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الجمعية السعودية لجراحة العظام
Saudi Orthopedic Association

Journal of Musculoskeletal Surgery and Research

Original Article

Exploratory and confirmatory factor analysis of the Arabic neck disability index: A cross-sectional study

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Received: 19 May 2021
Accepted: 08 July 2021
Published: 31 July 2021

DOI
10.25259/JMSR_54_2021

Quick Response Code:

ABSTRACT

Objectives: Neck pain is the fourth leading cause of disability. The most common validated tool assessing its effect on the participant's functional status is the neck disability index (NDI). We aimed to investigate the factorial structure of the Arabic NDI (NDI-Ar) using exploratory and confirmatory factor analysis (CFA) in a multioccupational sample.

Methods: A cross-sectional study conducted in Saudi Arabia. A total of 641 participants completed the NDI-Ar. The Cronbach's alpha test was used to test the reliability of the questionnaire. Exploratory factor analysis (EFA) was used to assess the existing factor structure within the 10-indicator NDI questionnaire. Parallel analysis (PA) and scree plot with the unidimensional congruence test, mean of item residual absolute loadings test, and explained common variance test were used to assess the number of the extractable factors and their unidimensionality. CFA was also carried out.

Results: EFA of the NDI-Ar suggested the presence of two-factor solutions. However, the analysis with the tests of closeness to unidimensionality, PA tests, and the more rigorous CFA indicated that the two-factor solutions were not tenable, and a single latent factor solution is a better fit with the observed data measured on Middle Eastern people.

Conclusion: The present study explored the factorial structure of the NDI-Ar. The two-factor solutions were not tenable and a single latent factor solution might be a better fit.

Keywords: Cross-sectional study, Neck, Neck pain, Statistical factor analysis, Validation study

INTRODUCTION

Neck pain is considered to be the fourth leading cause of disability.[1] Croft *et al.* reported that one of three adults would experience neck pain in the course of 1 year, which creates a major health burden.[2] Not only does neck pain and disability are affecting health but it was also reported that individuals with neck pain are more likely to skip workdays and be unproductive.[3] Significant effects on the quality of life may be the result of neck pain; disrupting the patient's activity of daily living, overall health, and work responsibilities.[4-6]

Self-administered questionnaires play a major role in understanding important outcomes like the perception of pain and the disability level.[4,7,8] The most commonly used validated tool for

How to cite this article: Awwad WM, Alabdulkarim NH, Alhaidri NE. Exploratory and confirmatory factor analysis of the Arabic neck disability index: A cross-sectional study. J Musculoskelet Surg Res 2021;5(3):171-7.

assessing the effect of neck pain is the neck disability index (NDI). It evaluates the effect of neck pain on the participant's functional status. It also measures results in clinical settings and research.[4,5] To use the NDI in various languages and societies, it has been properly translated and validated.[4,9-24] This provides a standardized measuring tool to be utilized clinically and in research projects in different parts of the world. This facilitates information exchange between researchers and clinicians globally.[4,25,26]

To assess the measurement model validity, we use exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). In EFA, data exploration is done to generate information about the required number of factors to represent the data, in which all measured variables are related to every latent variable. However, in CFA, the number of factors can be specified, and relations between measured variables and latent variables can be determined.[27]

In 2013, Shaheen *et al*. [4] translated the NDI to Arabic (NDI-Ar). Along with the translation, they investigated reliability, factor structure, validity, and cross-culturally adapted the NDI-Ar in individuals who speak Arabic and have neck complaints. In our study, we used exploratory and CFA to investigate the factorial structure of the 10-item NDI-Ar in a multioccupational sample.

MATERIALS AND METHODS

Participants

The participants of the sample used for the current study were originally recruited in 2019. They were sampled to represent the general population of Saudi Arabia and were participants in another cross-sectional study aiming to identify the prevalence of neck disability and the factors affecting it. Thus, the final sample consisted of 641 participants who completed NDI-Ar as a part of the original study (NDI-Ar available at http://links.lww.com/BRS/A749).[4] Aside from the NDI-Ar, data were collected on level of education, occupation, income, and type of work environment.

Statistical data analysis

The means and standard deviations were used to describe the continuous measured variables and the frequencies and percentages for the categorically measured variables. The Kolmogorov–Smirnov's and Mardia's statistical tests of normality with the histograms were used to assess the statistical normality assumption of the continuous variables and the Levene's test was applied to test the homogeneity of variance statistical assumption. The Cronbach's alpha test was used to test the reliability of the neck disability questionnaire. The EFA with principal components analysis and maximum likelihood factor analysis with Promax rotation was used to assess the existing factor structure within the 10-indicator NDI questionnaire with suppression of items with low (poor) loading below salient levels (<0.30) as a criterion, the parallel analysis (PA) and the scree plot with the unidimensional congruence (UniCo) test, mean of item residual absolute loadings (Mean IREAL) test, and explained common variance (ECV) test were used to assess the number of the extractable factors from the NDI questionnaire and its unidimensionality. As a next step to the EFA and unidimensionality findings, the structural equation modeling CFA was carried out for the covariance matrix of the NDI 10 indicators testing their measurement model of one latent factor and the loadings of the indicators for this latent single factor were expressed as standardized regression beta coefficients. The fitness of the CFA model was assessed with the Chi-squared test adjusted for degrees of freedom, the comparative fit index (CFI), the Tucker-Lewis index (TLI) fit, and the root mean square error of approximation (RMSEA) model fit indexes. The bivariate Pearson's correlation I test was used to describe the bivariate associations between metric variables. The Statistical Package for the Social Sciences IBM program Version 21 was used for the data analysis and the Stand-Alone FACTOR program Lorenzo-Seva U and Ferrando PJ (2013) Version 9.2 was used for the factor analysis, PA, and unidimensionality testing. The alpha significance was considered at the 0.050 level.

RESULTS

Participants

The demographics of the participants are summarized in Table 1. Six hundred and forty-one subjects living in Saudi

Table 1: Respondents' sociodemographic and professional characteristics. *n*=641.

	Frequency	Percentage
Gender		
Female	446	69.6
Male	195	30.4
Age (years)–Mean (SD)		31.8 (13.05)
Age groups		
11–19 years	57	8.9
20–30 years	314	49
31–40 years	112	17.5
41–50 years	82	12.8
≥51 years	76	11.9
Marital state		
Never married	339	52.9
Married/divorced/widowed	302	47.1
Educational level		
High school or less education	173	27
University degree	390	60.8
Master's degree	41	6.4
PhD level	37	5.8

Arabia completed the survey. The resulting findings display their sociodemographic, economic, and occupational characteristics. A percentage of the respondents (45.3%) have office-based jobs with minimal physical requirements, another 35.4% have field jobs requiring mobility, and the remainder 19.3% have jobs that require a mix of both.

Perception of NDI-Ar

Table 2 displays the descriptive statistics for people's perception of the Arabic version of the NDI indicators of a neck disability, the overall means and standard deviations of the NDI were found to be generally low, indicating that people, in general, reported low neck pain, difficulties in personal care, lifting, and reading. However, the highest rating given to people was assigned to headaches, which had a collective mean equal to 1.37 of 5.

The reliability analysis of the NDI-Ar

The Cronbach's alpha test of reliability showed that the 10 indicators of NDI-Ar were read and understood equally and reliably by the respondents. Cronbach's alpha = 0.79. However, the 10 indicators had a substantial corrected item-total correlation with their total scores. When these indicators were removed from their total, all the items had a corrected item-total correlation in excess of 0.42, denoting their relatively substantial shared covariance with each other. The reliability analysis of NDI-Ar indicators was followed by an EFA test and CFA test for 2-fold purposes: first, to ascertain the factorial structure (validity) and second to understand whether the 10 items will conform to the assumption of unidimensionality (i.e., the presence of one latent factor).

EFA

The EFA of the correlation matrix between the 10 items of the NDI-Ar [Table 3] showed that the items were suitable

Table 2: Descriptive analysis of the respondents' perceptions of the indicators of NDI questionnaire.

	Mean	SD	Median	Minimum	Maximum
Pain intensity	1.06	1.09	1	0	5
Personal care	0.16	0.42	0	0	3
Lifting	0.75	1.26	0	0	4
Reading	0.84	0.89	1	0	4
Headaches	1.37	1.22	1	0	5
Concentrating	0.81	1	1	0	5
Working	0.65	0.86	0	0	5
Driving	0.85	1.47	0	0	5
Sleeping	0.98	1.28	0	0	5
Recreational activity	0.51	0.81	0	0	5

NDI: Neck disability index

Table 3: The bivariate Pearson's (r) correlations between the NDI questionnaire indicators with their overall total score. *n*=641.

	NDI	Physical	Neurologic	Pain	Personal care	Lifting	Reading	Headaches	Concentrate	Work	Driving	Sleep
NDI total score	1											
Physical disability subscale	0.946**	1										
Neurological disability subscale	0.764**	0.514**	1									
Pain intensity	0.695**	0.719**	0.408**	1								
Personal care	0.483**	0.502**	0.280**	0.409**	1							
Lifting	0.582**	0.647**	0.252**	0.289**	0.215**	1						
Reading	0.666**	0.660**	0.448**	0.543**	0.315**	0.286**	1					
Headaches	0.592**	0.387**	0.798**	0.323**	0.208**	0.152**	0.349**	1				
Concentrating	0.568**	0.359**	0.791**	0.293**	0.186**	0.155**	0.350**	0.396**	1			
Working	0.624**	0.464**	0.731**	0.336**	0.269**	0.306**	0.346**	0.339**	0.477**	1		
Driving	0.601**	0.676**	0.243**	0.291**	0.207**	0.345**	0.306**	0.213**	0.132**	0.221**	1	
Sleeping	0.625**	0.631**	0.398**	0.387**	0.271**	0.242**	0.301**	0.311**	0.307**	0.308**	0.257**	1
Recreational activity	0.690**	0.723**	0.388**	0.501**	0.407**	0.450**	0.428**	0.247**	0.280**	0.403**	0.399**	0.311**

**Correlation is significant at the 00.01 level (two tailed). NDI: Neck disability index

for the factor analysis. That is evidenced by the presence of many inter-item correlations that are above 0.30. In addition, the Kaiser-Meyer-Olkin (K-M-O) index of sampling adequacy (K-M-O = 0.87) suggested the adequacy of the sample for the factor analysis with a statistically significant Bartlett's test of sphericity, indicating that the correlation matrix of the 10 NDI-Ar indicators is factor analyzable. χ^2 (45) = 1617.8, $P < 0.001$, indicating that the 10 indicators' correlations comprise an identity matrix that is suitable for the factor analysis, the determinant index = 0.079, which is not 0, indicating the absence of unwanted collinearity between the indicators. However, the interim analysis of the NDI-Ar items showed that they diverged on two-factor solutions with the principal components used initially. It also showed that the 10 items had loaded significantly to these two-factor solutions. The factor solution was accepted and rotated with the Promax method, allowing these two subtle factors to correlate. The factor extraction method was switched to the maximum likelihood method, and the resulted rotated pattern matrix, displayed in Table 4, showed that these two factors had explained a substantial amount (=50%) of the shared in common variance (i.e., covariance/correlations) between the 10 items. It is apparent from the pattern that the correlation matrix of the items assessing people's pain intensity, difficulties in recreational activities, weightlifting, driving, personal self-care, reading, and sleeping had loaded saliently (i.e., with item-factor correlation >0.30) to the physical dysfunction factor. Similarly, people who scored higher on this factor tended to measure significantly greater disability in the aforementioned points. On the contrary, the items that measured people's experienced headaches and difficulties in concentrating and coordinated working had loaded saliently to the neurological dysfunction factor. People who scored higher on this neurological dysfunction factor tended to measure greater headaches, concentration, and work coordination difficulties and vice versa. The two factors had correlated with each other significantly, r = 0.62, denoting that people who experienced greater physical difficulty due to their neck dysfunction tended to measure significantly greater neurological dysfunctions too, $P < 0.001$. Nevertheless, the closeness to unidimensionality tests were used, including PA test, UniCo = 0.960 test, mean IREAL = 0.831 test, and ECV = 0.220. All suggested that the NDI-Ar 10 indicators conformed better to one latent factor rather than two, as found in the EFA. These findings from the tests of unidimensionality required a CFA with the structural equation modeling as they had also agreed with the PA and scree plot tests; that one latent factor may be extractable from the NDI 10 indicators combined.

Table 4: Promax rotated factor analysis solution with maximum likelihood.

	Latent factors	
	Physical dysfunction	**Neurological dysfunction**
Recreational activity	0.753	
Pain intensity	0.621	
Lifting	0.575	
Driving	0.560	
Personal care	0.510	
Reading	0.476	
Sleeping	0.310	
Concentrating		0.895
Working		0.511
Headaches		0.488

Extraction method: Maximum likelihood. Rotation method: Promax with Kaiser normalization. Iterations=3.

CFA

The CFA of the 10 indicators tested the presence of one latent factor explaining the shared covariance between the 10 indicators of the NDI-Ar using the structural equation modeling program. The goodness-of-fit indexes yielded from this analysis model supported the fit between the proposed one latent factor with the observed data as evidenced with a non-significant RMSEA index of fit (RMSEA = 0.061, 90% CI RMSEA: 0.049–0.074, PCLOSE = 0.069), the RMSEA indicates good fit between the path model with the data if its value was <0.080 with a non-significant *P*-value. Furthermore, the CFI = 0.95 agreed with the RMSEA index on the presence of one latent factor as evidenced with a CFI above 0.93. Likewise, the TLI = 0.93 and the normed fit index (NFI = 0.94) indexes of fit agreed with the other tests on the presence of one latent factor, noting the CFI, TLI, and NFI indicate good fit between the proposed model with the data if their values were >0.93. The Chi-square test of goodness of fit was statistically significant. However, $\chi^2(31) = 3.41$, $P < 0.001$, which disagreed with the other goodness-of-fit parameters, but it is not surprising that the Chi-squared test would show significant Misfit with such big sample like the one used in this study (=641 people) due to the sensitivity of the Chi-squared test to the sample size, as such its value was evaluated in light of other adjusted goodness-of-fit indexes. Table 5 displays the standardized regression weights (i.e., correlations) between the indicators of the neck disability with the single latent factor confirmed with the latent factor analysis from the structural equation modeling program. All these items loaded significantly and saliently to the single latent factor, namely, the NDI. The path model suggested correlating lifting difficulty with driving and recreational difficulties, as well as headaches with concentration difficulty and working and concentrating difficulties, which were allowed in the model because they are expected to correlate theoretically.

Table 5: The standardized regression weights (i.e.,, loadings) of the NDI items to their single latent factor using structural equation modeling confirmatory factor analysis.

Indicators	Standardized regression weights	*P*-value
Pain intensity	0.733	<0.001
Personal care	0.522	<0.001
Lifting	0.434	<0.001
Reading	0.673	<0.001
Driving	0.456	<0.001
Sleep	0.517	<0.001
Recreation	0.682	<0.001
Headaches	0.468	<0.001
Concentrate	0.444	<0.001
Working	0.538	<0.001

Goodness-of-fit parameters: χ^2 (31)=3.41, *P*<0.001, RMSEA=0.061, 90% CI root mean square error of approximation (RMSEA): 0.049–0.074, PCLOSE=0.069, comparative fit index=0.953, Tucker-Lewis index of fit=0.932, normed fit index=0.940. NDI: Neck disability index

DISCUSSION

The reliability analysis of NDI-Ar indicators was followed by an EFA test and a CFA test for 2-fold purposes: first, to ascertain the factorial structure (validity) of the Arabic version of the NDI questionnaire and second to understand whether the 10 items will conform to the assumption of unidimensionality (i.e., the presence of one latent factor).

In our study, the Cronbach alpha was 0.79, which is very close to the result in the original version of NDI by Vernon and Mior (0.80).[5] Furthermore, results from the previous studies (0.74–0.92) are quite comparable with ours.[4,12-15,18-22,24,28-32]

The K-M-O measure of sampling adequacy in our study was equal to 0.87, which is near to the result found by the German version of the NDI (K-M-O = 0.89).[33] This suggests the adequacy of the sample for factor analysis. Nevertheless, the closeness to unidimensionality tests was used, including PA test, UniCo = 0.960 test, mean IREAL = 0.831 test, and ECV = 0.220. All suggested that the NDI-Ar 10 indicators conformed better to one latent factor rather than two, as found in the EFA. On the other hand, Shaheen *et al.* found that the factor analysis demonstrated a two-factor structure explaining 67.58% of the total variance.[4]

In the present study, the EFA of the Arabic version suggested the presence of two-factor solutions (physical and neurological dysfunction scores/factors). However, the analysis with the tests of closeness to unidimensionality and PA tests, as well as the more rigorous CFA, indicated that the two-factor solutions were not tenable and that a single latent factor solution might be a better fit with the observed data measured on people from the Middle Eastern community. A total score computed through adding up all the 10 indicators of the NDI can yield a factor that can characterize people's perceived neck disability reliably using this Arabic version of the NDI.[4] Similarly, Hains *et al*.[34] and other studies[12,13,15,19,24] also found a positive result for a one-factor model with variances of (41–59%).

However, it is generally agreed that factor analysis can be subjective and different from one analysis/analyst to another. This study was limited by the fact that that NDI-Ar questionnaire was only included without other tools to measure the psychometric properties. The addition of quality of life measuring questionnaire would have enhanced the results. We suggest adding those tools in further studies.

Ultimately, this leads to the conclusion that this validated tool is quite helpful in a clinical setting as it measures the functional status of the patients suffering from neck pain. It is important to consider that the measurement of a single total score might be affected by differences in the patients' state of mental function or any other special condition. Therefore, further research is recommended to study the NDI-Ar in various conditions along with the addition of a quality of life measuring questionnaire that would enhance the results. We suggest adding those tools in further studies.

CONCLUSION

The present study used a large, multioccupational sample to explore the factorial structure of the NDI-Ar. The EFA suggested the presence of two-factor solutions (physical and neurological dysfunction scores/factors). However, the analysis with the tests of closeness to unidimensionality and PA tests, as well as the more rigorous CFA, indicated that the two-factor solutions were not tenable and that a single latent factor solution might be a better fit with the observed data measured on people from the Middle Eastern community. It is important to consider that the measurement of a single total score might be affected by differences in the patients' state of mental function or any other special condition. Therefore, further research is recommended to study the NDI-Ar in various conditions.

RECOMMENDATIONS

The addition of quality of life measuring questionnaire would have enhanced the results. We recommend adding those tools in further studies.

AUTHORS' CONTRIBUTIONS

WMA conceived and designed the study, conducted research, provided research materials, and collected and organized data. NHA and NEH wrote the initial and final draft of the article. All authors have critically reviewed and approved the final draft and are responsible for the manuscript's content and similarity index.

ETHICAL APPROVAL

The project was approved by the King Saud University Institutional Review Board. Number: E-21-5819, Date: 6-4-2021. Participants gave their informed consent and were reminded that their participation was voluntary, could be withdrawn at any time without giving a reason, and that all information would be treated confidentially.

Declaration of patient consent

The authors certify that they have obtained all appropriate patients consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest

There are no conflicts of interest.

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