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The Arabic Version of the Prosthesis Embodiment Scale (AR-PEmbs): Translation, Cross-Cultural Adaptation, Reliability, and Validity in Lebanese Individuals with Lower-Limb Amputation

Nour El Hoda Saleh, DPT, Zainab Yassine, BS, Fatima Saleh, BS, Marwa Summaka, PhD, Fatima Hamieh, PhD, Ibrahim Naim, MD

ABSTRACT

Introduction: This study aimed to translate and cross-culturally adapt the Arabic version of the Prosthesis Embodiment Scale for Individuals with lower-limb amputation (AR-PEmbS-LLA) and evaluate its validity and reliability.

Methods: The AR-PEmbS-LLA was developed using a forward-backward translation process, expert reviews, and pilot testing with 10 individuals with lower-limb amputation (LLA). A cross-sectional, correlational study was conducted with 60 Lebanese adults with major LLAs who used prosthetic devices. Participants completed the AR-PEmbSLLA and the Houghton scale for prosthetic use, the revised Trinity Amputation and Prosthesis Experience Scale (TAPES-R) for adjustment and satisfaction, and the Locomotor Capabilities Index (LCI) for locomotor abilities. Internal consistency, test-retest reliability, and exploratory factor analysis were performed to assess the psychometric properties of the AR-PEmbS-LLA. Convergent validity was evaluated using Spearman correlations with the other scales.

Results: The AR-PEmbS-LLA demonstrated high internal consistency (Cronbach $\alpha = 0.97$) and test-retest reliability (intraclass correlation coefficient = 0.95, $P < 0.01$). Exploratory factor analysis confirmed a single-factor structure explaining 78.23% of the variance. Significant correlations were found with TAPES-R general adjustment ($r = 0.37$, $P < 0.001$), social adjustment subscales ($r = 0.33$, $P = 0.001$), and the LCI basic activities score ($r = 0.39$, $P < 0.001$), and the LCI advanced activities score ($r = 0.35$, $P < 0.01$).

Conclusions: The AR-PEmbS-LLA is a reliable and valid instrument for assessing prosthesis embodiment in Arabic-speaking individuals with LLA. It can be effectively used in clinical and research settings to understand and enhance the prosthesis integration experience.

Clinical Relevance: The AR-PEmbS-LLA represents a valuable addition to the limited toolkit for evaluating and optimizing prosthetic outcomes in Arabic-speaking individuals with LLA, enhancing clinical practice and research endeavors in this field. (*J Prosthet Orthot.* 2025;00:00–00)

KEY INDEXING TERMS: lower-limb amputation, embodiment, prosthesis, psychometrics

Successful prosthetic rehabilitation is essential to enhance the physical and mental repercussions of lower-limb amputations (LLAs).[1] Efficient prosthetic services must address patients' functionality, preferences, goals, and health status.[2] Accordingly, one of the main requirements for high-quality prosthetic care is user satisfaction,[3] and perspective on adjustment and comfort.[4,5]

Prior research identified variables linked to the adjustment to the amputation and prosthesis satisfaction of individuals with LLA such as the prosthesis fit, use, appearance, functional and physical features, and residual limb health,[4] as well as body image disturbance,[6] and symptoms of depression and anxiety.[7,8] Consequently, a new paradigm called "prosthesis embodiment" has recently emerged in the literature as an essential indicator of prosthetic satisfaction and adaptation to prosthesis use.[9]

The embodiment of a prosthesis has been described as incorporating the prosthetic device into the body representation of patients with amputation.[10,11] This definition has been debated in the literature.[12] Recently, an assessment tool was developed to define the psychometric structure of prosthesis embodiment

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and evaluate the embodiment experience from the viewpoint of individuals with amputation.[13] Consequently, a phenomenological principle of the embodiment has been operationalized by decomposing it into cognitive subdimensions that reflect the sense of agency and ownership, which are easier to describe and measure unambiguously.[14]

The Prosthesis Embodiment Scale for Lower-Limb Amputees (PEmbS-LLA) is a 10-item questionnaire designed to assess the experience of prosthesis embodiment. Initially, it was developed in the English and German languages, consisting of three subscales: Ownership/Integrity, Agency, and Anatomical Plausibility, and demonstrates good psychometric properties.[13] Additionally, a subsequent study explored the factors associated with prosthesis embodiment using the PEmbS-LLA, such as psychological variables and prosthesis satisfaction.[15] Recently, a detailed psychometric Rasch analysis was performed, and a revised version with unidimensional construct and scoring was developed.[14] The PEmbS-LLA was recently translated into Turkish.[16] This study aimed to develop an Arabic version of the PEmbS-LLA (AR-PEmbS-LLA) and to assess its validity and reliability in evaluating the prosthesis embodiment experience among Lebanese individuals with LLA.

METHODS

CROSS-CULTURAL ADAPTATION OF THE PROSTHESIS EMBODIMENT SCALE FOR LOWER-LIMB AMPUTEES

To produce the AR-PEmbS-LLA, we obtained the permission and approval of the initial author. The forward-backward translation process was performed according to guidelines for the cross-cultural adaptation of health status measures.[17] Two native Lebanese Arabic speakers, one a physical therapist and the other a rehabilitation nurse, individually translated the English PEmbS-LLA into Arabic. After discussing discrepancies between the two translations, a preliminary Arabic version was developed and independently back-translated by two native English speakers unaware of the original English version. Finally, an expert review committee, consisting of the four translators, a physical medicine and rehabilitation physician, and a clinical psychologist, reviewed the translated versions independently and then met to resolve all inconsistencies to develop a preliminary final AR-PEmbS-LLA for pilot testing (Supplementary Material 1, http://links.lww.com/JPO/A149).

Pilot testing was performed to assess the content validity of the prefinal version of the AR-PEmbS-LLA. Ten Lebanese individuals with LLA were asked to complete the scale, and then complete a questionnaire on the relevance, comprehensibility, and comprehensiveness of the translated items. After the questionnaire completion, interviews were conducted where the participants did not report any ambiguities or problems in understanding the questionnaire items.

STUDY DESIGN AND PARTICIPANTS

We conducted a cross-sectional, correlational study between January and April 2024, at the Health, Rehabilitation, Integration, and Research (HRIR) Center in Lebanon, a multidisciplinary rehabilitation center in three branches across three different Lebanese districts. Participants included Lebanese individuals aged above 18 years old who had acquired a major LLA, possessed a prosthetic device for limb loss, and could read and understand Arabic. Participants with congenital limb deficiencies or documented cognitive disorders were excluded.

SAMPLE SIZE CALCULATION

Based on the sample size requirement for validating clinical instruments suggesting a ratio of total subjects to scale items 5:1,[18] the minimal required sample size for validating the 10-item PEmbS-LLAPES is 50. However, our final sample included 60 participants, exceeding the required sample size.

PROCEDURE

Telephone interviews were conducted to invite and screen participants with LLAs. After explaining the study objectives and procedures, an informed consent form, which emphasized voluntary participation, was sent to those who met the inclusion criteria and expressed interest in participating. Participants who consented signed the form and returned it. Upon receiving the signed consent, participants were invited to a scheduled meeting to complete a questionnaire and required outcome measures. To evaluate test-retest reliability, a second assessment was conducted 2 months after the initial data collection for each participant. The study adhered to the research ethics principles outlined in the Declaration of Helsinki[19] and was approved by the HRIR Institutional Research Board (HRIR.P020.05.10/2023).

MEASURES

The questionnaire comprised three sections. The first section included sociodemographic questions, the second covered information on amputation and prosthesis use, and the third consisted of the outcome measures. These measures included the Houghton scale for evaluating prosthetic use,[20] the Arabic version of the revised Trinity Amputation and Prosthesis Experience Scale (TAPES-R) for assessing adjustment and satisfaction with the prosthesis,[21] the Locomotor Capabilities Index (LCI) for assessing locomotor skills,[22] and the AR-PEmbS-LLA.

THE HOUGHTON SCALE

The Houghton scale is a self-administered tool that comprises four items. The first three items, rated on a 4-point scale, assess prosthetic use habits. The fourth item consists of three dichotomous (yes/no) questions that evaluate a patient's comfort level when navigating various outdoor surfaces. The total score ranges from 0 to 12, with higher scores indicating better Community and Household Walking Ability.[23] Since there is no validated Arabic version of this scale, a group of five rehabilitation professionals translated the Houghton scale items into Arabic, and the translation was finalized through consensus. Further details regarding the scale can be obtained by reaching out to the corresponding author.

THE ARABIC VERSION OF THE REVISED TRINITY AMPUTATION AND PROSTHESIS EXPERIENCE SCALE

The TAPES-R is a self-reported multidimensional questionnaire evaluating three dimensions: psychological adjustment, activity restriction (AR), and prosthesis satisfaction.[24,25] The

psychosocial adjustment includes general adjustment (GA), social adjustment (SA), and adjustment to limitation (AL) subscales. Each subscale includes five items on a 4-point Likert scale, ranging from 1 for "strongly disagree" to 4 for "strongly agree." By summing the values of each item and dividing the total by the number of items, each subscale can be individually scored, yielding a total score between 1 and 4, with higher scores indicating greater adjustment.

The AR scale consists of 10 items scored on a 3-point scale (limited a lot, limited a little, not limited at all). The subscale is graded by averaging the results of all of the items, with higher restrictions linked to higher scores. Prosthesis satisfaction is divided into Aesthetic Satisfaction (AS) (three items) and Functional Satisfaction (FS) (five items) subscales. These items are rated on a scale ranging from "not satisfied" to "extremely satisfied," and each item is scored from 0 to 3.[25] The scoring of each subscale is obtained by summing the values of the items, with higher scores associated with greater prosthesis satisfaction.

TAPES-R has been translated into various languages with good psychometric properties and has been universally used for clinical and research purposes.[24,26,27] The Arabic version has been demonstrated to be a reliable and valid tool for measuring multidimensional adjustment to amputation; factor analysis resulted in similar three dimensions of the original TAPES-R, with high Cronbach α of 0.892, 0.894, and 0.873 for the three subscales.[21] Within the current study, we used the Arabic version of the TAPES-R.

THE LOCOMOTOR CAPABILITIES INDEX

The LCI is a 14-item questionnaire developed for evaluating the walking abilities of individuals wearing lower-limb prostheses. It consists of evaluating the ability to perform basic (7 items) and advanced activities (7 items) and the independence level while executing these activities. Each item is scored on a 4-point Likert scale: 0 (not able to), 1 (yes, with help from another person), 2 (yes, with supervision), and 3 (yes, independently). The total LCI score ranges from 0 (worst) to 42 (best), which is obtained by summing the 14-item scores. It is a valid and reliable tool for evaluating the ability of LLAs to perform activities with prostheses.[22] Since there is no validated Arabic version of this scale, five rehabilitation professionals translated the LCI into Arabic, reaching a consensus on the translation. Further details regarding the scale can be obtained by reaching out to the corresponding author.

THE ARABIC PROSTHESIS EMBODIMENT SCALE FOR LOWER-LIMB AMPUTEES

The Prosthesis Embodiment Scale measures prosthesis embodiment experiences and may be used to accurately identify variables related to the perception of prosthesis integration into an individual with LLA's body representation.[13] The 10 items that make up the PEmbS-LLA focus on the dimensions of Ownership/Integrity (a sense of belongingness for the prosthesis), Agency (a sense of being in control of the prosthesis), and Anatomical Plausibility (referring to the spatial-structural characteristics of the prosthesis concerning the individual with LLA's body).[13] These characteristics assess the extent to which a prosthesis is cognitively and perceptually integrated as a part of the individual with LLA's body, as opposed to being merely a tool.[15] Participants are asked to look at or walk with the prosthesis before indicating their agreement or disagreement with given statements, using a Likert scale ranging from –3 (strongly disagree) to +3 (strongly agree). The total score, representing an overall measure of perceived prosthesis embodiment, is calculated by averaging all valid items, with higher scores indicating higher prosthesis embodiment.[13]

A recent Rasch analysis of the PEmbS-LLA indicates the essential unidimensionality of the instrument, confirming that it measures a single underlying construct, which is crucial for calculating meaningful global scores. The analysis also led to simplifying the rating scale structure, now utilizing a 4-point Likert scale ranging from "strongly disagree" to "agree strongly." To address the local dependence identified between two items on the scale, the calculation of the global score was adjusted by using only the lower score between items #9 ("The prosthesis is moving the way I want it to move") and #10 ("I am in control of the prosthesis").[14] The revised version of the PEmbS-LLA is considered a psychometrically sound instrument for assessing prosthesis embodiment in individuals with LLA for research and clinical purposes.[14] The PEmbS-LLA was originally developed in English and German and then adapted recently to Turkish.[16]

In our study, we utilized the original English-language items from the original version of the PEmbS-LLA,[13] and we adopted the revised scoring system. Note that the revised version does not change any of the items.[14]

STATISTICAL ANALYSIS

Data analysis was performed using the statistical software SPSS version 26.0. For descriptive statistics, continuous variables were described using means and standard deviations (SDs), whereas categorical variables were presented as frequencies and percentages. Cronbach α was calculated to evaluate internal consistency, with a coefficient above 0.7 indicating high internal consistency.[28] To assess test-retest reliability, a second assessment was conducted at least 2 weeks after the initial data collection, and the intraclass correlation coefficient (ICC) was evaluated.

Following the initial author's suggestion, exploratory factor analysis was conducted using principal axis factoring to investigate the factor structure of the AR-PEmbS-LLA. Sampling adequacy was assessed via the Kaiser-Meyer-Olkin (KMO) measure along with Barlett's test of sphericity. Eigenvalues greater than 1 and visual inspection of the scree plot were considered with the aim of determining the number of factors retained in the scale. Nonparametric Spearman correlations between the AR-PEmbS-LLA, the Houghton score, the subscales of the Arabic TAPES-R, and the LCI were calculated for further validation.

RESULTS

BASELINE CHARACTERISTICS OF THE PARTICIPANTS

Sixty Lebanese adults with LLA participated in the current study. Participants had a mean age of 39.77 ± 13.15 years, and 85% of them were males. The average time since amputation was 13.21 ± 11.22. Most participants had a transtibial amputation

(71.7%), with a traumatic cause in 85%. The sociodemographic and clinical details of the sample are reported in Table 1.

OUTCOME MEASURES

Table 2 presents the outcome measures of the participants on the different scales used. Results of the Houghton score demonstrated an average of 8.46 ± 2.43 out of 12, indicating that the majority of the sample had limited prosthesis use. Results of the TAPES subscales demonstrated high psychosocial adjustment to amputation, reflected by high scores in general adjustment (3.28 ± 0.64 out of 4) and social adjustment (3.32 ± 0.69 out of 4). Adjustment to limitation was moderate with an average of 2.816 ± 0.880 out of 4. Activity restriction was average, with a mean score of 1.02 ± 0.59 out of 2. Satisfaction with the prosthesis was good, as indicated by a mean score of 6.10 ± 1.51 out of 9 on the TAPES aesthetic satisfaction subscale, and 10.33 ± 2.94 out of 15 on the TAPES functional satisfaction subscale. Additionally, an average of 32.80 ± 11.25 out of 42 on the LCI reflected good locomotor capabilities with the prosthesis. For the prosthesis embodiment, the mean total score of the AR-PEmbS was 13.63 ± 8.69 out of 27, reflecting an average score.

Table 1. Baseline characteristics of participants (n = 60)

Variable	Frequencies	Percentage (%)
Gender		
Male	51	85
Female	9	15
Educational level		
Elementary	16	26.66
Secondary	21	35
High school	11	18.33
University	10	16.66
Postgraduates	2	3.33
Employment status		
Employed	24	40
Unemployed	36	60
Marital status		
Married	48	80
Unmarried	12	20
Cause of amputation		
Traumatic amputation	51	85
Peripheral vascular disease	6	10
Congenital limb deficiency	3	5
Level of amputation		
Transfemoral amputation	13	21.66
Knee disarticulation	3	5.0
Transtibial amputation	43	71.66
Foot amputation	1	1.66
	Mean ± SD	
Age	39.76 ± 13.15	
Time since amputation	13.21 ± 11.22	
Time since the first prosthesis	11.94 ± 10.72	
Time since the current prosthesis	4.62 ± 5.61	

SD, standard deviation.

Table 2. Total scores of the outcome measures

Measures	Possible Values	Mean ± SD
Houghton score	0–12	8.466 ± 2.438
TAPES GA subscale	1–4	3.280 ± 0.643
TAPES SA subscale	1–4	3.326 ± 0.695
TAPES AL subscale	1–4	2.816 ± 0.880
TAPES AR subscale	0–2	1.028 ± 0.592
TAPES AS subscale	3–9	6.100 ± 1.514
TAPES FS subscale	5–15	10.333 ± 2.943
LCI basic activities score	0–21	15.01 ± 6.62
LCI advanced activities score	0–21	17.78 ± 5.23
AR-PEmbS total score	0–27	13.633 ± 8.698
Retest AR-PEmbS total score	0–27	13.083 ± 9.097

SD, standard deviation; TAPES, Trinity Amputation and Prosthesis Experiences Scales; GA, General Adjustment subscale; SA, Social Adjustment subscale; AL, Adjustment to Limitation subscale; AR, Activity Restriction subscale; AS, Aesthetic Satisfaction subscale; FS, Functional Satisfaction subscale; LCI, Locomotor Capabilities Index; AR-PEmbS Total Score, total score of the Arabic Prosthesis Embodiment Scale; Retest AR-PEmbS Total Score, total score of the Arabic Prosthesis Embodiment Scale at retest.

EXPLORATORY FACTOR ANALYSIS

Exploratory factor analysis was performed on the 10 items of the AR-PEmbS to assess its factor structure. KMO measure confirmed sampling adequacy for the analysis, KMO = 0.90, and Bartlett's test of sphericity was significant, $\chi^2 = 82.19$, $P < 0.001$, indicating that correlations between items were sufficiently high for PAF. One factor has been extracted with an eigenvalue of 8.03, explaining 78.23% of the total variance (Table 3). The inspection of the Scree plot confirmed the unidimensionality of the scale as displayed in Figure 1. Factor loadings ranged between 0.83 and 0.93, and the extracted communalities ranged between 0.69 and 0.87.

RELIABILITY ANALYSIS

The internal consistency of the AR-PEmbS, expressed in terms of Cronbach α, was 0.97. The test-retest reliability was assessed using the average measure of the ICC, which was 0.95 (0.92–0.97) with a significant $P < 0.001$ The average duration between the first and second assessments was 67.95 ± 5.80 days, with a range of 62 to 81 days.

CONVERGENT VALIDITY

Table 4 displays the convergent validity of the AR-PEmbS, assessed through Spearman correlations. Due to multiple comparisons, we applied the Bonferroni correction to control for type I errors. With 45 correlations tested and an original significance level of 0.05, the adjusted significance threshold was set at α-adjusted <0.001. Correlations with P values below this threshold were considered statistically significant. The results showed a significant correlation of the total score of the AR-PEmbS and the TAPES GA and SA subscales ($r = 0.37$, $P < 0.001$ and $r = 0.33$, $P < 0.001$, respectively). Moreover, a fair

correlation is observed with the LCI basic activities score (r = 0.39, P < 0.001), and the LCI advanced activities score (r = 0.35, P < 0.01).

DISCUSSION

This study aimed to provide a cross-cultural adaptation of the PEmbS and to investigate its psychometric properties among Lebanese individuals with LLA. The findings indicate that the AR-PEmbS exhibits good validity and reliability similar to the original English and German versions as well as the recent Turkish version.[13,14,16]

In the current study, we utilized the original English-language items from the original version of the PEmbS-LLA, and we adopted the revised scoring system.[14] Note that the revised version does not change any of the items; however, the revised scoring system was developed to improve the scale's psychometric properties, including its reliability and validity.[14] This revised scoring system provides a more accurate and sensitive measure of prosthetic embodiment.

Participant demographics were characterized by a predominantly male sample with an average age of 39.77 years, with the majority of whom had LLA of traumatic cause. The outcome measures revealed that participants had limited prosthesis use as indicated by the Houghton score. The TAPES subscale scores demonstrated high psychosocial adjustment, moderate adjustment to physical limitations, and generally good satisfaction with the prosthesis. These results align with the sociodemographic and clinical characteristics and satisfaction with prosthesis levels observed in Lebanese individuals with LLA in a previous study.[29] Specifically, participants showed an average level of prosthesis embodiment (13.63 ± 8.69 out of 27), which contrasts with findings from a previous study in the German population showing higher PEmbS-LLA total scores.[13]

This discrepancy in prosthesis embodiment scores can be explained by several factors. First, the majority of participants in the current study had limited community ambulation and a reduced frequency of prosthesis use, which has been shown to correlate with lower levels of prosthesis embodiment.[13] Additionally, the state of prosthetic and orthotic technology and development in this population is notably behind compared with countries like Germany and Turkey, which are higher-income countries, with Germany classified as high-income and Turkey as upper-middle-income, whereas Lebanon falls into the lower-middle-income category. This economic difference significantly influences the availability of resources, technological advancements, and the infrastructure needed for prosthetics and orthotics services. In contrast, there is a limited number of centers for prosthetics and orthotics in Lebanon, and the local National Committee of Prosthetics and Orthotics in Lebanon comprises a restricted range of stakeholders, including prosthetists/orthotists, health care providers, doctors, and representatives from the Ministry of Public Health. This committee has limited power in terms of coordination and capacity to advance the development and accessibility of services. Moreover, there is a lack of comprehensive guiding frameworks for the advancement and

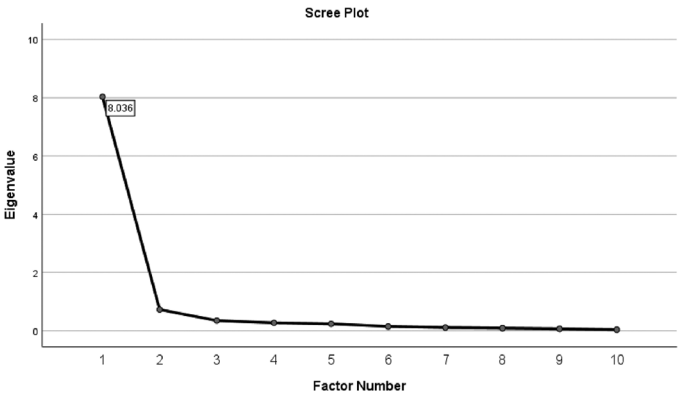

Figure 1. Scree plot representing the unidimensionality of the AR-PEmbS. Scree plot representing the unidimensionality of the AR-PEmbS.

Table 3. Exploratory factor analysis of the AR-PEmbS

Items	Factor Loading	Communalities
My body feels complete.	0.93	0.87
The prosthesis belongs to me.	0.92	0.86
The prosthesis is in the location where I would expect my leg to be, if it was not amputated	0.92	0.84
The prosthesis is a part of my body.	0.89	0.80
The prosthesis is my leg.	0.89	0.79
The prosthesis is moving the way I want it to move.	0.87	0.76
I am in control of the prosthesis.	0.85	0.73
It feels as if I had two legs.	0.85	0.72
I feel as if I was looking directly at my own leg, rather than at a prosthesis.	0.84	0.71
The posture of the prosthesis corresponds to that of a real leg.	0.83	0.69
Eigenvalue	8.03	
Percentage of explained variance	78.22	
Cronbach α	0.97	

Extraction method, principle axis factoring; rotation method, oblique rotation with Kaiser normalization. Factor loadings are arranged in descending order.

Table 4. Convergent validity of the AR-PEmbS

Scale/Subscale	Houghton Score	TAPES GA	TAPES SA	TAPES AL	TAPES AR	TAPES AS	TAPES FS	LCI Basic Activities Score	LCI Advanced Activities Score
AR-PEmbS	0.314 $P = 0.01$	0.371 $P < 0.001$	0.332** $P < 0.001$	−0.039 $P = 0.768$	−0.230 $P = 0.078$	0.158 $P = 0.228$	0.194 $P = 0.138$	0.390* $P < 0.001$	0.356** $P < 0.001$

*Spearman correlation.

**Correlation is significant at the 0.001 level.

AR-PEmbS, The Arabic Prosthesis Embodiment Scale; TAPES, Trinity Amputation and Prosthesis Experiences Scales; GA, General Adjustment subscale; SA, Social Adjustment subscale; AL, Adjustment to Limitation subscale; AR, Activity Restriction subscale; AS, Aesthetic Satisfaction subscale; FS, Functional Satisfaction subscale; LCI, Locomotor Capabilities Index.

delivery of prosthetics and orthotics services.[30] These factors collectively may hinder optimal prosthetic use and embodiment in this population, further explaining the observed differences from the German cohort.

The exploratory factor analysis of the AR-PEmbS revealed a unidimensional structure, explaining 78.23% of the total variance. High factor loadings and communalities indicate that the items on the AR-PEmbS are strongly related to the underlying construct of prosthetic embodiment. Exploratory factor analysis of the initial English and German PEmbS, and the new Turkish version demonstrate three subscales.[13,16] Therefore, this one-dimensional structure is consistent with the latest study, indicating the instrument's essential unidimensionality.[14]

For reliability analysis, Cronbach α of the scale (α = 0.973) and test-retest reliability (ICC = 0.95) indicated excellent internal consistency for the AR-PEmbs. This is close to Cronbach α calculated in the original version (α = 0.91 and ICC = 0.84),[13] and of the Turkish version (α = 0.90 and ICC = 0.82).[16] These high-reliability results suggest that the AR-PEmbS is a stable and consistent measure of prosthetic embodiment over time.

The significant correlations between the AR-PEmbS and established measures like the TAPES subscales, and the LCI subscales provide moderate evidence for the convergent validity of the scale. These findings are consistent with previous results, revealing that prosthesis embodiment is significantly and positively associated with both aesthetic and functional prosthesis satisfaction.[15,16] Additionally, similar to the Turkish validation study of the PEmbS-LLA,[16] the AR-PEmbS showed correlations with advanced locomotor capabilities and frequency of prosthesis use.[13] These correlations indicate that while the AR-PEmbS is related to other prosthetic use and adjustment measures, it also captures unique aspects of prosthetic embodiment such as the sense of ownership over the prosthetic limb, its integration into the user's body image, and the feeling of agency in using the prosthesis.

Previous studies on prosthesis embodiment are rare.[31] To the best of our knowledge, our study is the first to validate an AR-PEmbS-LLA in the Lebanese population. Currently, the PEmbS is only available in English, German, and Turkish.[16] This effort can fill a significant gap in the literature and set a basis for further research in this area. The validation of the AR-PEmbS provides clinicians and researchers with a culturally relevant tool to assess prosthetic embodiment in Arabic-speaking populations. This scale can be used by rehabilitation and prosthetics professionals to better understand the psychological and functional aspects of prosthetic use, facilitating targeted interventions to improve overall rehabilitation outcomes for individuals with LLA.

The study has several limitations. First, the sample size of 60 participants restricts the generalizability of the findings concerning prosthesis embodiment among Lebanese individuals with LLAs. However, according to the COSMIN checklist,[32] which sets guidelines for measurement instrument validation, the sample size meets the minimum requirement for validating the AR-PEmbS (10 items), indicating adequacy for structural validity assessment. Second, the sample's homogeneity, predominantly comprising male participants with traumatic amputations, further limits generalizability. This demographic representation reflects higher incidence

rates of LLA among males,[33] particularly in regions affected by conflict, such as Lebanon. Future studies should aim to validate the AR-PEmbS in larger and more diverse samples, encompassing females and individuals with nontraumatic amputations. Future research should aim to validate the AR-PEmbS in larger and more heterogeneous samples, including a more balanced representation of genders and individuals with both traumatic and nontraumatic amputations. This will help in assessing the scale's applicability across different demographic and clinical groups, ultimately enhancing its robustness and generalizability.

Additionally, while Arabic versions of the LCI and the Houghton scale were not available, they were translated for this study by five rehabilitation professionals who reached a consensus on the translation. However, these translations were not further validated, which may affect the reliability of these measures. Future studies should focus on validating Arabic versions of these measures to ensure their accuracy and applicability in Arabic-speaking populations. Finally, longitudinal studies are needed to assess the responsiveness of the AR-PEmbS to changes in prosthetic embodiment over time. While cross-sectional studies provide useful insights, they capture only a single point in time and do not account for the dynamic process through which individuals develop a sense of ownership and agency over their prostheses. Embodiment, as a multifaceted experience, changes over time as users become more accustomed to their prosthesis, refine their motor skills, and psychologically accept the device as part of their body schema. Tracking changes in prosthesis embodiment longitudinally allows researchers to observe how these processes develop across different stages of adaptation, from initial fitting to long-term use. Moreover, longitudinal studies can reveal how factors such as changes in physical condition, psychological well-being, or even the introduction of new prosthetic technologies affect the long-term embodiment of the device. This type of research is crucial for identifying predictors of successful adaptation and for informing interventions that aim to improve outcomes. Therefore, longitudinal research offers a more comprehensive understanding of prosthetic embodiment, contributing to improved clinical practices and prosthesis design.

CONCLUSIONS

The AR-PEmbS-LLA is a psychometrically sound instrument for assessing prosthetic embodiment among Lebanese adults with LLA. Its robust reliability and validity support its application in both clinical and research settings, facilitating comprehensive evaluations and the enhancement of rehabilitation programs for individuals with LLA.

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