PSYKHE
2024, 33(2), 1-12
https://doi.org/10.7764/psykhe.2022.49359

ISSN 0717-0297
www.psykhe.cl

Psychometric Evaluation of the Athens Insomnia Scale in Adults and Older Adults in Mexico

Evaluación Psicométrica de la Escala Atenas de Insomnio en Adultos y Adultos Mayores de México

Alejandro González-González, María Enriqueta Sánchez Hernández, José Fidel Laguna Chimal and Diana Betancourt Ocampo

Faculty of Psychology, Universidad Anáhuac México

The present study sought to obtain evidence of validity, reliability, and invariance for the Athens Insomnia Scale (AIS) in both its 8-item and 5-item versions in adults and older adults in Mexico. A non-probabilistic sample of 4,047 adults (62.9% women and 37.1% men) with an age range of 26 to 100 years (M=62.34, SD=15.42) was selected. The adapted version of the AIS for the Mexican population (α = 0.90), the Patient Health Questionnaire (PHQ-9) to assess depressive symptoms (α=0.89) and the scale for Generalized Anxiety Disorder (GAD-7, α= 0.82) were applied. The results of the confirmatory factor analysis indicated that the most parsimonious model was the 5-item version (AIS-5), and for the 8-item version (AIS-8) it was the bifactorial model. Significant correlations were found between the AIS and depressive symptomatology and anxiety, providing evidence of concurrent validity. The results on the invariance of the bifactorial AIS-8 showed strict invariance by sex and scalar invariance by age; for the AIS-5, metric invariance was obtained for both sex and age. It is concluded that the AIS-5 and AIS-8 proved to be valid and reliable instruments to assess insomnia in the Mexican population.

Keywords: Athens Insomnia Scale, sleep disorders, validity, reliability

En la presente investigación se buscó obtener evidencias de validez, confiabilidad e invarianza para la Escala Atenas de Insomnio (AIS, por sus siglas en inglés) tanto en su versión de 8 como en la de 5 reactivos en adultos y adultos mayores de México. Se seleccionó una muestra no probabilística de 4.047 adultos (62,9% fueron mujeres y 37,1% hombres) con un intervalo de edad de 26 a 100 años (M=62,34, DE=15,42). Se aplicó la versión adaptada para población mexicana de la AIS (α = 0,90), el Cuestionario sobre la Salud del Paciente (PHQ-9) para evaluar síntomas depresivos (α = 0,89) y la escala para el Trastorno de Ansiedad Generalizada (GAD-7, α = 0,82). Los resultados del análisis factorial confirmatorio indicaron que el modelo más parsimonioso fue el de la versión de 5 reactivos (AIS-5), y para la versión de 8 reactivos (AIS-8) fue el modelo bifactorial. Se encontraron correlaciones significativas entre la AIS y la sintomatología depresiva y la ansiedad, lo que aporta evidencia sobre validez concurrente. Los resultados sobre la invarianza de la AIS-8 bifactorial mostraron invarianza estricta por sexo e invarianza escalar por edad; para la AIS-5, se obtuvo la invarianza métrica tanto por sexo como por edad. Se concluye que la AIS-5 y la AIS-8 mostraron ser instrumentos válidos y confiables para evaluar el insomnio en población mexicana.

Palabras clave: Escala de Insomnio Atenas, desórdenes del dormir, validez, confiabilidad

The World Health Organization ([WHO], n. d...) suggests that health is one of the fundamental rights of every human being, so different disciplines have sought to provide information on lifestyles that favor this right, specifically it is proposed that aspects such as diet, physical activity, maintaining proper hygiene, as well as caring for emotional well-being, good quality of sleep and rest, can be considered as habits that will

Alejandro González-González https://orcid.org/0000-0002-6323-3851
María Enriqueta Sánchez Hernández https://orcid.org/0000-0003-1043-4905
José Fidel Laguna Chimal https://orcid.org/0000-0002-0529-8710
Diana Betancourt Ocampo https://orcid.org/0000-0001-6405-9827

We thank the Secretaría de Desarrollo Social del Gobierno del Estado de México for their support in the collection of data for this research. There is no conflict of interest to disclose. Correspondence concerning this article should be addressed to Diana Betancourt Ocampo, Faculty of Psychology, Universidad Anáhuac México, Avenida Universidad Anáhuac #46, Colonia Lomas Anáhuac, C.P. 52786, Huixquilucan, Estado de México, México. Email: diana.betancourt@anahuac.mx

favor a healthy life. Within these, good sleep, specifically the sleep process, is considered a physiological function of great importance for most living beings (Carrillo-Mora et al., 2018).

In this regard, Cirelli et al. (2017) mention that the American Academy of Sleep Medicine and the Sleep Research Society recommend that adults aged 18 to 60 years should sleep six to eight hours on average per night to achieve adequate sleep efficiency and quality. On the other hand, the US National Sleep Foundation conducted a study with a panel of experts, where through an exhaustive review of the literature, they determined the recommendations regarding hours of sleep by age group. One of the first aspects to be analyzed was that of age groups or categories, so that the experts could make recommendations on the time (in hours) that people should sleep based on these. Although the experts made proposals for all age groups (from newborns to older adults), only the groups under study will be mentioned here. For the adult group (26-64 years of age) they indicated that the recommended hours of sleep are seven to nine hours per night and for the older adult group (65 years and older) seven to eight hours (Hirshkowitz et al., 2015).

Chattu et al. (2018) and Carrillo-Mora et al. (2018) conducted systematic reviews and found that not getting enough sleep is associated with a range of negative physical health outcomes (e.g. hypertension, cardiovascular accidents, risk of diabetes, obesity, cancer), as well as mental health outcomes (e.g. depression, negative feelings, irritability, anxiety, hyperactivity, impulsivity, aggression, as well as cognitive aspects (e.g. memory, reaction time, cognitive performance, learning, cognitive performance, learning).e.g. depression, negative feelings, irritability, anxiety, hyperactivity, impulsivity, aggression), as well cognitive aspects (e.g. memory, reaction time, cognitive performance, learning, decision making).

Among the various sleep disorders, insomnia is one of the most prevalent and, according to the International Classification of Diseases 11th edition (ICD-11), is characterized by persistent difficulty in falling and staying asleep, together with problems with sleep quality and duration, despite the existence of appropriate circumstances for getting a good night's sleep (World Health Organization, 2019). Furthermore, according to ICD-11, this type of disorder is often accompanied by fatigue, depressed mood, irritability, general malaise and cognitive impairment.

Globally, there are different studies that provide information on the prevalence of insomnia, for example, Bhaskar et al. (2016) found in adults (aged 18 to 60 years) in India a prevalence of 33% of participants with insomnia, of which the highest proportion were women (68%) and were older than 35 years. In another study (Torrens et al., 2019) conducted in a Spanish population aged 18-80 years, they found a prevalence of insomnia of 21.1% and of clinical insomnia of 6.9%. In addition, they reported that insomnia was more frequent in women, widowed or divorced, and retired people, as well as in unemployed people, but the authors found no differences by age or schooling (Torrens et al., 2019).

Khaled et al. (2021) conducted a study with a representative sample from Qatar and found a prevalence of insomnia between 3% and 5.5%. Peng et al. (2021) conducted research in older adults in Taiwan and found a prevalence of insomnia of 30%, the authors found no differences by age in terms of older adults with and without insomnia, but they did find differences by sex, with a higher proportion of women than men. In Mexico, Collado et al. (2016) conducted a study where through polysomnography in a population aged one month to 93 years, the authors found that insomnia was the second most frequent pathology (39.2%) and onset and intermediate insomnia was the most common subtype in women aged 40-45 years.

As can be seen, the prevalence of insomnia is variable in different studies, which could be due to the type of assessment tools or instruments used to obtain the information. In this regard, Fabbri et al. (2021) carried out a review of tools for assessing sleep quality, the authors mention that the methods available can be classified into objective and subjective. Among the former are polysomnography and actigraphy, which have proven to be highly reliable in providing information on sleep parameters; however, these tools are difficult to access due to their high cost and the time they require to generate a diagnosis.

Among the subjective methods, there is the sleep diary where people record some indicators about their sleep pattern, as well as subjective assessment of sleep quality, however, this tool depends on the person making their records properly upon awakening, which can be difficult for certain population groups such as older adults. On the other hand, according to Fabbri et al. (2021) there are questionnaires or scales as subjective measures, which are widely used due to their low cost and their great potential to be applied to different populations, since most of the time they are self-applicable and do not require supervision, in addition to the fact that they do not involve much time.

One of the instruments that are considered to be the gold standard among scales assessing insomnia due to its diagnostic accuracy (Okajima et al., 2020) is the Athens Insomnia Scale (AIS), which is recognized for being brief and easy to interpret. It was developed by Soldatos et al. (2000) based on the diagnostic criteria for non-organic insomnia of the International Classification of Diseases 10th edition (ICD-10). This instrument has two versions, one with eight items (AIS-8) and one with five items (AIS-5). In both versions, five of the items correspond to ICD-10 criterion A and assess sleep difficulties from a quantitative and qualitative point of view. For the eight-item version (AIS-8), three items are added to assess the daytime impact of insomnia, which correspond to ICD-10 criterion C. According to Soldatos et al. (2000), in both versions of the instrument, factor analyses showed that the items were grouped into a single factor. Regarding internal consistency, the results showed a Cronbach's alpha of 0.89 for the ISA-8 and 0.87 for the AIS-5; furthermore, they report a test-retest reliability of 0.89 for the AIS-8 and 0.88 for the AIS-5.

In their review, Fabbri et al. (2021) found that the AIS is one of the most widely used instruments to assess sleep disorders and that it has demonstrated adequate validity and reliability indices in its two versions. The results of this review (Fabbri et al., 2021) indicated that the AIS has shown evidence of convergent/divergent validity with different scales that assess sleep, as well as with other psychological variables, for example, evidence of divergent validity with alcohol use disorders and socioeconomic status. In addition, evidence of convergent validity with anxiety and depression is reported in this review, where the results indicate positive correlations (with correlation coefficients between 0.42 and 0.64) between these variables and the two versions of the AIS. The authors also explain that validity has been confirmed in different populations (e.g. psychiatric patients, people diagnosed with insomnia or cancer patients, as well as groups without insomnia problems).

Jeong et al. (2015) conducted validation of the AIS-8 in a South Korean population. The authors revealed that the factor analysis showed that the items were grouped into one factor and obtained a reliability of 0.88 (Cronbach's alpha), in addition to reporting a test-retest reliability of 0.94 and significant correlations with other instruments that assess aspects of sleep (quality, insomnia), they also report divergent validity with alcohol consumption and socioeconomic status. In another study conducted in a Japanese population (Iwasa et al., 2019) where the psychometric properties of the AIS-8 were analyzed, the authors found that the confirmatory factor analysis showed a better fit for the two-factor model than the one-factor model, where the first five items were grouped in the first factor on nocturnal problems and the remaining three items were grouped in the second factor on daytime functional disturbances. Furthermore, they obtained an acceptable reliability for the instrument as a whole (Cronbach's alpha of 0.81); tests measuring invariance confirmed strict invariance by sex and by history of mental illness but not by age. The authors report a significant interaction between age (age group 16-64 and 65+) and sex by scale score, no significant effects were found for men, suggesting that younger men scored similarly to older men. However, for women, effects were found, with older women having higher scores (M=3.49) than younger women (M=3.19). The effect by sex was significant for both age groups, indicating that women had higher scores than men.

On the other hand, Enomoto et al. (2018) analyzed the performance of the AIS-8 and AIS-5 in patients with chronic pain. The results showed that for the AIS-8 the best-fitting model was the two-factor model (night-time sleep problems and daytime dysfunction) and for the AIS-5 it was grouped into a single factor. For both versions, acceptable reliabilities were found (Crobach's alpha of 0.87 for the AIS-8 and 0.89 for the AIS-5), as well as evidence of convergent validity (both versions) with depression (r=0.64 for the AIS-8 and 0.52 for the AIS-5), anxiety (r=0.54 for the AIS-8 and 0.42 for the AIS-5) and chronic pain (r=0.46 for the AIS-8 and 0.37 for the AIS-5). Baños-Chaparro et al. (2021) conducted a study where they psychometrically analyzed the AIS-5 in a Peruvian population, the results showed that the unidimensional model of the confirmatory factor analysis was acceptable and they report a Lambda value (for reliability) of 0.83. In addition, the authors calculated gender invariance and found that no differences were found between men and women.

Nenclares and Jiménez-Genchi (2005) validated the Spanish version of the AIS-8 for Mexico with a general population (high school, university and postgraduate students) and a clinical population (psychiatric inpatients and outpatients). The reliability coefficient of the AIS-8 for the total sample was .90. As expected, the lowest internal consistency estimate was found in the control group (Cronbach's alpha 0.77) and the highest in psychiatric patients (inpatients 0.88 and outpatients 0.93). The results of the factor analysis showed that the eight items were grouped into a single factor, explaining 59.2% of variance.

Since the AIS has been shown in different studies to be a valuable tool for detecting insomnia problems in different population groups, and Mexico is no exception (e.g. García et al., 2016; Delgado-Quiñones & Hernández-Vega, 2015; Rodríguez-Hernández et al, 2021), it is important to have evidence regarding the psychometric functioning of this tool, since although the work of Nenclares and Jiménez-Genchi (2005) provide data on the validity and reliability of the AIS-8, the authors only provide information on Exploratory Factor Analysis (EFA). It is therefore relevant to have evidence of greater psychometric precision in the Mexican population using Confirmatory Factor Analysis (CFA) because this type of analysis allows a more precise contrast of the theoretical model from which the instrument arises with empirical data from the population of interest. In addition, it is important to have data on measurement invariance, which will allow us to corroborate that regardless of gender or age group, the scores obtained from the AIS are interpreted in the same way. Having more empirical evidence on the performance of a measurement tool in a population group allows us to be certain about the scores obtained, either for practical-clinical purposes (e.g. diagnosis) or for research purposes. For this reason, the present research seeks to obtain evidence of validity, reliability and invariance of both the AIS-8 and the AIS-5 in adults and older adults in Mexico.

Method

Design

The type of research was instrumental, as the psychometric properties of a psychological measurement instrument were analyzed (Ato et al., 2013).

Participants

A non-probabilistic sample of 4,047 adults from the State of Mexico was selected, 62.9% (2,545) were women and 37.1% (1,502) men, aged between 26 and 100 years (M=62.34, SD=15.42).

Instruments

Athens Insomnia Scale

The version adapted for the Mexican population of the AIS-8 was used, which has evidence of validity and reliability (α=0.90) (Nenclares & Jiménez-Genchi, 2005), consisting of eight items in Likert-type format with four response options. The first response option indicates no problem with insomnia and the following response options increase in intensity with respect to insomnia (e.g. *No problem* to *Serious problem*). As previously mentioned, the AIS was designed by Soldatos et al. (2000) based on the ICD-10 clinical criteria, where five of the items aim to assess sleep difficulties (e.g. indicate difficulties experienced at least three times a week in the last month: falling asleep [taking time to fall asleep after turning off the light], waking up during the night) and the remaining three items measure the daytime impact of insomnia (e.g. feeling of well-being during the day, physical and mental functioning during the day).

Patient Health Questionnaire

The Patient Health Questionnaire (PHQ-9) was used, which is a Likert-type scale with four response options (from *No/Never* to *Almost every day*), consisting of nine items that assess depressive symptoms in the last two weeks according to DSM-IV criteria. It has evidence of validity and reliability (α=0.89) for the Mexican population (Donlan & Lee, 2010; Familiar et al., 2015).

Scale for Generalised Anxiety Disorder

The Generalized Anxiety Disorder Scale (GAD-7) was used, which was developed to assess generalized anxiety in the two weeks prior to its application, based on DSM-IV criteria (Spitzer et al., 2006). The GAD-7 is a Likert-type scale with four response options (from *No/Never* to *Almost every day*), composed of seven items. The instrument has shown good internal consistency (α=0.82) and validity for the Mexican population (Castro Silva et al., 2017).

Sociodemographic Aspects Questionnaire

A questionnaire was administered with five questions on socio-demographic aspects: gender, age, academic degree, occupation and marital status.

Procedure

Initially, the instruments were designed in electronic format through the *Google Forms* platform. In order to access the population, we had the support of the State Council for Women and Social Welfare of the State of Mexico (CEMyBS), an organization that has permanent contact with beneficiaries of government social programs or are part of the database managed by CEMyBS. The information was collected using two field strategies, according to age group.

The population aged 18-59 was contacted via email, in which they were invited to participate by answering the electronic version of the instruments. For the population aged 60 and over, CEMyBS staff contacted them via telephone (data were obtained from the aforementioned database). It was considered pertinent to carry out the contact this way due to the difficulties that could imply for older adults to access an email or the limitations that exist regarding the use of a computer or a device with internet access. Therefore, the CEMyBS staff applied the instruments as an interview and captured the information directly in the electronic version.

Participants took approximately 10 minutes to complete the instruments. Data collection took approximately 10 days. It should be noted that the online form contained a brief description of the study, as well as the ethical implications and safeguarding of the information, advising them that the information did not represent any physical or psychological risk for the participants.

All principles of the Declaration of Helsinki were followed. The instrument included a brief informed consent describing the general aim of the study, the purpose of the questions, the voluntariness and confidentiality of participation, as well as the institutions involved in the conduct of the study. Before starting to answer the instruments, respondents were asked to tick the consent box or were asked verbally, in the case of those who answered by telephone. The research protocol was approved by the Bioethics Committee of the Faculty of Health Sciences - Universidad Anáhuac México (202003, CONBIOETICA-15-CEI-004-20160729).

Data Analysis

The statistical analyses were performed using SPSS version 24 and Amos version 5. Initially, descriptive analyses (e.g. frequencies, measures of central tendency and dispersion) were performed to determine the distribution of the participants in the response options of the socio-demographic indicators, which was carried out for the total sample, as well as by age groups: 26 to 64 years and 65 to 100 years. It is important to note that these age groups were determined according to the recommendations of the National Sleep Foundation of the United States (Hirshkowitz et al., 2015), in terms of recommended hours of sleep.

The AIS items were analyzed to ensure that they met the following psychometric quality criteria: a) they had skewness and kurtosis values ≤ 2, b) they had correlations with the total score ≤ 0.30 and c) the alpha value of the total scale did not increase if the item was removed. The Kaiser-Meyer-Olkin (*KMO*) measure of sampling adequacy and the significance of Bartlett's test of sphericity were obtained. Both tests indicate the suitability of the data for structure detection if the *KMO* value is >0.5 and the Barlett's test of sphericity is significant at $p \leq 0.05$. In addition, EFA was performed, with eight items entered and principal axes used as the extraction method. This iterative method is based on the extraction of factors that explain most of the common variance and is robust to violations of the normality assumption. The rotation method was oblimin, which tries to find a simple structure regardless of the fact that the rotations are orthogonal. Based on the suggestions of Richaud (2005) and Freiberg et al. (2013), polychoric correlations were used for both the AFE and the AFC, because according to these authors, when purely ordinal items are used, this is the most appropriate method to use.

To obtain evidence of the validity of the AIS, CFAs were performed using the maximum likelihood estimation method, which is a procedure that iteratively improves the estimated parameters to minimize a specific adjustment function (Hair et al., 1999) and which, according to Ximénez and García (2005), provides unbiased, consistent and efficient estimators. Furthermore, McDonald (1999) recommends using this method

in large samples as is the case in this study. Three different models were considered: one factor of five items (AIS-5), one factor of eight items (AIS-8) and two factors (AIS-8, one of five items and one of three), where item errors were correlated. It is important to note that because previous evidence has not been consistent with the structure of the AIS-8 (there are studies that speak of one factor and others indicate that it is made up of two factors), in the present study the three structures were analyzed to identify which one was more appropriate. To determine the fit of the proposed models, the following indices were analyzed (Hu & Bentler, 1999): $\chi 2$ goodness-of-fit test; being a parameter sensitive to sample size, the $\chi 2/gl$ (*CMIN/DF*) ratio was considered, whose value <3 indicates an adequate fit; the indices: *CFI* (*Comparative Fit Index*), *TLI* (*Tucker-Lewis Index*), which with values >0.90 are interpreted as typical of an adequate fit; and the error indices: *SRMR* (*Root Mean Square Residual*), *RMSEA* (*Root Mean Square of Approximation*),which show an adequate fit if their value <0.05 in the first case, and <0.08, in the second.

Subsequently, correlations were obtained between the insomnia variable measured by the AIS and the depression (PHQ-9) and anxiety (GAD-7) variables to obtain evidence of concurrent validity, which implies that these variables are related. Evidence of reliability of the AIS was obtained by calculating Cronbach's alpha. In addition, the invariance of the AIS by gender and age group was analyzed and the comparison criteria used were those proposed by Cheung and Rensvold (2002): $\Delta\chi 2$: p>.05, ΔCFI: ≤ 0.01 and $\Delta RMSEA$: ≤0.015.

Results

As shown in Table 1, the highest percentage of participants were women and more than half reported being married.

Table 1
Sociodemographic Characteristics of the Total Sample and by Age Groups

		Total N=4.047 *%(n)*	26-64 years old n=1.627 *%(n)*	65-100 years n=2.420 *%(n)*
Sex				
	Men	37,1 (1502)	35,6 (580)	38,1 (922)
	Women	62,9 (2545)	64,4 (1047)	61,9 (1498)
Marital status				
	Married	61,5 (2489)	57,0 (927)	64,5 (1562)
	Widower	15,3 (620)	4,0 (65)	22,9 (555)
	Single	11,9 (483)	21,0 (341)	5,9 (142)
	Divorced/separated	6,2 (252)	8,6 (140)	4,6 (112)
	Free union	5,0 (203)	9,5 (154)	2,0 (49)
Academic degree				
	None	11,7 (473)	3,9 (64)	16,9 (409)
	Primary	44,2 (1790)	17,1 (278)	62,5 (1512)
	Secondary	12,9 (522)	14,1 (229)	12,1 (293)
	Technical Career	6,0 (242)	9,9 (161)	3,3 (81)
	High school	6,5 (263)	12,1 (197)	2,7 (66)
	Bachelor's degree	14,4 (584)	32,5 (528)	2,3 (56)
	Postgraduate	4,3 (173)	10,5 (170)	0,1 (3)
Occupation				
	Employee	30,6 (1237)	61,6 (1003)	9,7 (234)
	Housewife	45,0 (1822)	25,0 (407)	58,5 (1415)
	Retired	10,5 (425)	4,1 (67)	14,8 (358)
	Unemployed	13,8 (560)	9,0 (147)	17,1 (413)
	Another	0,1 (3)	0,2 (3)	-

In the youngest group (26 to 64 years old) the predominant schooling was a bachelor's degree and their main occupation was being employed; in the oldest group (65 years old and over) primary schooling predominated and as an occupation being a housewife. The mean age of the 26-64 age group was 47.56 (SD=12.57) and in the 65+ age group it was 72.28 (SD=6.76).

All items met the evaluation criteria, except for having less than 50.0% in all response options. In addition, the results showed satisfactory *KMO* values and significance of Bartlett's test of sphericity for both the AIS-8 (*KMO=0.*925, *p<0.*001) and the AIS-5 (*KMO=0.*871, *p<0.*001). It is important to note that because previous evidence has not been consistent with the structure of the AIS-8 (there are studies that speak of one factor and others indicate that it is made up of two factors), in the present study the two structures were analyzed to identify which one was more appropriate in this population. As can be seen in Table 2, the results of the PFA showed factor loadings above 0.40. Cronbach's alpha for the AIS-8 was 0.93 and for the AIS-5 0.91, which means that the instrument has a high reliability.

Subsequently, the CFA of the scale was performed and by correlating item errors (items one-two, items two-three and item four-five) adequate fit indices were obtained for the AIS-5, as well as for the unifactorial and bifactorial AIS-8.

Table 2
Factor Loadings of the AIS-*8 and* AIS-*5 items*

Item	Factorial loading		
	AIS-5	AIS-8 (Unifactorial)	AIS-8 (Bifactorial)
Falling asleep (taking time to fall asleep after turning off the light)	0,803	0,777	0,815*
Waking up during the night	0,812	0,783	0,901*
Final awakening earlier than desired	0,772	0,752	0,796*
Total sleep duration	0,868	0,854	0,706*
Overall sleep quality	0,859	0,876	0,600*
Feeling of well-being during the day	-	0,829	0,843**
Daytime functioning (physical and mental)	-	0,780	0,909**
Daytime sleepiness	-	0,760	0,440**
Percentage of variance	67,84	64,39	70,1

Note: * Factor 1: difficulty sleeping; ** Factor 2: daytime impact of insomnia.

Based on the AIC (Akaike Information Criterion), the most parsimonious model was the AIS-5, followed by the two-factor AIS-8 and the one-factor version had the highest AIC and therefore the least parsimonious model (Table 3). Therefore, of the AIS-8 options, the two-factor version will be taken into account for subsequent analyses as it was the one that adequately covered the largest number of criteria.

Table 3
Confirmatory Factor Analysis Fit Indices of the AIS-8 and the AIS-5

Model	X^2 */gl*	*CMIN*	*IFC*	*TLI*	*SRMS*	*RMSEA (IC)*	*AIC*
AIS-5	7,02/2	3,60	1,000	0,998	0,001	0,025 (0,007-0,046)	33,20
AIS-8 (1 factor)	1112,14/17	65,42	0,956	0,927	0,016	0,126 (0,120-0,133)	1150,14
AIS-8 (2 factors)	391,95/16	24,49	0,985	0,973	0,011	0,076 (0,070-0,083)	431,95

Regarding the results of the correlations (Table 4), positive, moderate and statistically significant correlations were found between insomnia and depressive symptomatology and anxiety.

Table 4
Correlation Coefficients of the AIS-8 and the AIS-5 with Depression and Anxiety

	Depression	Anxiety
AIS-5	0,69	0,66
AIS-8		
Factor 1. *Difficulty sleeping*	0,69	0,66
Factor 2. *Daytime impact of insomnia*	0,70	0,68

Note. All correlations were significant at p<0.001.

Multi-group CFA was conducted to test measurement invariance for both the AIS-8 (two-factor) and the AIS-5. The configuration invariance, baseline or free (M1) model was tested in males and females and in age groups of 26-64 years and 65-100 years; factor loadings, intercepts and error variances were allowed to be estimated freely. The indices obtained (*CFI*, *RMSEA*, χ2/gl) indicated that the fit of the model to the data was adequate (Tables 5 and 6).

Table 5
AIS-8 and AIS-5 Invariance Models Considering Gender

	Model	χ^2 *(gl)*	χ^2 */gl*	*IFC*	*RMSEA* (CI 90%)	Comparison	$\Delta\chi^2$	*ΔCFI*	*ΔRMSEA*
AIS-5	M1	10,65 (4)	2,66	1,000	0,020 (0,006-0,035)				
	M2	17,58 (8)	2,20	0,999	0,017 (0,006-0,028)	M2 vs M1	6.93(4), *p=0,*140	-0,001	-0,003
	M3	91,30 (13)	7,02	0,994	0,039 (0,031-0,046)	M3 vs M2	73.72(5), *p=0,*000	-0,005	0,022
	M4	205,73 (22)	9,35	0,986	0,045 (0,040-0,051)	M4 vs M3	114.43(9), *p=0,*000	-0,008	0,006
AIS-8	M1	425,83 (32)	13,31	0,984	0,055 (0,051-0,060)				
	M2	434,90 (38)	11,45	0,984	0,051 (0,047-0,055)	M2 vs M1	9.07 (6) *p=0,*170	0,000	-0,004
	M3	512,27 (46)	11,14	0,981	0,050 (0,046-0,054)	M3 vs M2	77.37 (8) *p=0,000*	-0,003	-0,001
	M4	668,06 (57)	11,72	0,975	0, 051 (0,048-0,055)	M4 vs M3	155.79 (11) *p=0,*000	-0,006	0,001

Note. M1. Configuration invariance (Baseline); M2. Metric or weak invariance (restricted λ); M3. Scalar or strong invariance (λ and τ constrained); M4. Strict invariance (restricted λ, τ and θ).

Next, the metric invariance model (M2) was tested, in which factor loadings were restricted to be equal between males and females and for persons aged 26-64 and 65-100. The indices showed that the model fitted well and when compared to M1, the *ΔCFI* was = <0.001 and the *ΔRMSEA* was <0.015 and the $\Delta\chi2$ was non-significant ($p<0.05$) for the AIS-5 and for the AIS-8 the $\Delta\chi2$ was significant; however, given that the $\chi2$ is sensitive to sample size and non-normality in the distribution of the data (Hair et al., 1999), it was decided to take up the criterion of Cheung and Rensvold (2002) who propose that if the difference between the *CFI* of the two models is equal to or less than 0.01 the models compared are equivalent. This criterion was taken up for Models 3 and 4 as again the $\Delta\chi2$ value was significant for both versions of the instrument.

The scalar invariance model test (M3), in which the intercepts, in addition to the factor loadings, were restricted to be equal across groups (by gender and age group), showed a good fit for the AIS-8 (bifactor), but not for the AIS-5; the 5-item version did not show invariance by gender or age group as the *ΔRMSEA* was >0.015.

Finally, in the strict invariance model (M4), in which factor loadings, intercepts and error variances were restricted, an adequate fit was found for the AIS-8 considering the sex variable. For the variable age group, the AIS-8 did not reach strict invariance since the *ΔRMSEA* was >0.015 (Table 6). In the case of the bifactor AIS-8, strict invariance was achieved for the sex variable and strong or scalar invariance for the age variable. The AIS-5 achieved metric or weak invariance for both sex and age.

Table 6

AIS-8 and AIS-5 Invariance Models by Age Group

	Model	χ^2 *(gl)*	χ^2 */gl*	*IFC*	*RMSEA* (CI 90%)	Comparison	$\Delta\chi^2$	*ΔCFI*	*ΔRMSEA*
AIS-5	M1	11,22 (4)	2,80	0,999	0,021 (0,007-0,036)				
	M2	16,72 (8)	2,09	0,999	0,016 (0,004-0,028)	M2 vs M1	5,50(4), *p=0,239*	0,000	-0,005
	M3	219,47 (13)	16,88	0,985	0,063 (0,056-0,070)	M3 vs M2	202,74(5), *p=0,*000	-0,014	0,047
	M4	703,92 (22)	31,99	0,949	0,088 (0,082-0,093)	M4 vs M3	484,45(9), *p=0,*000	-0,036	0,025
AIS-8 (bifactorial)	M1	375,35 (32)	11,73	0,986	0,052 (0,047-0,056)				
	M2	398,66 (38)	10,49	0,985	0,048 (0,044-0,053)	M2 vs M1	23,31(6) *p=0,001*	-0,001	-0,004
	M3	644,57 (46)	14,01	0,975	0,057 (0,053-0,061)	M3 vs M2	245,91(8) *p=0,000*	-0,010	0,009
	M4	1271,00 (57)	22,30	0,950	0,073 (0,069-0,076)	M4 vs M3	626,78(11) *p=0,000*	-0,025	0,016

Note. M1. Configuration invariance (Baseline); M2. Metric or weak invariance (restricted λ); M3. Scalar or strong invariance (λ and τ constrained); M4. Strict invariance (restricted λ, τ and θ).

Discussion

The present study examined the validity, reliability and invariance evidence of both the AIS-8 and the AIS-5 in adults and older adults in Mexico. Results showed that all three versions of the AIS presented evidence of both validity and reliability for measuring insomnia symptoms in the population group studied, however, the bifactor AIS-8 had the most adequate validity and reliability evidence.

With regard to the findings of the EFA, in the present study it was found that for both the AIS-8 and the ISA-5 the items are grouped into a single factor, these results are consistent with what was initially reported by Soldatos et al. (2000) and later by Nenclares and Jiménez-Genchi (2005) in a Mexican population and by Jeong et al. (2015) in a Korean sample. Despite this coincidence in the data, it is important to note that in the present study the percentage of variance explained by the bifactorial AIS-8 was higher compared to the variance explained by the unifactorial AIS-8 obtained in Mexican population by Nenclares and Jiménez-Genchi (2005).

On the other hand, when analyzing the results found in this research on the CFA, evidence of construct validity of the AIS-5 and AIS-8 was obtained given that the fit indicators of the CFA were adequate. This result was similar to that found by Baños-Chaparro et al. (2021) for the AIS-5 in the Peruvian population and for the two-factor AIS-8 version in the Japanese population (Enomoto et al., 2018; Iwasa et al., 2018), where the first five items were grouped into one factor on night-time problems and the remaining three items on daytime problems. The fact that both the five-item version and the eight-item version (single- and two-factor) present adequate fit indices coincides with the results that Fabbri et al. (2021) obtained when reviewing the use of the AIS, the authors found that of the eight studies they analyzed, three of them provide information that supports the unidimensionality of the AIS-8 and three more report that it is made up of two factors, and the last two papers they analyzed use the AIS-5.

Regarding the evidence of reliability of the instrument, the results of the present study provided evidence of high reliability in the Mexican population, a finding that is similar in samples from other countries (Baños-Chaparro et al., 2021; Enomoto et al, 2018; Fabbri et al. 2021; Iwasa et al., 2018; Jeong et al., 2015) and Mexico (Nenclares & Jiménez-Genchi, 2005), which provides evidence of the confidence that can be had regarding the consistency of the score obtained by the instrument.

In this research, evidence of convergent validity of the AIS was obtained through the positive and statistically significant correlations between insomnia, depression and anxiety, variables that other research has also used for this purpose and where significant correlations have been reported (Enomoto et al., 2018; Fabbri et al., 2021). Furthermore, it is important to note that the correlation coefficients found in this research were slightly higher than those reported in other studies, which confirms that there is a close relationship between the AIS score and the depression and anxiety scales. These results could provide empirical evidence that the AIS (in its two versions) assesses insomnia symptoms.

Regarding the analysis of invariance by sex, similarity was found between the results of this research and the study by Iwasa et al. (2018), who reported strict invariance for the bifactor AIS-8; furthermore, discrepancy was found with Baños-Chaparro et al. (2021) because these authors report strict invariance for the AIS-5 and the data from this research showed metric invariance for that same version. On the other hand, in age invariance, like Iwasa et al. (2018) strict invariance was not obtained for the bifactor AIS-8, but strong or scalar invariance was achieved. These findings show that the groups examined (by gender and by age group) remain statistically similar, which implies that the AIS scores apply in the same way for both males and females or by age group, that is, for adults and older adults. This is important for practical purposes, as it allows the same instrument to be used and its score to be interpreted in the same way for these population groups.

When comparing the evidence of validity and reliability of the AIS-5, AIS-8 unifactorial and AIS-8 bifactorial, it can be noted that the AIS-8 bifactorial presents more indicators of psychometric quality than the other two versions of the instrument: (a) its reliability index is higher than that of the AIS-5, (b) its AIC is lower with respect to the single-factor AIS-8 which means that it is a more parsimonious model, (c) the AFC fit indices were better than the single-factor AIS-8 and (d) it achieved strict invariance in sex and strong invariance by age. On the other hand, the AIS-5 performed better on the following indicators: a) lower AIC than the eight-item versions, and b) better fit indices on the CFA. This leads us to conclude that, regardless of which version is used and how it is interpreted for clinical or research purposes, whether from one or two dimensions, the results will be reliable and comparable with other studies.

As can be seen, the AIS provided psychometric data of good performance in both the adult population and in older Mexican adults. This could be associated with the suggestion by Okajima et al. (2020) that this scale is distinguished by its accuracy in the diagnosis of insomnia. In addition to having the advantages of being a simple, brief and easy to interpret instrument, which favors its application in different populations because it does not require greater supervision and is self-applicable. In particular, we highlight the usefulness of this scale in sensitive populations, such as the elderly, who often present instrumental or logistical complications in undergoing long or complicated evaluations, maintaining its reliability, validity and invariance both in both sexes and in the age groups analyzed.

It is important to note that although there are several studies that provide data on the prevalence of this condition in different populations (e.g. Bhaskar et al., 2016; Torrens, et al., 2019; Khaled et al., 2021), consistent data have not been found, which may be largely due to the fact that each study uses a different tool to assess insomnia. Therefore, it is of utmost importance to have instruments that can be used in different cultural contexts, as this will allow for more accurate comparisons and to know that if there are differences in prevalence, it is due to other variables and not because of the difference in the measurement tool.

One of the limitations of this study is that, although a considerable sample size was obtained, it is not a probability sample; furthermore, it corresponds to residents of a single state in the country, which affects the representativeness of the population group studied, as well as a limitation in obtaining stable parameters and being able to generalize the findings obtained. In addition to the above, it is important to consider in future research some aspects of medical or health conditions, especially for the group of older adults, as this could be a factor that considerably affects their sleep patterns.

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Date of receipt: March 2022.
Acceptance date: March 2023.