

Construct Validity and Factor Structure of Sinhalese Version of Epworth Sleepiness Scale

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ABSTRACT

Objective:

This study is the first to validate the Epworth Sleepiness Scale (ESS) in Sri Lanka population. ESS is a tool used to evaluate patients' habitual sleepiness during the day and is used worldwide. This work examined the psychometric properties of the Sinhalese version of eight items ESS among heavy vehicle drivers in Sri Lanka.

Methods:

A sample of 403 participants was randomly split into two to evaluate dimensionality by exploratory factor analyses (EFA) and confirmatory factor analyses (CFA).

Results:

Study findings suggest that the single version of ESS is a reliable and valid instrument for sleep evaluation. The analysis identified two-factor structures for the Sinhalese version of ESS. Factor one included sitting and talking, watching TV, car in traffic, sitting in public and sitting and reading, summarized as sitting and doing something. Factor two included lying down, being a car passenger, and sitting quietly, indicating sitting without engaging in any particular activity.

Conclusions:

Sinhalese version of the ESS is a bi-dimensional instrument that is reliable and valid for assessing daytime sleepiness in Sri Lankan heavy vehicle drivers. However, the Sinhalese version of the ESS needs further evaluation among the general population and those with sleep disturbances.

Keywords:

Psychometric, Sleepiness, Factor analysis, Sri Lanka, Sinhalese

INTRODUCTION

The general population frequently views daytime sleepiness as a shared experience and a predictable consequence of insufficient sleep. However, daytime sleepiness can seriously impact on an individual's health, safety, and quality of life.¹ Daytime Sleepiness is characterized by the subjective reporting of disturbances in sustaining alertness while awake, associated explicitly with quick sleep onset in sedentary situations. Daytime

Sleepiness is a fast-growing sleep-related disorder with a reported prevalence rate of 10 to 45 percent globally.²

Most objective procedure for assessing daytime sleepiness involves expensive techniques, such as Multiple Sleep Latency Test (MSLT). However, most healthcare systems, including Sri Lanka, can't afford it due to limited resources. Subjective measurement based on a comprehensively validated questionnaire is the most practical and cost-effective way to screen patients to determine their daytime sleepiness.

As reported by Johns³ ESS is a self-administered 8-item questionnaire developed as a simple method of measuring daytime sleepiness in adults. More than 4000 articles cited this original article through a Google scholar search (day accessed ?). ESS takes into consideration the fact that people have different daily routines. So even if the person has not done any activity mentioned in ESS, person is asked how

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it will affect himself. ESS also tries to differentiate fatigue from sleepiness by asking subjects to distinguish dozing from feeling tired. In the original study³, normal controls had a mean ESS score of 5.9 ± 2.2 (Range 2-10).

Reliability and factor analysis of the ESS by Johns⁴ showed that testing and retesting of 87 healthy medical students with a gap of five months did not change their ESS score significantly ($r = .82$). As measured by Cronbach's alpha (0.88) ESS had a high level of internal consistency. Factor analysis of item scores showed only one factor for 104 medical students. In this study, medical students had a mean ESS score of $7.6(+3.9)$ ranging from 0-18.

There were no validated tools for screening daytime sleepiness in the Sinhalese population in Sri Lanka. Because of this deficiency, this psychometric analysis of ESS was done on the Gunawardane et al.⁵ study conducted among heavy vehicle drivers using ESS to measure their daytime sleepiness.

Ethical clearance was obtained from the Ethical Review Committee of the Faculty of Medicine Colombo.

METHODS

Subjects and design

This is a secondary data analysis of a descriptive cross-sectional study carried out among heavy vehicle drivers attending the National Transport Medical Institute, Kandy, Sri Lanka, to renew heavy vehicle driving licenses. A total of 403 heavy vehicle drivers were included in the study through a non-random sequential sampling technique. An interviewer-administered close-ended questionnaire, including the Sinhalese version of ESS, was used for data collection.

The sample was split into two groups for Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) subsequently. EFA was conducted to identify the underline factor structure, and CFA to confirm the dimensionality. Recommendations for the minimum sample size for EFA vary from 3 to 20 times the number of variables.⁶ On the other hand, it is advisable to have a minimum and maximum sample size of 200 to 400 to perform CFA.⁷ With that background for EFA, a sample of 120 (15 per variable) was selected randomly and the rest of the sample was used for the CFA (283 subjects).

Epworth sleepiness scale

The Epworth Sleepiness Scale is a brief, self-administered questionnaire with eight questions that refer to the usual way of life in recent times of a person. "It provides a measure of a person's general level of daytime sleepiness or their average sleep propensity in daily life. The ESS asks people to rate, on a 4-point scale (0-3), their usual chances of dozing off or falling asleep in 8 different situations or activities that most people engage in as

part of their daily lives, although not necessarily every day". "The total ESS score is the sum of 8 item scores and can range between 0 and 24. The higher the score, the higher the person's level of daytime sleepiness". A score of more than 10 out of 24 may indicate Excessive Daytime Sleepiness and may indicate a sleep disorder.⁸

Translation

Initially, two bilingual literary language experts translated the English version of the ESS questionnaire into Sinhalese. They had no prior knowledge regarding the questionnaire's purpose, content, or interpretation. Then, two bilingual language experts carried the back translation of the Sinhalese version into English. After this, the English back-translated version was compared with the original English form of ESS. It was found to follow the original version. Then, the Sinhalese version was pilot tested among a sub sample of heavy vehicle drivers ($n = 20$) to assess the difficulty of understanding the questions. Based on feedback during pilot testing, no modifications were suggested, and the final Sinhalese version of ESS was obtained.

Statistical analysis

An exploratory Principal Component Analysis (PCA) was run on the randomly selected 120 subjects, followed by the CFA on the rest of the sample. Prior to performing PCA, suitability of the data was assessed. Bartlett's test of sphericity was used to examine the hypothesis that the variables are uncorrelated in the population, and Kaiser Meyer Olkin's test was used to measure the sampling adequacy. Analysis showed that it was appropriate to proceed with factor analysis. Then EFA was conducted by Principal Component Analysis (PCA) with Oblimin rotation. Kaiser's criterion (Eigen value > 1), screen plot and parallel analysis were used to decide the number of factors to retain. The uniqueness (U) was analyzed for every item. U is the percentage of variance for a variable not explained by the common factors; thus, it is a useful parameter to study an item's contribution to the final solution. U should be interpreted as commonality = $1 - U$. Therefore, a value of U closer to 1 indicates that the item should be removed, and a U value < 0.60 represents an adequate contribution of the item. The proportion of variance explained was also calculated, and a solution that represented at least 50% of the total variance was considered to be satisfactory. The factors that lead to a meaningful interpretation and theoretical sense were ultimately selected. Rotated factor loadings of ≥ 0.4 were considered sufficient, while items with factor loadings ≥ 0.4 on more than one factor were considered cross-loading.

The factors that the EFA identified were tested using CFA. The dimensionality of the ESS is debatable. Therefore a CFA was performed on the previously reported factor structures (1-Factor and 3-Factor) of ESS in addition to the

factor structure derived from PCA. CFA was performed in the second split sample, using maximum likelihood. Model fit was evaluated by using criteria based on fit indices, such as the chi-square to degree of freedom ratio (χ^2/df), root mean square error of approximation (RMSEA), comparative fit index (CFI), Tucker–Lewis index (TLI), standardized root mean square residual (SRMR), coefficient of determination (CD), Akaike information criterion (AIC), and Bayesian information criterion (BIC).¹⁸ The following criteria were used as evidence of reasonable good fit; χ^2/df values between 1- 2, RMSEA values < 0.06 or below, CFI $\geq$ 0.95, TFI $\geq$ 0.95 and SRMR < 0.08.^{9, 10}

Finally, scale reliability was assessed. The Cronbach α was calculated for the overall scale, with acceptable values ranging from 0.60 to 0.95.¹⁸ In addition, inter-item correlations were calculated to detect possible redundancy among items ($r > 0.80$). All analyses were conducted with Jamovi, version 2.2.2.0.

RESULTS

Demographic characteristics

the demographic and occupational variables are shown in Table 01. All the participants were males. No significant differences existed between samples used for exploratory and confirmatory factor analysis. The mean ESS score was 6.57 ± 4.07 . The prevalence of excessive daytime sleepiness was 14.4% when the cutoff value was set at 10.⁵

Table 1. Demographic and occupational characteristics of study participants.

Characteristics	All (n=403) Mean (SD)	EFA (PCA) (n= 120)	CFA (n= 283)	P value
Age (Years)	36.51(8.6)	36.45 (9.0)	36.53 (8.4)	0.932
BMI (Kg/m2)	22.92 (3.8)	23.05 (3.9)	22.86 (3.8)	0.658
Heavy vehicle driving experience (Years)	10.13 (7.1)	9.72 (7.7)	10.31 (6.9)	0.455
Work hours/day (Hours)	9.37 (2.2)	9.23 (2.3)	9.43 (2.2)	0.422

PCA - Principal Component Analysis, EFA - Exploratory Factor Analysis, CFA - Confirmatory Factor Analysis, SD- Standard Deviation

Exploratory factor analysis

Principal component analysis with oblique rotation found a two-component model based on eigenvalues (>1), screen plot and parallel analysis. KMO value 0.812 indicates that the overall sampling adequacy measure

was statistically adequate. BTS showed a statistically significant correlation among variables in the population ($\chi^2 (28) = 354, p < 0.001$).

Table 2. Pattern matrix from exploratory factor analysis for the Sinhalese version of ESS

ESS 8 items	Factor 1	Factor 2
Item – 6 Sitting and talking to someone	0.834	0.162
Item – 3 Sitting, inactive in a public place like a theater or a meeting	0.796	0.045
Item – 1 Sitting and reading	0.749	0.054
Item – 2 Watching TV	0.733	0.034
Item – 8 In a car, while stopped for a few minutes in traffic while driving	0.623	0.205
Item – 4 As a passenger in a car for an hour without a break	0.014	0.697
Item – 5 Lying down to rest in the afternoon when circumstances permit	0.114	0.694
Item – 7 Sitting quietly after a lunch without alcohol	0.225	0.649

In two factor model, all items had loadings of more than 0.6. The first component, “sitting and doing something,” showed high loadings for items 1, 2, 3, 6, and 8, which explain 36.6% of the variance. Component two, sitting quiet, had high loadings for items 4, 5 and 7, explaining 18.9% of the variance. Uniqueness values less than 0.60 indicate an adequate item contribution to the model. The inter-component correlation was 0.312 (Table 02).

Confirmatory factor analysis

The dimensionality of the ESS is debatable; therefore, a CFA was performed on the previously reported factor structures of ESS in addition to the hypothesized PCA model. CFA was used to screen 3 models; 1) PCA model 5/3, 2) one-factor model and 3) three-factor model.

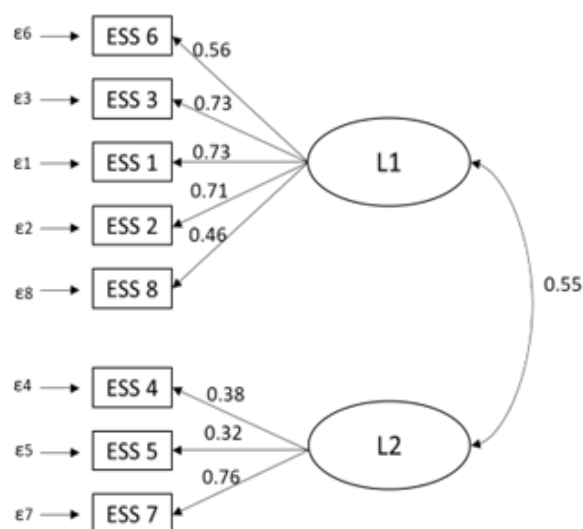
Factor solution comparisons were conducted using adjusted χ^2 , incremental fit indices and model comparison statistics. The indices confirmed that the ESS has a bi-dimensional structure (5/3). Two-factor model yield through EFA was analyzed through CFA. CFA analysis revealed that all indices achieve recommended values (Table 03).

Table 3. Fit indices for the confirmatory factor analysis model

Fit indices	Expected values	Models		
		PCA model (5/3 two-factor)	One factor model	Three-factor model
χ^2/df	1-2	1.66	2.805	2.00
P	< 0.05	0.038	0.01	0.008
CFI	≥ 0.95	0.964	0.890	0.948
TFI	≥ 0.95	0.944	0.846	0.914
SRMR	<0.08	0.0425	0.0572	0.0469
RMSEA	≤ 0.06	0.0576	0.0950	0.0709
AIC	The lower, the better	3860	3882	3866
BIC	The lower, the better	3946	3961	3955

PCA - Principal Component Analysis, χ^2/df - Chi-square to degree of freedom ratio, RMSEA - Root Mean Square Error of Approximation, CFI - Comparative Fit Index, TLI - Tucker–Lewis Index, SRMR - Standardized Root Mean Square Residual, CD - Coefficient Of Determination, AIC - Akaike Information Criterion, and BIC - Bayesian Information Criterion

Figure 1 shows the factor loadings of the final model. All the factor loadings were significant. The inter-component covariance was 0.55, indicating that the factors are distinct.

**Figure 1 - Factor structure of the Sinhalese version of ESS.**

Reliability

The overall tool's reliability coefficient (Cronbach's α) was 0.742, indicating very good internal consistency.

DISCUSSION

This study is the first one to validate the use of ESS in Sri Lanka. ESS is a tool used to evaluate patients' habitual sleepiness during the day and is used worldwide.^{3,11} The study examines the psychometric measures of the

Sinhalese version of eight items Epworth Sleepiness Scale among heavy vehicle drivers in Sri Lanka, and findings suggest that the single version of ESS is a reliable and valid instrument for sleep evaluation.

The ESS was validated in different cultures and contexts and was found to have good reliability with Cronbach alpha ranging between 0.69 and 0.88.¹² The internal consistency assessed by Cronbach alpha (0.74) was good in the study population and tallied with this range. In 1992 John⁴ reported a slightly lower value of the Cronbach alpha of 0.72 among medical students.

The developer describes ESS as a unidimensional 8-item scale.⁴ The unidimensionality of the ESS has been debatable because of varied findings in different populations. Specifically, several studies reported two-factor models in addition to 3-factor models.^{2, 13-15}

The factor analysis results identified two-factor structures for the Sinhalese version of ESS. Factor one included sitting and talking, watching TV, car in traffic, sitting in public and sitting and reading which can be summarized as sitting and doing something. Factor two included lying down, being a car passenger, and sitting quietly, indicating sitting without engaging in any particular activity. A similar factor structure has been reported in the study done among shift workers by Park et al.¹¹ In conclusion, it was demonstrated that the Sinhalese

version of the ESS is a bi-dimensional instrument that is reliable and valid for assessing daytime Sleepiness in Sri Lankan heavy vehicle drivers. However, the findings of this study must be interpreted in light of several limitations. The present analysis could not evaluate test-retest reliability because data were collected only once. In this analysis, the criterion validity of the tool cannot be evaluated because a standard measure to diagnose daytime sleepiness was not performed. In addition, there were no female participants in this study,

limiting its applicability primarily to men. Therefore, the Sinhalese version of the ESS is suggested to be evaluated further among the general population and those with sleep disturbances.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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AUTHOR CONTRIBUTIONS

Conceptualization, Data Curation, Formal Analysis and Writing: Gunawardane DA

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