good.[40] Test-retest reliability was evaluated using the $ICC_{(2,1)}$ (two-way random, absolute agreement, single rater) with 95% confidence intervals (CIs); values > 0.80 indicated good reliability.[40] Measurement error was estimated using the standard error of measurement (SEM) = standard deviation $(SD)_{Total} \times \sqrt{(1\text{-}ICC_{(2,1)})}$,[40] with SEM ≤ ½ SD_{Total} considered acceptable.[40,41] The minimal detectable change (MDC) was calculated as MDC = SEM × √2 × 1.96 and the MDC% was calculated using the formula: MDC% = (MDC/Scale Range) × 100.[41] Face validity was assessed qualitatively and quantitatively. The Item Impact Method (IIM) employed a 5-point Likert scale (1 = not at all important to 5 = very important), and items with an item impact score (IIS) > 1.5 were considered relevant.[42] Content validity was examined using the Content Validity Ratio (CVR) and the Content Validity Index (CVI). CVR was calculated as (Ne − N/2)/(N/2), where Ne is the number of experts rating the item as essential and N is the total panel size; for 15 experts, CVR > 0.49 was acceptable. Item-level CVI (I-CVI) was defined as the proportion of experts rating an item 3 or 4 on a 4-point scale, with values > 0.79 considered acceptable, while the scale-level CVI (S-CVI/Ave) was derived as the mean of I-CVI scores, with ≥ 0.90 deemed acceptable.[43]

The factor structure was examined in two stages. EFA using maximum likelihood extraction and varimax rotation with Kaiser normalization was first conducted to identify the underlying factor structure (loadings ≥ |0.40| are bolded to indicate primary factor membership). CFA was used to test the model fit of the identified structure. Model fit was evaluated by root mean square error of approximation (RMSEA), Tucker-Lewis index (TLI), comparative fit index (CFI), and the chi-square to degrees of freedom ratio (χ^2/df). RMSEA ≤ 0.08 and CMIN/DF < 3 indicated adequate fit, and an acceptable fit was indicated by TLI and CFI values ≥ 0.9.[44,45]

Construct validity was further examined through Spearman correlation coefficients between PM-3D4D dimensions and the CIQ, PM-PAC, SWLS, and PIL-SF. Correlations were interpreted as weak (< 0.30), moderate (0.30-0.70), or strong (> 0.70).[15] Due to the non-normal distribution, the Kruskal-Wallis and Mann-Whitney U tests were applied to assess discriminative validity by disability level and fatigue severity. For significant Kruskal-Wallis tests, pairwise comparisons were performed using Mann-Whitney U tests with Bonferroni correction, with an adjusted significance level of P < 0.017. For all other analyses, statistical significance was set at P < 0.05.

Results

Participants: Table 1 presents the demographic and clinical characteristics of the 230 PwMS included in the study, comprising 185 women and 45 men. Participants with incomplete data were excluded from the reliability and validity analyses.

Acceptability and Reliability: The PM-3D4D demonstrated acceptable distribution properties, with no notable floor or ceiling effects observed in the overall scores or most subscales. However, ceiling effects were present in the social domain, specifically in the diversity (33.5%) and difficulty (22.6%) dimensions. Internal consistency was strong, with Cronbach's alpha coefficients of 0.79 for the social domain, 0.89 for the community domain, and 0.81 for the productivity domain. The more robust McDonald's omega coefficients further confirmed this reliability, yielding values of 0.83 for the social domain, 0.92 for the community domain, and 0.84 for the productivity domain (Table 2). Test-retest reliability was high, with $ICC_{(2,1)}$ values ranging from 0.81 to 0.91 across domains (Table 3). SEM values ranged from 0.06 to 8.25, and MDC values ranged from 0.16 to 22.86, reflecting acceptable measurement precision across the PM-3D4D scales.

Validity: All items were reported as unambiguous during qualitative interviews. IIS scores ranged from 3.07 to 5.00. CVR values for all PM-3D4D items ranged between 0.60 and 1.00, while I-CVI values fell between 0.86 and 1.00. The S-CVI/Ave was 0.95, reflecting excellent content validity at the scale level (Table 4).

Table 2. Internal consistency of the Persian version of the Participation Measure-3 Domains, 4 Dimensions (PM-3D4D) subscales (n = 230)

Subscale	Cronbach´s α	McDonald's ω	Item-total correlation (range)
Social			
Community	0.79		
Productivity	0.89	0.83	-0.235 ~0.736
	0.81	0.91	-0.148 ~ 0.824
		0.84	-0.018~0.746

Sampling adequacy for factor analysis was verified [Kaiser-Meyer-Olkin (KMO) = 0.867; Bartlett's test of sphericity: χ^2 = 16604.287, P < 0.001]. The EFA revealed substantial cross-loadings across factors, and the CFA demonstrated variable factor loadings, with many items falling below the conventional 0.40 threshold (Supplementary Tables S1-S5). Global fit indices for the CFA were acceptable (RMSEA = 0.08, χ^2/df = 2.76). Construct validity was thoroughly examined through 12 predefined hypotheses, as detailed in tables 5-7. As shown in table 5, strong correlations were observed between the diversity and frequency dimensions (r_s = 0.70-0.88), while moderate to strong correlations were found among diversity, frequency, and difficulty (r_s = 0.37-0.82). The desire for change dimension showed weak to moderate negative correlations with the other dimensions (r_s = -0.13 to -0.57).

As presented in table 5, the frequency dimension showed strong positive correlations with CIQ (r_s = 0.71-0.83). The difficulty dimension demonstrated strong negative correlations with all PM-PAC subscales (r_s = -0.75 to -0.85). The desire for change dimension showed weak negative correlations with SWLS (r_s = -0.16 to -0.29) and moderate negative correlations with PIL-SF (r_s = -0.33 to -0.51).

Table 6 reports significant differences across all PM-3D4D dimensions based on disability severity as measured by EDSS. As hypothesized, participants with higher disability levels showed reduced total diversity (H = 135.88, P < 0.01) and frequency (H = 114.53, P < 0.01), along with greater perceived total difficulty (H = 138.15, P < 0.01) and desire for change (H = 46.59, P < 0.01). It should be noted that for desire for change within the productivity domain, significant differences were only found between the mild and severe disability groups, but not between adjacent severity levels.

Similarly, table 7 illustrates significant differences across all PM-3D4D dimensions between participants classified with and without fatigue based on FSS.

Table 3. Test-retest reliability, standard error of measurement (SEM), and minimal detectable change (MDC) of the Persian version of the Participation Measure-3 Domains, 4 Dimensions (PM-3D4D) (n = 50)

Variable	Test [median (IQR)]	Retest [median (IQR)]	ICC (95% CI)	SEM	MDC	MDC%
Social						
Diversity	0.833 (0.334)	0.833 (0.167)	0.85 (0.76-0.91)	0.07	0.18	18.00
Frequency	3.083 (1.249)	3.166 (1.166)	0.91 (0.84-0.95)	0.24	0.67	11.21
Desire for change	0.333 (0.334)	0.500 (0.333)	0.82 (0.69-0.89)	0.10	0.28	27.90
Difficulty	71.050 (30.385)	71.050 (23.783)	0.81 (0.69-0.89)	8.25	22.86	22.86
Community						
Diversity	0.583 (0.417)	0.583 (0.334)	0.85 (0.75-0.91)	0.09	0.24	23.50
Frequency	1.291 (1.292)	1.666 (0.959)	0.89 (0.82-0.94)	0.24	0.66	10.93
Desire for change	0.583 (0.271)	0.583 (0.166)	0.82 (0.71-0.89)	0.06	0.17	16.60
Difficulty	47.350 (19.770)	47.350 (13.770)	0.85 (0.74-0.91)	5.09	14.12	14.12
Productivity						
Diversity	0.333 (0.167)	0.500 (0.271)	0.88 (0.79-0.93)	0.09	0.23	23.00
Frequency	1.166 (1.000)	1.166 (1.167)	0.87 (0.78-0.92)	0.23	0.64	10.66
Desire for change	0.500 (0.375)	0.500 (0.333)	0.86 (0.76-0.92)	0.09	0.24	23.80
Difficulty	46.310 (34.563)	49.720 (20.820)	0.87 (0.78-0.92)	7.12	19.73	19.73
Total						
Diversity	0.604 (0.344)	0.666 (0.260)	0.82 (0.69-0.89)	0.08	0.21	21.00
Frequency	1.833 (0.990)	1.875 (0.896)	0.84 (0.73-0.91)	0.24	0.65	10.90
Desire for change	0.500 (0.218)	0.500 (0.167)	0.83 (0.72-0.90)	0.06	0.16	15.70
Difficulty	57.813 (26.405)	55.083 (21.205)	0.90 (0.84-0.94)	5.00	13.86	13.86

ICC: Intraclass correlation coefficients; CI: Confidence interval; SEM: Standard error of measurement; MDC: Minimal detectable change; MDC%: Minimal detectable change percentage; IQR: Interquartile range

Table 4. The results of face and content validity of the Persian version of the Participation Measure-3 Domains, 4 Dimensions (PM-3D4D)

Item	IIS	CVR	I-CVI
1	5.00	1.00	1.00
2	4.80	1.00	0.86
3	4.93	1.00	1.00
4	4.66	0.86	1.00
5	3.25	0.86	0.86
6	3.47	0.73	0.93
7	3.46	0.73	0.86
8	4.66	1.00	1.00
9	5.00	1.00	1.00
10	4.86	0.73	1.00
11	4.80	0.86	1.00
12	3.07	0.73	0.93
13	4.03	0.73	1.00
14	4.28	1.00	1.00
15	3.57	0.73	1.00
16	3.87	0.73	0.86
17	4.80	0.86	1.00
18	3.87	0.86	0.93
19	4.93	1.00	1.00
20	3.87	0.86	1.00
21	4.28	0.86	1.00
22	4.80	1.00	1.00
23	3.96	0.73	0.93
24	3.47	0.60	0.86

IIS: Item impact score; CVR: Content validity ratio; I-CVI: Item-level content validity index

Those with fatigue reported lower total diversity ($U = 1543.00$, $P < 0.01$) and frequency ($U = 1704.00$, $P < 0.01$), as well as higher perceived difficulty ($U = 835.50$, $P < 0.01$) and greater desire for change ($U = 3271.00$, $P < 0.01$) in participation.

Discussion

MS symptoms exert a substantial influence on participation,[26] and the inherently multidimensional nature of participation[10] underscores the need for comprehensive evaluation tools. The PM-3D4D addresses this need by assessing multiple participation domains in PwMS. To the authors' knowledge, this is the first study to evaluate the test-retest reliability, measurement error, internal consistency, and construct validity of the PM-3D4D in this population. Findings indicate high test-retest reliability, acceptable internal consistency, and confirmed construct validity for the Persian version.

No significant floor or ceiling effects were observed, except in the social diversity (33.5%) and social difficulty (22.6%) subscales. These ceiling effects, consistent with Chang et al.,[10] may result from item simplicity, the exclusion of participants with severe cognitive impairment, and sociocultural factors in Iran, such as gender roles, social expectations, and limited opportunities for advanced participation. While adding more challenging items could improve discrimination, such items may not be relevant for most PwMS.[10]

The PM-3D4D demonstrated high test-retest reliability across all subscales, with $ICC_{(2,1)}$ values ≥ 0.8, consistent with previous findings.[11] The one-week interval, also supported by Chang was appropriate for minimizing clinical change and recall bias.[11] Cronbach's alpha and McDonald's omega values confirmed strong internal consistency,[10] indicating that items within each subscale are homogeneous and measure single constructs. Compared with the CIQ, which shows low-to-moderate reliability in PwMS,[29] the PM-3D4D provides superior internal consistency, representing a distinct psychometric strength.

SEM values were below ½ SD_{Total}, indicating acceptable measurement precision and stability across test and retest phases.[40] MDC estimates defined the most minor detectable change for each subscale, ensuring that observed differences represent actual clinical change rather than measurement error or random variability. The MDC% values, ranging from 10.66% to 27.9%, establish clinically applicable thresholds. A lower MDC%, such as the 10.66% observed for "productivity frequency", indicates higher measurement precision. Conversely, a higher MDC%, like the 27.9% for "social desire for change", necessitates a larger magnitude of change to confirm a genuine clinical effect.

Both qualitative and quantitative assessments supported face validity. Patients reported no ambiguities in item interpretation, and quantitative evaluation using the IIM confirmed that all items with scores > 1.5 were highly relevant for assessing participation in PwMS.[42] Content validity was further reinforced, as both CVR and CVI exceeded established thresholds.[43] Collectively, these findings confirm that the PM-3D4D items adequately represent the construct of participation. This study, therefore, provides a unique contribution to the existing literature by comprehensively validating the Persian version of the instrument.

The factor analysis results provide compelling empirical evidence supporting the formative nature of the PM-3D4D.[10]

Table 5. Correlation among the four dimension scores of the Persian version of the Participation Measure-3 Domains, 4 Dimensions (PM-3D4D) with Community Integration Questionnaire (CIQ), Participation Measure for Post-Acute Care (PM-PAC), Satisfaction with Life Scale (SWLS), and Purpose in Life Test-Short Form (PIL-SF) (n = 230)

PM-3D4D	Diversity	Frequency	Desire for change	CIQ	PM-PAC	SWLS	PIL-SF
Social							
Diversity	1						
Frequency	0.70* (0.63~0.76)#	1					
Desire for change	-0.39* (-0.55~-0.35)#	-0.52* (-0.61~-0.42)#	1			Total -0.24* (-0.37~-0.13)#	Total -0.49* (-0.59~-0.39)#
Difficulty	0.37* (0.34~0.55)#	0.59* (0.52~0.68)#	-0.53* (-0.65~-0.47)#		Social -0.82* (-0.86~-0.77)#		
Community							
Diversity	1						
Frequency	0.88* (0.85~0.91)#	1		Community 0.71* (0.63~0.76)#			
Desire for change	-0.54* (-0.63~-0.44)#	-0.53* (-0.64~-0.46)#	1			Total -0.26* (-0.35~-0.10)#	Total -0.46* (-0.57~-0.37)#
Difficulty	0.78* (0.72~0.83)#	0.79* (0.71~0.81)#	-0.50* (-0.63~-0.41)#		Community -0.75* (-0.79~-0.68)#		
Productivity							
Diversity	1						
Frequency	0.83* (0.79~0.87)#	1		Productivity 0.83* (0.79~0.87)#			
Desire for change	-0.13* (-0.27~-0.01)#	-0.17* (-0.30~-0.05)#	1			Total -0.16* (-0.28~-0.02)#	Total -0.33* (-0.43~-0.20)#
Difficulty	0.69* (0.60~0.74)#	0.63* (0.54~0.69)#	-0.23* (-0.34~-0.09) #		Productivity -0.81* (-0.88~-0.81)#		
Total							
Diversity	1						
Frequency	0.87* (0.60-0.74)#	1		Total 0.76* (0.70~0.81)#			
Desire for change	-0.49* (-0.47~-0.24)#	-0.57* (-0.67~-0.47)#	1			Total -0.29* (-0.40~-0.17)#	Total -0.51* (-0.60~-0.41)#
Difficulty	0.82* (0.58~0.73)#	0.81* (0.76~0.85)#	-0.56* (-0.65~-0.47)#		Total -0.85* (-0.83~-0.73)#		

The values presented are Spearman correlation coefficients.

*Correlation is significant at the 0.01 level (2-tailed); #95% confidence interval (CI)

PM-3D4D: Participation Measure-3 Domains, 4 Dimensions; CIQ: Community Integration Questionaire; PM-PAC: Participation Measure for Post-Acute Care; SWLS: Satisfaction with Life Scale; PIL-SF: Purpose in Life Test-Short Form

Table 6. Known-group validity of the Persian version of Participation Measure-3 Domains, 4 Dimensions (PM-3D4D) based on the severity of disability of patients with multiple sclerosis (MS) (n = 230)

PM-3D4D	Disability level			Kruskal-Wallis H	η^2	%Diff group 1 vs. group 2	%Diff group 1 vs. group 3	%Diff group 2 vs. group 3
	Group 1 (n = 134) [median (IQR)]	Group 2 (n = 69) [median (IQR)]	Group 3 (n = 27) [median (IQR)]					
Social								
Diversity	0.833 (0.167)	0.833 (0.167)	0.666 (0.333)	38.34	0.16	0.00*	25.08*	25.08*
Frequency	3.500 (1.167)	2.666 (1.000)	2.166 (1.333)	56.04	0.24	31.28*	61.59*	23.09*
Desire for change	0.333 (0.334)	0.500 (0.333)	0.666 (0.500)	35.53	0.15	-33.40*	-50.00*	-24.92*
Difficulty	81.690 (24.040)	56.880 (14.310)	43.480 (24.800)	125.07	0.54	43.58*	87.83*	30.79*
Community								
Diversity	0.750 (0.167)	0.333 (0.166)	0.166 (0.250)	131.51	0.57	125.23*	351.81*	100.60*
Frequency	1.958 (0.750)	0.833 (0.541)	0.416 (0.416)	122.27	0.53	135.05*	370.67*	100.24*
Desire for change	0.500 (0.167)	0.583 (0.250)	0.750 (0.167)	51.53	0.22	-14.24*	-33.33*	-22.27*
Difficulty	61.990 (13.300)	40.390 (11.900)	30.210 (8.430)	141.96	0.62	53.48*	105.20*	33.70*
Productivity								
Diversity	0.500 (0.166)	0.333 (0.167)	0.166 (0.167)	99.05	0.43	50.15*	201.20*	100.60*
Frequency	1.666 (0.667)	0.833 (0.666)	0.500 (0.500)	85.09	0.37	100.00*	233.20*	66.60*
Desire for change	0.500 (0.333)	0.500 (0.333)	0.666 (0.500)	8.80	0.03	0.00	-24.92*	-24.92
Difficulty	66.450 (15.100)	38.720 (20.900)	22.080 (21.500)	121.78	0.53	71.62*	200.95*	75.36*
Total								
Diversity	0.708 (0.094)	0.416 (0.166)	0.291 (0.208)	135.88	0.59	70.19*	143.30*	42.96*
Frequency	2.166 (0.500)	1.333 (0.625)	0.958 (0.625)	114.53	0.49	62.49*	126.10*	39.14*
Desire for change	0.458 (0.208)	0.541 (0.187)	0.666 (0.292)	46.59	0.19	-15.34*	-31.23*	-18.77*
Difficulty	71.490 (15.770)	45.320 (11.480)	33.450 (16.840)	138.15	0.60	57.74*	113.72*	35.49*

Group 1: Mild disability [Expanded Disability Status Scale (EDSS): 0-3]; Group 2: Moderate disability (EDSS: 3.5-6); Group 3: Severe disability (EDSS ≥ 6.5)
*Pairwise comparisons (Mann-Whitney U) using Bonferroni correction (P < 0.017)
PM-3D4D: Participation Measure-3 Domains, 4 Dimensions; %Diff: Percentage difference between group medians

Table 7. Known-group validity of the Persian version of Participation Measure-3 Domains, 4 Dimensions (PM-3D4D) based on the severity of fatigue of patients with multiple sclerosis (MS) (n = 230)

PM-3D4D	Severity of Fatigue					
	Group 1 (n = 89) [median (IQR)]	Group 2 (n = 141) [median (IQR)]	Mann-Whitney U	r	P	%Diff group 1 vs. group 2
Social						
Diversity	0.833 (0.167)	0.833 (0.334)	4315.50	0.28	< 0.01	0.00
Frequency	3.666 (0.834)	2.666 (1.251)	2883.00	0.46	< 0.01	37.51
Desire for change	0.333 (0.334)	0.500 (0.333)	3755.00	0.34	< 0.01	-33.40
Difficulty	100.000 (18.310)	59.860 (20.110)	1071.00	0.70	< 0.01	67.09
Community						
Diversity	0.750 (0.167)	0.416 (0.333)	1546.00	0.64	< 0.01	80.29
Frequency	2.000 (0.709)	1.000 (0.917)	1802.00	0.60	< 0.01	100.00
Desire for change	0.500 (0.208)	0.583 (0.250)	3353.00	0.39	< 0.01	-14.24
Difficulty	63.880 (12.420)	41.810 (19.400)	1123.00	0.69	< 0.01	52.79
Productivity						
Diversity	0.666 (0.166)	0.333 (0.334)	2403.00	0.53	< 0.01	100.00
Frequency	1.666 (0.667)	1.000 (0.917)	2585.00	0.49	< 0.01	66.60
Desire for change	0.500 (0.333)	0.500 (0.333)	4897.00	0.19	< 0.01	0.00
Difficulty	70.290 (17.240)	42.640 (27.470)	1370.00	0.66	< 0.01	64.84
Total						
Diversity	0.750 (0.104)	0.458 (0.292)	1543.00	0.64	< 0.01	63.76
Frequency	2.333 (0.500)	1.416 (0.896)	1704.00	0.61	< 0.01	64.76
Desire for change	0.416 (0.167)	0.541 (0.208)	3271.00	0.40	< 0.01	-23.11
Difficulty	77.260 (12.280)	47.490 (24.060)	835.50	0.73	< 0.01	62.64

All pairwise comparisons were significant at $P < 0.01$ (Mann-Whitney U test); Group 1: Without fatigue [Fatigue Severity Scale (FSS) < 4]; Group 2: With fatigue (FSS ≥ 4)

PM-3D4D: Participation Measure-3 Domains, 4 Dimensions; IQR: Interquartile range; %Diff: Percentage difference between group medians

The observed pattern – acceptable global model fit alongside problematic item-level parameters (substatial cross-loadings in EFA and low factor loadings in CFA) – creates a psychometric profile that would be considered problematic for a reflective instrument but is entirely consistent with formative measurement theory. In formative models, items are conceptualized as independent determinants that collectively define the construct rather than as interchangeable effects of a latent variable.[24] Consequently, these psychometric patterns are not indicative of poor quality but are instead the expected statistical signature of a formative model, where items represent independent, non-redundant determinants that collectively form the composite construct.

Interrelationships among dimensions matched the predefined hypotheses.[5] Weak associations were also noted between the objective and subjective aspects of the PM-3D4D[5] and the Participation Objective, Participation Subjective (POPS).[46] Diversity and frequency were strongly correlated, while both showed moderate-to-strong associations with difficulty and weak associations with desire for change. External validity was reinforced by strong correlations between frequency and the CIQ and between difficulty and the PM-PAC.[5] The desire-for-change dimension showed weak negative correlations with the SWLS, reflecting its distinction from overall life satisfaction.[46,47] As noted in Chang et al.'s research, individuals may feel dissatisfied with their participation yet lack the motivation to change; conversely, they may be satisfied with life while still wishing to alter their participation.[5] In contrast, strong correlations with the PIL-SF suggest a closer link with life purpose, as individuals with explicit goals are more motivated to alter participation.[48]

Participation scores also differed significantly across disability and fatigue subgroups. Disability, measured by the EDSS, was a major predictor.[2] Studies have shown that patients with lower disability reported greater participation,[49] whereas those with moderate to severe disability showed marked restrictions.[2] Notably, we found that desire for change in productivity followed a different pattern, increasing significantly only in severe disability rather than showing gradual increases across all disability levels. This indicates that substantial functional loss may be necessary to trigger meaningful motivation for changing

productive activities. Fatigue further limited participation,[4,7] particularly in complex social and work activities,[7] even in the early stages of MS.[50] These findings supported the study hypotheses. According to COSMIN standards, acceptance of ≥ 75% of hypotheses indicates adequate construct validity.[24] In the present study, all 12 hypotheses (100%) were confirmed, demonstrating strong construct validity.

Conclusion

The PM-3D4D, validated for reliability and clinical applicability, provides a structured, evidence-based instrument for assessing participation in PwMS. Its use supports intervention planning and treatment prioritization by identifying specific restrictions across daily activities and social roles. Given the substantial impact of participation limitations on quality of life (QOL) and overall well-being, the instrument holds significant clinical and research relevance. By offering a functional framework for rehabilitation, the PM-3D4D enables clinicians to establish targeted therapeutic goals, allocate resources effectively, and direct interventions toward the most affected domains. Future research should establish the minimal clinically important difference (MCID) for the PM-3D4D to determine its sensitivity to subtle but clinically meaningful changes in participation levels.

The predominance of female participants reflects the known gender distribution of MS but may reduce generalizability. Exclusion of PwMS with severe cognitive impairment, necessitated by the self-report format, represents an additional limitation. Moreover, the use of convenience sampling and the cross-sectional design restricted causal inferences and precluded assessment of longitudinal changes. Future longitudinal investigations are, therefore, recommended to address these methodological constraints. Finally, the lack of comparable validated versions in other languages limited opportunities for cross-linguistic validation and broader contextual interpretation.

Conflict of Interests

The authors declare no conflict of interest in this study.

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