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RESEARCH ARTICLE

Factor Structure of the Trinity Amputation and Prosthesis Experience Scales (TAPES) with Individuals with Acquired Upper Limb Amputations

ABSTRACT

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Objectives: To investigate the factorial composition of the Trinity Amputation and Prosthesis Experience Scales (TAPES), a multidimensional assessment of adaptation to amputation and prosthesis, for use with individuals with acquired upper limb amputations.

Design: Cross-sectional survey of members of the British Limbless Ex-Service Men's Association.

Results: A total of 101 individuals (men, 100; mean age, 73.8 yrs, SD 11.94) with acquired upper limb amputations (98 traumatic cases) completed the TAPES. Principal components analyses with varimax rotation revealed four psychosocial subscales (general adjustment, social adjustment, optimal adjustment, and adjustment to limitation), four activity-restriction subscales (restriction of lifestyle, social restriction, occupational restriction, and restriction of mobility), and a single prosthesis-satisfaction subscale. Each of these subscales had high internal reliability.

Conclusions: The TAPES structure can be meaningfully represented in terms of nine internally consistent subscales. Additional research needs to be done on the TAPES for use with individuals with upper limb amputations. In particular studies of the scales, predictive validity is warranted.

Key Words: Amputation, Upper Limb, Outcome Assessment

The amputation of an upper limb engenders a multitude of physical and psychosocial challenges and represents a distinct and significant challenge in terms of clinical rehabilitation and prosthetic restoration. However, in comparison with understanding of the functional and psychosocial outcomes for those who sustain lower limb amputations,[1–3] relatively little is known about the outcomes for individuals with upper limb amputations. This is likely a consequence of a number of factors, including the smaller numbers of individuals with upper limb amputations and the fact that there is no comprehensive, widely used, psychometrically validated outcome measure for adults with upper limb amputations in use throughout the United Kingdom, Australia, and the United States.[4]

The Trinity Amputation and Prosthesis Experience Scales (TAPES)[5,6] were originally developed as a multidimensional assessment of adaptation to lower limb amputation and prosthesis use. However, the inherent objective of facilitating examination of the psychosocial processes involved in adjusting to an artificial limb, the specific demands of wearing a prosthesis, and the potential sources of maladjustment[5] also have potential applicability and clinical relevance in cases of upper limb amputation, for which such standardized assessments are lacking. The purpose of the current study was therefore to investigate the factorial structure and scale properties of the TAPES in a sample of respondents with acquired upper limb amputations as a first step in the assessment of its suitability as an outcome measure for those with upper limb amputations.

Description of the TAPES

Through refinement of an empirically and theoretically derived item pool, Gallagher and MacLachlan[5] developed a multidimensional assessment to facilitate examination of the psychosocial processes involved in adjusting to an artificial limb, the specific demands of wearing a prosthesis, and the potential sources of maladjustment. The resulting assessment, the TAPES, is a 54-item self-report questionnaire comprising nine factor analytically derived subscales assessing three dimensions of psychosocial adjustment (general adjustment, social adjustment, and, adjustment to limitation), three dimensions of activity restriction (functional restriction, social restriction, and athletic activity restriction), three dimensions of prosthesis satisfaction (weight satisfaction, functional satisfaction, and esthetic satisfaction). In addition, phantom and residual limb pain experiences and other medical problems unrelated to the amputation are assessed. Completion of the entire assessment takes approximately 15–20 mins when self-administered. Although abbreviated versions of the scales are not currently available, it is envisaged that future scale development will include investigation of the reliability of using a shorter version of the assessment (P. Gallagher, personal communication, 2005).

The TAPES General Adjustment subscale reflects the extent of adjustment to and acceptance of an artificial limb and incorporates items such as, "As time goes by, I accept my artificial limb more," and "Although I have an artificial limb, my life is full." The Social Adjustment subscale pertains to the influence of the artificial limb in social situations, encompassing ease of talking about the limb and dealing with the reactions of people to it. The Adjustment to Limitation dimension reflects restriction ensuing from having an artificial limb and incorporates items such as, "Having an artificial limb makes me more dependent on others than I would like." Items on the Psychosocial Adjustment subscales are rated on a 5-point Likert scale. Scores range from 5 to 25, and higher scores indicate more favorable adjustment.

The three Activity Restriction subscales reflect different arenas in which limitation of pursuits or interests may be manifest. Some of the items in the Activity Restriction section were based on items from the SF-36 Health Survey.[7] The Functional Restriction subscale covers rudimentary functional tasks such as walking 100 yards and climbing one flight of stairs. The Athletic Restriction subscale refers to limitation of activities that involve more dynamic physical effort, for instance, sport and recreation and running for a bus. The final Activity Restriction dimension, Social Restriction, addresses limitation of social activities such as visiting friends and working on hobbies. Items on the Activity Restriction subscales are scored on a 3-point scale ranging from 2 (limited a lot) to 0 (not limited at all). Scores range from 0 to 8. Higher scores are indicative of greater limitation.

The Functional Satisfaction subscale of the Prosthesis Satisfaction scale assesses extent of satisfaction associated with the following functional characteristics of the artificial limb: reliability, comfort, fit, and overall satisfaction. Esthetic Satisfaction reflects contentment with cosmetic characteristics such as shape, color, and noise, and the final subscale, Weight Satisfaction, is a single-item measure assessing satisfaction with the weight of the prosthesis. The Prosthesis Satisfaction subscale items are rated on a 5-point scale ranging from 1 (very dissatisfied) to 5 (very satisfied). Higher scores indicate greater Prosthesis Satisfaction. Scores on the Weight Satisfaction subscales range from 1 to 5, scores on the Esthetic Satisfaction subscale range from 4 to 20, and scores on the

Functional Satisfaction subscale range from 5 to 25.

Initial examination of the TAPES dimensional structure, reliability, and validity[5] was conducted on a group of men ($n = 78$) and women ($n = 26$) with lower limb amputations (49% trauma-related; mean age, 45.3; SD 18.9). These analyses revealed that the TAPES subscales had high internal consistency (alpha reliability coefficients ranged from 0.763 to 0.886) and good face, construct, content, and predictive validity. Furthermore, recent research suggests that the TAPES can be used in the assessment of quality of life among individuals with amputations.[6] Such findings illustrate the scale's applicability and utility both as a research tool and as a supplement to clinical assessment. Indeed, the TAPES is now being used in Spain, Portugal, Germany, Japan, Brazil, the United Kingdom, and the United States with individuals with upper and lower limb amputations, thus underscoring the theoretical and practical importance of investigating its psychometric properties.

The TAPES may be freely copied and downloaded for teaching, clinical, or research purposes (http://www.tcd.ie/Psychoprosthetics/). Salient scoring and psychometric data are published in Gallagher and MacLachlan.[5,6]

METHOD

Procedure

The TAPES was completed by members of the British Limbless Ex-Service Men's Association (BLESMA) as part of a postal survey investigating psychosocial adaptation to amputation. BLESMA is a national charity dedicated to promotion of the welfare of those who have lost a limb or limbs, one or both eyes, or the use of a limb in any branch of Her Majesty's Forces or Auxiliary Forces. Almost three quarters of BLESMA's 2500 members have acquired amputations.

Covering letters, the questionnaire, and a prepaid reply envelope were distributed to all eligible members. Incentives were not offered for completion, and due to financial constraints, individualized reminders to return completed questionnaires were not issued to nonresponders. However, a general reminder notice was published in a subsequent edition of BLESMA's quarterly publication, *BLESMAG*. The utility of postal questionnaires as a reliable and valid method of data collection with individuals who have undergone amputations has been demonstrated elsewhere.[8] The ethics committee of the authors' institution approved the study protocol.

Statistical Analyses

Statistical analyses were performed using SPSS 11.0 for Windows. The Psychosocial Adjustment, Activity Restriction, and Prosthesis Satisfaction sections of the questionnaire were each separately factor analyzed using principal-components extraction with varimax rotation, following the procedure implemented by Gallagher and MacLachlan.[5] Appropriateness of factor analysis as a statistical procedure with the data was determined through inspection of the Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's index. Factor determination was based on a combination of Kaiser criterion[9] and scree test methods,[10] together with consideration of the percentage of variance explained and the interpretability of the factor solutions. In determining the stability of the factor solutions, variable saturation with the factors, indicated by the size of the factor loadings, was considered.[11] Cronbach's alpha values were calculated for each factor identified to examine the internal consistency.

Sample

A total of 1222 questionnaires were returned, representing a response rate of 49%; of these, 1121 contained sufficient data for analysis (44%). A total of 937 respondents (84%) had either upper or lower limb amputation(s), and 141 respondents had sustained an upper limb amputation(s). Only participants with upper limb amputation who had complete subscale protocols were included in the current analyses; thus, 101 responses were available for analysis. Characteristics of the sample are outlined in Table 1. As indicated, respondents were predominantly men, and the most prevalent cause of amputation was trauma. The most common level of amputation was above elbow. A total of 97 respondents indicated that they currently wear an artificial limb. Of the four nonusers, one person indicated that pain prohibited prosthesis use and another reported that he had used a prosthesis at some time in the past but had discontinued use.

RESULTS

Prosthesis Satisfaction

For the ten items making up the Prosthesis Satisfaction scale, Bartlett's test of the correlation matrix was significant at the $P < 0.0001$ level. The Kaiser-Meyer-Olkin measure of sampling adequacy was 0.903. The mean sampling adequacy for each individual item was >0.90. Principal components analysis revealed a one-factor solution accounting for 66.9% of the variance. Table 2 presents the unrotated factor loadings. Cronbach's alpha for the scale was 0.9396, indicating good internal reliability.

Activity Restriction

Although a number of items on the Activity Restriction scale pertain to activities that involve

TABLE 1. Characteristics of the upper limb amputation sample

Characteristic	n	%	Mean (SD)	Range
Sex				
Male	100	99.0		
Female	1	1.0		
Cause of amputation				
Active combat	61	60.4		
Training accident	15	14.9		
Other accident	18	17.8		
Other	4	4.0		
Trauma total	98	97.0		
Cancer	1	1.0		
Other	1	1.0		
Disease total	2	2.0		
Not specified	1	1.0		
Amputation level				
Hand	14	13.9		
Both hands	5	5.0		
Below elbow	27	26.7		
Through elbow	5	5.0		
Above elbow	46	45.5		
Bilateral arm	4	4.0		
Age, yrs			73.81 (11.95)	39–91
Time since amputation, yrs			49.11 (14.00)	4.6–49.1
Prosthesis users	97	96.0		

TABLE 2. Exploratory principal components analysis of the Prosthesis Satisfaction scale (component matrix)

Prosthesis Satisfaction Scale	Factor Loading
Shape	0.904
Appearance	0.878
Overall satisfaction	0.851
Reliability	0.813
Fit	0.809
Comfort	0.807
Weight	0.800
Noise	0.797
Color	0.769
Usefulness	0.738

extensive use of the lower limbs and do not essentially necessitate direct upper limb involvement, these items were included in the analysis because of the potential for upper limb involvement in maintaining balance and coordination. It was hypothesized, however, that the items referring to lower limb use would form a single factor.

The overall significance of the correlation matrix assessed with the Bartlett test was significant at the $P < 0.0001$ level. The Kaiser-Meyer-Olkin measure of sampling adequacy was 0.768. In addition, the mean sampling adequacy for each individual item was >0.75.

After exploration of various factor solutions, it was determined, on the basis of eigenvalues, screeplot analyses, and variance accounted for, that a four-factor solution accounting for 85.0% of the variance was the most suitable (Table 3). As anticipated, those items relating to walking, running, and climbing, Restriction of Mobility, formed a distinct factor, accounting for 37.3% of the variance. The second factor, Athletic Restriction, accounted for 17.6% of the variance and included items relating to restriction of activities requiring vigorous physical effort such as running for a bus and sport and recreation. The third factor, Social Restriction accounted for 16.2% of the variance and comprised two of the items from the original social restriction scale: maintaining friendships and visiting friends. The final factor, Occupational Restriction, accounted for 13.8% of the variance and contained two items, working on hobbies and going to work. Although the Social Restriction and Occupational Restriction factors each comprise only two items, the variables are heavily saturated with the factors and may thus be considered acceptable indicators of the construct.[11]

Internal reliability for each of the scales reached acceptable levels. Cronbach's alpha for the Restriction of Mobility scale was 0.940; the alpha coefficients for the Social Restriction scale, the Athletic Restriction scale, and Occupational Restriction scale were 0.8931, 0.7317, and 0.7201, respectively.

TABLE 3. Principal components analysis of the Activity Restriction scale (rotated solution)

	Mobility Restriction	Athletic Restriction	Social Restriction	Occupational Restriction
Percentage of variance	37.28	17.64	16.22	13.84
Walking 100 yards	0.953	5.339E-02	5.310E-02	0.158
Walking half a mile	0.942	0.164	−2.706E-03	0.173
Climbing several flights of stairs	0.924	0.108	0.139	3.147E-02
Climbing one flight of stairs	0.888	0.261	−6.505E-02	0.200
Walking more than a mile	0.816	0.358	0.279	−8.427E-02
Vigorous activities	0.101	0.843	−7.206E-02	0.118
Sport and recreation	0.184	0.811	−1.485E-02	0.279
Running for a bus	0.510	0.687	0.111	−9.060E-02
Visiting friends	0.118	−5.849E-02	0.955	0.101
Maintaining friendships	5.669E-02	2.585E-02	0.928	0.226
Working on hobbies	2.963E-02	0.148	0.192	0.846
Going to work	0.217	0.117	0.123	0.825

The highest factor loadings for each item are represented in bold face.

Psychosocial Adjustment

Finally, the 14 items of the psychosocial adjustment scale were subjected to principal components analysis. One item, "I don't care if anyone notices I am limping," was excluded from this analysis as it was deemed inappropriate for individuals with upper limb amputations; indeed, examination of missing data indicated that only 29 respondents answered this question. The Kaiser-Meyer-Olkin measure of sampling adequacy was satisfactory at 0.712, and the mean sampling adequacy for each variable was >0.73. The overall significance of the correlation matrix assessed with Bartlett's test was significant at the $P < 0.0001$ level.

Inspection of the scree plot and eigenvalues led to derivation of a four-factor solution, which explained 72.4% of the variance. Table 4 illustrates the item loadings on each subscale of the Psychosocial Adjustment scale. The items comprising the first factor, Adjustment to Limitation, which accounts for 21.7% of the variance, are identical to those found in the original TAPES Adjustment to Limitation scale and refer to restriction experienced as a consequence of having an artificial limb. The second factor, General Adjustment, accounted for 19.6% of the variance and contained three of the items of the original TAPES General Adjustment scale. It incorporates items referring to adjustment to and acceptance of wearing an artificial limb. The third factor, Social Adjustment, accounted for 18.3% of the variance and incorporates items relating to talking about one's artificial limb and dealing with the reactions of others. The items loading on this factor are consistent with the lower-limb Social Adjustment scale; however, the original scale also includes the item "I do not care if somebody notices that I am limping," which was excluded form the current analysis. The final factor, Optimal Adjustment, accounted for 12.7% of the variance explained and contained two items referring to dealing successfully with the challenges posed by amputation and leading a full life.

Internal reliability for each of the scales was adequate: Cronbach's alpha coefficients were 0.8030, 0.9072, 0.7880, and 0.8369 for the Adjustment to Limitation, General Adjustment, Social Adjustment, and Optimal Adjustment scales, respectively.

Mean values, standard deviations, ranges, and subscale intercorrelations are presented in Table 5. Inspection of the correlation coefficients reveals some overlap between the scales; however, most of the correlations are <0.50, indicting relative independence of the subscales. The highest scale intercorrelations relate to the associations between Adjustment to Limitation and Occupational Restriction ($r = 0.635$) and Athletic Restriction and Restriction of Mobility ($r = 0.710$).

DISCUSSION

This study examined the factor structure of the TAPES in a sample of veterans with acquired upper limb amputations to explore its dimensionality and potential acceptability as an outcome measure for those with upper limb amputations. In an expanding climate of evidence-based care, there is a recognized demand for psychometrically validated instruments to assess the multidimensional functional and psychosocial aspects of adaptation to upper limb amputation and prosthesis use.[4]

Although there was no assumption that Prosthesis Satisfaction was unidimensional, principle components analysis of the TAPES Prosthesis Satisfaction scale with the current upper limb amputation sample revealed a single-factor solution ac-

TABLE 4. Principal components analysis of the Psychosocial Adjustment scale (rotated solution)

	Adjustment to Limitation	General Adjustment	Social Adjustment	Optimal Adjustment
Percentage of variance	21.70	19.60	18.34	12.72
Having an artificial limb limits the amount of work I can do	0.850	−4.684E-03	8.956E-02	0.166
Having an artificial limb limits the kind of work that I can do	0.793	7.731E-03	−7.921E-02	0.130
Being an amputee means that I cannot do what I want to do	0.732	−9.000E-02	0.251	0.103
Having an artificial limb makes me more dependent on others than I would like	0.720	1.562E-02	0.140	0.129
An artificial limb interferes with my ability to do my work	0.697	0.261	8.227E-02	−9.866E-02
I have gotten used to wearing an artificial limb	5.731E-02	0.943	0.100	9.894E-02
I have adjusted to having an artificial limb	0.124	0.884	0.112	0.259
As time goes by, I accept my artificial limb more	−5.290E-02	0.850	6.592E-02	0.120
I do not mind people asking about my artificial limb	3.580E-02	0.238	0.911	5.262E-02
I find it easy to talk about my artificial limb	9.676E-02	0.218	0.865	0.197
I have difficulty talking about my limb loss in conversation	0.112	−0.154	0.669	7.212E-02
I do not care if somebody looks at my artificial limb	0.238	0.158	0.574	0.388
Although I have an artificial limb, my life is full	0.138	0.139	0.168	0.884
I feel that I have dealt successfully with this trauma in my life	0.169	0.319	0.228	0.794

The highest factor loadings for each item are represented in bold face.

TABLE 5. Subscale Intercorrelations for the Trinity Amputation and Prosthesis Experience Scales for those with Upper Limb Amputations (TAPES-Upper)

Subscale	Mean (SD)	Range	1.	2.	3.	4.	5.	6.	7.	8.
1. Prosthesis satisfaction	34.89 (8.89)	10–50								
2. Restriction of mobility	2.85 (3.79)	0–10	−0.014							
3. Athletic restriction	4.33 (1.77)	0–6	−0.141	0.710[a]						
4. Social restriction	.79 (1.28)	0–4	−0.088	0.292[b]	0.191					
5. Occupational restriction	1.99 (1.52)	0–4	−0.193	0.216	0.302[b]	0.357[a]				
6. Adjustment to limitation	12.09 (4.66)	5–25	0.152	−0.165	−0.282[b]	−0.450[a]	−0.635[a]			
7. General adjustment	11.57 (3.28)	3–15	0.590[a]	0.043	0.026	−0.152	−0.134	0.068		
8. Social adjustment	15.53 (3.56)	4–20	0.206	0.074	−0.012	−0.295[a]	−0.368[a]	0.235[b]	0.454[a]	
9. Optimal adjustment	8.13 (1.93)	2–10	0.276[b]	−0.269[b]	−0.221	−0.422[a]	−0.302[b]	0.244[b]	0.615[a]	0.480[a]

[a] $P < 0.01$.
[b] $P < 0.05$.

counting for 66.9% of the variance, indicating that prosthesis satisfaction was a unidimensional construct in this sample. This finding is consistent with the observations of Pillet and Didierjean-Pillet,[12] who suggest that because of the salience of the hands in communication and self-presentation, the esthetic and functional tasks performed by upper limb prostheses are not distinct constructs. In the case of lower limb amputation, the dissociation between the Weight, Functional, and Esthetic dimensions of the Prosthesis Satisfaction scale may be related to the relative concealability of lower limb prosthesis use.[5] Davidson[4] notes that whereas those with lower limb amputations can wear trousers, shoes, and socks to conceal their prostheses, it is more difficult to cover upper limb prostheses in a socially acceptable manner.

In keeping with the analyses of Gallagher and MacLachlan[5] based on cases of lower limb amputation, exploration of the structure of the Activity Restriction scale yielded an easily characterized multidimensional structure. As anticipated, items referring to activities involving extensive use of the lower limbs, for example walking more than a mile and climbing several flights of stairs, formed a single factor, namely Mobility Restriction. Average scores on this dimension were low, indicating relatively low levels of mobility impairment. This contrasts with findings from analyses of lower limb amputation in which mobility is the most signifi-

cantly impaired category in quality-of-life assessment.[13] In the case of upper limb amputation, it would be informative to develop an item pool relating specifically to activities involving bimanual upper limb dexterity such as using a knife and fork, cutting fingernails, tying a necktie, and tying shoes. The assessment of limitations in such activities would give a more comprehensive description of the activity restriction encountered after upper limb amputation. This analysis revealed that Athletic, Social, and Occupational Restriction formed distinct and meaningfully interpretable constructs. The emergence of these distinct dimensions highlights the complexity of individual responses to amputation and the importance of determining individual needs and expectations when designing and implementing interventions to improve outcomes of care.

In terms of the Psychosocial Adjustment scale, the current analyses revealed a four-factor structure closely allied to that reported in analyses of cases of lower limb amputation.[5] Seventy-two percent of the cumulative variance was explained by these four factors. Differences between structures derived from the upper and lower[5] limb amputation data center on the bipartition of the TAPES (lower) General Adjustment factor to form TAPES (upper) General Adjustment and Optimal Adjustment factors and on the exclusion of a single item relating to gait impairment (I do not care if somebody notices that I am limping). The Optimal Adjustment factor reflects the development of an optimistic outlook and the positive appraisal of life, despite the trauma associated with amputation or the use of an artificial limb. Previous research has investigated the adoption of such perspectives as a means of coping[14] and suggests that such efforts are associated with salutary outcomes, including lower levels of depressive symptomatology and higher levels of self-esteem. Whether such items are representative markers of positive psychosocial outcome or reflect mediating coping efforts requires further investigation.

Although reliability analyses of each of the subscales indicated adequate internal consistency, it must be acknowledged that three of the subscales (Occupational Restriction, Social Restriction, and Optimal Adjustment) each comprised just two items. In keeping with recommendations,[11] variable saturation with the factors was high (range, 0.794–0.955); however, some authors[15] argue that three variables per factor are needed to identify common factors. In future research, it may be necessary to identify additional items to define factors of interest as increasing the number of indicators per factor improves factor stability.[11]

As the first investigation on the dimensionality of the TAPES for use with individuals with acquired upper limb amputations, this study reflects a number of limitations that must be addressed in future research. Our sample drawn from BLESMA may not necessarily be representative of the general population of persons with upper limb amputations; members of BLESMA are mostly veterans with combat-related traumatic amputations and thus represent a specialized sample. Furthermore, previous research has demonstrated that age and time since amputation are important factors in postamputation adjustment.[16,17] The advanced age and relatively long period of time elapsed since amputation reported by participants in the current analyses may have influenced the item clustering. Further research is necessary to determine whether the structures derived in this sample are generalizable to younger individuals with relatively recent amputations. In addition, the survey response rate may have resulted in bias in the analysis, and as is the case with all mail surveys, the conditions under which the questionnaires were completed were uncontrolled and thus might have affected the study findings. Furthermore, this study exclusively addressed the dimensionality of the TAPES with individuals with upper limb amputations. Further research is necessary to determine the predictive validity of the scales and their associations with established standardized measures.

CONCLUSIONS

This research provides preliminary evidence for the factorial composition and internal consistency of the TAPES for use with individuals with acquired upper limb amputations—the TAPES-Upper. Additional research is needed. Confirmatory factor analytic studies are necessary to investigate the replicability of the factor structure derived here and replication of the scales' internal consistency findings are necessary to verify the psychometric properties of the TAPES. Studies of predictive validity are also desirable to support the relevance of the scale as a clinically relevant measure of adaptation to upper limb amputation.

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