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Work Ability Index: Psychometric Testing in Aeronautical Industry Workers

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ABSTRACT

Background: The Work Ability Index (WAI) is an instrument that measures work ability. The wide dispersion of the WAI internationally has led to its adaptation for use in different countries. This study aimed to evaluate the psychometric properties of the Spanish version of the WAI.
Methods: A methodological design was used over an opportunistic sample of 233 workers in the aeronautical industry in Spain. Reliability was evaluated through internal consistency. Factorial validity, known groups, and convergent validity were tested.
Results: The Cronbach's alpha and item-total correlation indicated an adequate internal consistency. The confirmatory factor analysis, performed to evaluate the factorial validity, found adequate fit indices for a two-factor solution with a high correlation between the factors. Factor 1, "Subjectively estimated work ability and resources", was composed of 3 subscales and factor 2, "Ill-health-related", of 2 subscales. Subscales 4 and 6 had loading in both factors. Workers under 45 years of age obtained higher significant scores than older ones. Convergent validity was also evidenced since WAI was highly correlated with self-assessment of health status.
Conclusions: The Spanish version of the WAI has shown evidence of reliability and validity in this study, supporting its use in individual and collective health surveillance by occupational health professionals. The factorial solution that was found has previously been reported in another international context. However, further research is needed to resolve the discrepancies detected in the role of some subscales between other national and international studies.

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1. Introduction

The COVID-19 pandemic has brought substantial changes to workers and companies. They have had to adapt in record time to new working conditions as modifications in collective and individual protection measures, increase in teleworking, changes in working times and shifts, and constant variations in working processes to comply with the recommendations and protocols established by governments. These changes in working conditions have negatively impacted many professionals' physical and psychological health and well-being [1].

Work ability (WA), defined as the degree to which a worker is mentally and physically able to perform the tasks required in his or her job, involves a balance between the worker's physical and mental resources and work demands [2,3]. Sustainable employability requires maintaining and promoting WA at all ages and in all circumstances to avoid decline and possible early exit from working life. Assessing WA allows one to analyze and implement strategies to adapt the demands of the job to the resources of the workers, intervening in the maintenance of productive staff throughout their working life and the quality of life until the moment of retirement.

Different methods have been used to measure WA. The most widely used instrument in occupational health, both in practice and research, is the Work Ability Index (WAI) [2,3]. The WAI is a self-administered questionnaire, an indicator of WA based on the worker's perception of their performance in terms of job demands, individual health, and mental resources, comparing the balance between personal resources and job demands [4]. This tool can be carried out in individual and collective health surveillance and allow for analysis of whether an imminent reduction in WA was foreseeable and what actions might be developed to promote the workers' health [4].

The international dissemination of the WAI has required its translation, adaptation to the particularities of each country's culture and professional practice and psychometric properties evaluation [5]. Consequently, this instrument has now been translated into a number of languages and validated in workers of different occupational categories from countries in Europe [6–8], Latin America [9–12], and Asia [13]. These studies have obtained different factorial structures of one, two, or even three factors. One study [14] found two different structures depending on the occupational category of the sample. Thus, factors such as the local context in which it is applied, the occupational sector, and other factors such as age and sex could be sources of differences in psychometric outcomes [15].

In Spain, the Spanish National Institute for Safety and Health at Work adapted the WAI using the method of translation, back-translation, and pilot testing with permission of the authors [17]. This institute published a technical prevention report to raise awareness of the Spanish version of the WAI among the country's occupational health practitioners in 2020 [17]. However, a few studies have assessed the validity and reliability of the Spanish version of the WAI. Bascour-Sandoval et al [17] evaluated the psychometric performance in a sample of workers from a hospital and a public university, and Mateo Rodríguez et al [15] in healthcare workers with adequate psychometric results, but discordant in terms of the factor structure of the instrument. Therefore, the psychometric properties of the Spanish version of the WAI should be considered preliminary, pending the accumulation of further evidence [17].

As stated before, there is only published information on the psychometric performance of the Spanish version of the WAI in health professionals [16,17]. However, there are other productive sectors in which the evaluation of WA may be significant. In Spain, the industrial sector is the second most important branch of activity in terms of employment, after the services sector, and, within this, the aeronautical industry is strategic [18]. Given the volume of industrial workers in Spain, it is necessary to generate evidence on the psychometric performance of tools that allow the adequate evaluation of WA in this population and, therefore, the implementation of strategies to maintain or recover the WA of the staff of this essential productive sector.

This study pretended to contribute to building that evidence. Therefore, this study aims to evaluate the psychometric properties of the Spanish version of the WAI in a sample of industry workers in Spain, specifically from the aeronautical industry, a productive sector in which they have not been assessed before.

2. Materials and methods

2.1. Design

A cross-sectional survey study was developed.

2.2. Subjects

The sample were workers of a multinational aeronautical company factory in the south of Spain and had at least one year of seniority in the same position. The factory, which employed 354 workers at the time of the study, was dedicated to manufacturing and assembling aircraft components. At the preventive level, the company has an on-site medical service composed of physicians and nurses who assume the competencies of health surveillance and emergency and urgent care functions. Participants were excluded if they had physical (visual impairment) or mental (intellectual disability or psychiatric disorder) limitations that prevented them from completing the questionnaire correctly. The patient's statement on these limitations, routinely collected in a health survey during the periodic health assessment, was considered.

The sample was selected by non-probability consecutive sampling [19]. Current trends recommend a minimum sample size of 200 cases, even under optimal conditions of high communalities and well-defined factors of instruments [20]. However, the literature suggests that larger samples provide more precise estimates of the factor loadings of each item and establish more stable factors [21]. Therefore, an effort was made to maximize the sample size and thus obtain participants above that size proposed *a priori*.

The recruitment took place between 2019 and 2022. The worker was summoned for a periodic health assessment per the medical service's usual procedure. A healthcare professional offered workers the opportunity to participate, explained the study's aim and implications, and ensured that they signed the informed consent form.

2.3. Instruments

The following variables and instruments were considered:

- Socio-demographic variables: age (years) and gender (male, female, other).
- Occupational variables: position (sheet metal worker, aircraft assembler, office worker, Titanium worker, machine operator, aircraft painter, composites worker, workshop technician, quality verifier), work shift (fixed morning, fixed afternoon, fixed night, rotating without nights, rotating with nights, split), experience in the position (years).
- Work Ability Index (WAI). The WAI consists of sixty items distributed in seven subscales: 1) Current WA compared with the lifetime best (1 item); 2) WA in relation to the demands of the job (2 weighted items); 3) Number of current diseases

diagnosed by a physician (list of 51 possible illnesses), 4) Estimated impairment of WA due to illness (1 item); 5) Sick leave during the past 12 months (1 item); 5) Own prognosis of WA two years from now (1 item); and 6) Mental resources (3 items) [4]. The scores for each subscale are summed to give an overall score representing the worker's perception of the ability to perform the work. The overall score could range from 7 to 49, allowing workers to be classified into four categories: poor (7–27), moderate (28–36), good (37–43), and excellent WA (44–49) [4]. These categories were derived from the 15th and 85th percentiles of scores obtained from a population of Finnish municipal employees in 1981, and the resulting cut-off points have not changed since that time [5]. However, numerous studies have dichotomized the score, merging the poor and moderate categories into "inadequate WA" (7–36) and the good and excellent into "adequate WA" (37–49). This dichotomization could be due to statistical reasons but also because both poor and moderate categories are those in which the worker already has an imbalance between individual resources and job demands and, therefore, needs actions to restore or improve their WA. For this study, the Spanish translation proposed by the Spanish National Institute for Safety and Health at Work was used [15].

- Perceived health status: perceived health status in the previous twelve months measured on a 5-point Likert scale (5: excellent, 4: very good, 3: good, 2: fair, 1: poor) based on the single question "In the last twelve months, how would you say your health status has been?" This question has been used in the Spanish national health survey since 1987, and despite its single question, it is accepted that there is a close association between health status and other health outcomes [22].

The WAI was administered in the paper format during the periodical health surveillance assessment. Perception of health status is data included in a health survey that the participants should fill in prior to undergoing the health assessments as standard practice. The socio-demographic and occupational variables data were collected from the company's Electronic Health Records.

2.4. Statistical analysis

Descriptive statistics were used to summarize the variables and scores of instruments. Quantitative variables are expressed in means and dispersion (standard deviations and ranges), and categorical variables in frequency and percentages. The Kolmogorov–Smirnov Z-test for one sample with Lilliefors correction was used to assess the normality of the variables.

Reliability was estimated by assessing internal consistency. The internal consistency was assessed by determining: a) Cronbach's alpha coefficient (α), considered adequate if the value of alpha was between 0.70 and 0.90 [23]. In addition, the values adopted by the α were calculated when eliminating each item; b) the item-total score correlation when the item is removed, calculated using Pearson's correlation coefficient [24], considering adequate values between 0.30 and 0.70 [25].

Validity was estimated based on the assessment of factorial, known groups, and convergent validity. Factorial validity was tested using a Confirmatory Factor Analysis (CFA). Martus et al [26] evaluated several factor structures of the WAI in samples of workers of different professions. They found that a two-factor correlated model with two subscales loadings on both factors was the most appropriate. Factor 1 was composed of subscales 1, 2, 7, 4, and 6, while factor 2 was composed of subscales 3 and 5. Subscales 4 and 6 were those loading on both factors. In this study, the factorial validity of the Spanish version of the WAI was tested, replicating this model on the data obtained from aeronautical industry workers. For CFA, the maximum likelihood estimation method and the covariance matrix between the items were used as input for the data analysis. The fit indices suggested by Kline [27] were used to assess the fit of the data to the proposed model: a) statistical significance of the Chi-square test: if the result is not significant, it indicates that the model achieves a perfect fit with the observed data; b) comparative fit index (CFI): values $\geq$ 0.90 are indicative of a good fit [28]; c) Tucker-Lewis Index (TLI): values $\geq$ 0.90 are suggestive of a good fit (Tucker & Lewis, 1973); d) root mean square error of approximation (RMSEA): values $\leq$ 0.05 are indicative of an excellent fit and $<$0.08 of acceptable fit of the data to the model [29]; d) standardized root mean square residual (SRMR): values $\leq$ 0.05 are suggestive of a good fit [30].

Table 1
Socio-demographic and occupational characteristics of the sample [SD: standard deviation]

Characteristics		Frequency	Percentage	Mean	SD
Participants		233	100%		
Age (range: 25–60 years)				41.5	7.5
Gender	Male	206	88.4%		
	Female	27	11.6%		
Position	Sheetmetal Worker	22	9.4%		
	Aircraft Assembler	35	15.0%		
	Office worker	43	18.5%		
	Titanium worker	8	3.4%		
	Machine Operator	23	9.9%		
	Aircraft painter	9	3.9%		
	Composites Worker	55	23.6%		
	Workshop technician	12	5.2%		
	Quality verifier	26	11.2%		
Work shift ($N = 214$)	Fixed morning	82	38.3%		
	Fixed afternoon	1	0.5%		
	Rotating without nights	78	36.4%		
	Rotating with nights	36	16.8%		
	Split	17	7.9%		
Length of service				11.3	10.21

The WAI overall score should be compared between groups presumed to differ in the attribute measured because of a known characteristic to determine known group validity [31]. Age is a factor that has been found to modulate WA in multiple studies [32] that have found that older people have poorer WA, or, in other words, younger people have higher WAI scores. Therefore, participants were classified as 44 years or under and 45 years or older, and WAI scores were compared between these two groups using the Mann-Whitney U test. The instrument was considered to show evidence of known group validity if this test was significant.

The correlation between the WAI overall score and the workers' perceived health status in the last twelve months was used to determine the convergent validity using Spearman's Rank Order Correlation. The WA and perceived health status were correlated in previous studies [10]. The health status variable was transformed into a quantitative ordinal one for analysis. A coefficient $r_s > 0.3$ indicates a fair correlation [33].

The results were considered statistically significant if the *p*-values were $<$.05. Data were analyzed using IBM SPSS Statistics for Windows, version 29, and IBM AMOS, version 22.

The approval of the Research Ethics Committee was given. Participants volunteered and signed an informed consent form. Anonymity and confidentiality were assured.

3. Results

3.1. Descriptive results

The sample consisted of 233 aeronautical workers. Table 1 shows in detail the socio-demographic and occupational sample

Table 2
Distribution of the WAI and its subscales scores in the sample and results of reliability tests [SD: standard deviation]

WAI subscale	Possible range	Mean ± sd	Corrected item-total correlation	α if the item was deleted
1. Current work ability compared with the lifetime best	0–10	8.7 ± 1.41	0.69	0.65
2. Work ability in relation to the demands of the job	2–10	9.0 ± 1.14	0.61	0.68
3. Number of current diseases diagnosed by a physician	1–7	4.8 ± 2.12	0.45	0.76
4. Estimated impairment of workability due to illness	1–6	5.7 ± 0.82	0.57	0.70
5. Sick leave during the past 12 months	1–5	4.4 ± 0.96	0.36	0.73
6. Own prognosis of work ability two years from now	1–7	6.8 ± 0.96	0.45	0.71
7. Mental resources	1–4	3.6 ± 0.61	0.35	0.74
Overall WAI	7–49	42.87 ± 5.41	—	0.74

characteristics. The mean age was 41.55 years (SD = 7.51; range: 25–60), and 88.4% were male. Of the nine positions included, titanium workers were the most represented (23.6%), followed by office workers (18.5%) and quality verifiers (11.2%). The average job experience was 11.3 years (SD = 10.21). Table 1 shows the WAI overall and subscales score distribution for the sample. The average subscale scores were above 87% of the maximum possible score, except for subscale 3, "Illnesses or injuries diagnosed by a doctor from which you are currently suffering", in which the sample obtained 68.6% of the possible score. Twenty-nine workers (12.4%) showed "inadequate WA". Of these, 5 (2.1%) were classified in the "poor WA" category and 26 (11.2%) in "moderate WA". Two hundred four (87.6%) workers have adequate WA, with 131 (56.2%) classified in the "excellent WA" category and 71 (30.5%) in "good WA".

3.2. Reliability

Concerning the evidence of reliability, the WAI showed an α value of 0.74, indicative of adequate internal consistency. Only subscale 3 improved the α minimally if it was removed. All subscales were in the range considered indicative of adequate internal consistency in item-total correlation tests. Table 2 reports these results in detail.

3.3. Validity

Regarding factorial validity, the CFA was performed to determine the fit of the data. Initially, the data fit to the classic single-factor model was evaluated, finding unacceptable fit indices ($\chi 2 = 60.55$ ($p < 0.001$); CFI = 0.90; TLI = 0.85; RMSEA = 0.12 (90% CI: 0.90–0.15); SRMR = 0.08). Then, the two-factors model proposed by Martus et al [26] was tested, revealing adequate fit indices: Chi-square ($\chi 2 = 17.38$ ($p = 0.09$); CFI = 0.98; TLI = 0.97; RMSEA = 0.05 (90% CI: 0.00–0.09); SRMR = 0.03). Fig. 1 shows the evaluated model with the factor loadings of each subscale and the correlation between factors. Based on Martus et al [26], factor 1, comprising subscales 1, 2, and 7, could be named "Subjectively estimated WA and resources", and factor 2, subscales 3 and 5, constitute factor 2 "Ill-health-related". Subscale 4, "Estimated impairment of WA due to illness", and 6, "Own prognosis of WA two years from now", contributed to both factors. All subscales had loadings above 0.40 on their respective factors except for subscales 4 and 6. Subscale 4 had a factor loading of 0.27 on factor 1, and subscale 6 had a factor loading of 0.55 on factor 2. Both factors had a high correlation between them (0.55).

Workers of 44 years of age or under ($\bar{x}_1 = 43.3$; SD = 5.34) obtained higher scores and, therefore, showed better WA than those of 45 or older ($\bar{x}_2 = 41.6$; SD = 5.44) with statistically significant difference between these groups (U = 4226.00; $p = 0.005$) supporting known groups validity.

The WAI showed convergent validity with workers' self-assessment of health status as its overall score was highly correlated with this construct ($r_s = 0.48$; $p < 0.001$).

4. Discussion

The evidence provided by the present study supports the reliability and validity of the Spanish version of the WAI and, therefore, the use of this instrument on industrial aeronautical workers. This evidence should be considered preliminary since the instrument's psychometric properties can only be established if they remain stable in many studies conducted in different contexts.

This study is the first published evaluation of the workers' WA in the aeronautical industry. Therefore, to compare these results, studies in industries with similar work processes, such as the automobile manufacturing industry, had to be consulted. Only two studies were found. A study conducted on Iranian workers belonging to petrochemical and automobile manufacturing industries with a mean age of 37.4 years [34] found a mean score of the WAI of 38.1, somewhat lower than the average found in this study, a score of 42.87 in workers with an average age of 41.55 years. The distribution of WA in categories showed that 36.4% of the workers in the study conducted in Iran could be classified in the inadequate WA category, which is almost three times more than the values reported by this study (12.4%). The other study, Börner, Kerstin et al [35], conducted on 54 German female assembly line workers in the automotive industry with a mean age of 43.9 years, found WA ranges between 37 and 43, which falls into the category of good WA. However, the authors of this study used a short version of the WAI. As can be seen, the heterogeneity of the studies originating from the combination of workers from various industries, different gender and age distributions, and the use of different versions of the WAI makes comparison difficult. Moreover, other factors such as different physical and mental requirements of positions, workplace environment and organizational factors, and a healthy worker effect could also be sources of heterogeneity of results between studies.

The WAI has shown evidence of reliability in this research. The α values were adequate and similar to other studies in other samples in Spain. Bascour-Sandoval et al [17] reported an α of 0.75, a value almost analogous to the one found in this study, which was 0.74. Mateo Rodríguez et al [15] obtained an α of 0.81, a slightly higher value than the one obtained among industrial workers. In the present study, only subscale 3, "illnesses or injuries diagnosed by a doctor from which you are currently suffering", increased α slightly to 0.76 when not considered in the calculations. This finding may be because this scale measures the amount of illness present, not the quality of the illness. It means that a patient with only one particular disease may have much more impact in a physically demanding job than a worker with more than one pathology that

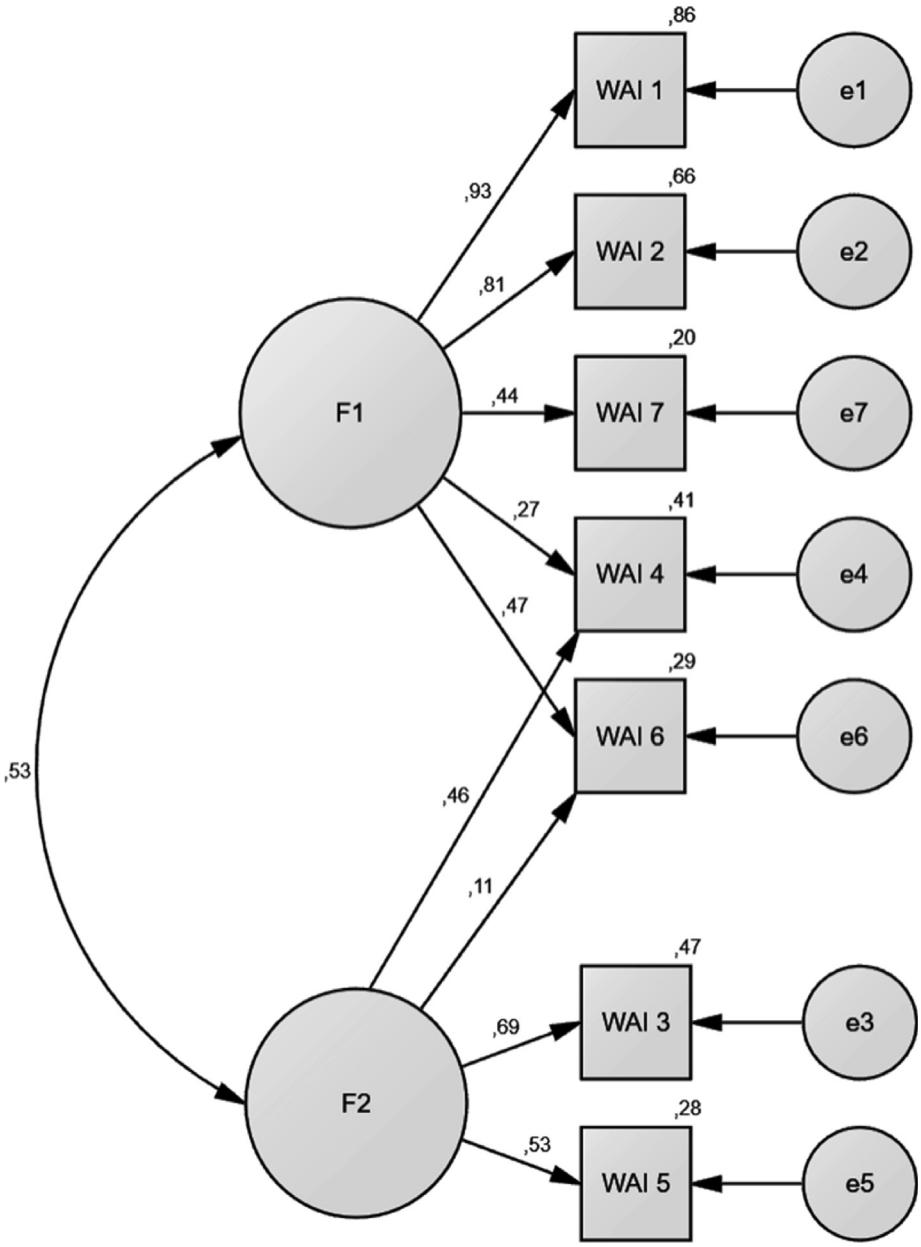

Fig. 1. Model evaluated with factor loadings of the items on the factors and the correlation between them. Note: Factor loadings are standardized. F = factor; WAI = WAI subscale; e = error.

does not affect the performance of his or her tasks. However, the same finding was not found in the study by Bascour-Sandoval et al [17], while this aspect was not evaluated by Mateo Rodríguez et al [15]. On the other hand, the results of item-total correlations were satisfactory, contrary to Bascour-Sandoval et al [17], who reported correlations below 0.3 for subscales 5 and 6. Although the reliability results were generally adequate, new evidence is necessary to clarify the discrepancies detected in the above subscales.

Regarding evidence of validity, discordance in the literature on the dimensional structure of the WAI should be emphasized. Although the WAI was initially considered a one-factorial instrument, a multinational study with a large sample of European nurses found a two-factor solution in seven out of nine participating countries [36]. Given this fact, Martus et al [26] tested various dimensional structures in a study on German workers of different professions, the classical one-factor solution and three different two-factor solutions, one with no correlation between factors and two with a correlation between factors. This study considered a structure of two correlated factors with a unique role of subscales 4 and 6, with loadings in both factors as the most appropriate. This factorial structure was evaluated in our data, and similar fits were achieved. The fact that subscales four (Estimated impairment of WA due to illness) and six (Own prognosis of WA two years from now) have loadings on the two factors may be due to the alteration and prognosis of WA being determined by both the health status of the worker and the resources he or she has. The loading of subscales four and six on both factors could imply that these subscales better reflect the consequences of an imbalance between the resources and the health demands of workers.

In other studies developed in Spain, Bascour-Sandoval et al [17] found a three-factor structure only previously seen in a Brazilian

study [37]. The third factor was constituted only by subscale 7, "Mental resources". As an objection, it should be noted that authors considered in the analysis the three items that make up the subscale and not the aggregate score of the items, something that could have altered the dimensionality of the instrument. On the other hand, the study developed by Mateo Rodríguez et al [15] found a two-dimensional structure, with one factor formed by subscales 3, 4, and 5 and another by items 1, 2, 6, and 7. Therefore, a two-factor structure of the Spanish version of WAI should be supported based on Mateo Rodríguez et al [15] and the results of this study. The results of this study could contribute to the ongoing discussion on whether the WAI is a two-factor instrument. This debate should also include clarifying the structural role of subscales 4 and 6 since these subscales correlate with one factor, the other, or both, depending on the study consulted.

Researchers have found a reasonably consistent negative relationship between age and WAI score [38]. This correlation was expected, knowing there is a positive relationship between age and perceived and objective disability. The hypothesis was that workers aged 44 and under would have a better WA than those aged 45 and over. The results of the present study showed significantly different mean scores of the WAI between younger and older workers, supporting the instrument's ability to detect expected differences in the construct between groups with different attributes.

WA was highly correlated with workers' self-assessed health status, supporting the convergent validity of the instrument and confirming that the two constructs were correlated as expected. This positive relationship should be expected, given that the WAI includes items that capture the current diseases diagnosed and the estimated impairment due to illness. Thus, a conceptual overlap is established between the WAI and existing measures of perceived health. Positive relationships with other health status instruments, such as the SF-12 Health Questionnaire [15] or the General Health Index [27], have been found in multiple studies.

There are several potential limitations of the study should be discussed. The use of a small convenience sample limits the generalizability of the results. Furthermore, the fact that the sample comes from the same company may be a source of limitations when generalizing the results to all aeronautical workers in the country. Not all aspects of reliability or validity were assessed, nor was the instrument's sensitivity to change, which, if corroborated, could be used to assess the effectiveness of government and companies' initiatives to maintain, improve, or restore WA. New studies are also desirable using a more comprehensive measure of perceived health status in convergent validity, allowing comparison of the perception of physical and mental health with the subscales related to these constructs.

4.1. Research implications

The Spanish version of the WAI has shown evidence of reliability and validity in a sample of workers in the aeronautical industry. This evidence supports its use as a tool for individual and collective health surveillance by occupational health professionals. Its use could help them explore workers' WA, making it possible to plan and implement preventive measures, avoiding premature abandonment of working life and healthier companies. This study revealed in a Spanish sample the same factorial structure previously found in another international context. However, further research with larger samples is needed to consolidate this study's results and resolve the discrepancies detected in the role of some subscales between other national and international studies. Furthermore, progress must be made to improve the applicability of the WAI in the Spanish context, determining the most appropriate cut-off points for each age range or according to the occupational category, as has been studied in other international versions of the instrument [14,39].

Author contributions

All co-authors have made essential contributions to the paper and confirm it. Study conception and design: María Eugenia GONZÁLEZ-DOMÍNGUEZ, José Manuel ROMERO-SÁNCHEZ and Olga PALOMA-CASTRO; data collection: Paz RIVAS PÉREZ; analysis and interpretation of results: José Manuel ROMERO-SÁNCHEZ, Luis LÓPEZ-MOLINA, Regina María GONZÁLEZ-LÓPEZ, Jesús GARCÍA-JIMÉNEZ and Elena FERNÁNDEZ-GARCÍA; draft manuscript preparation: José Manuel ROMERO-SÁNCHEZ, María Eugenia GONZÁLEZ-DOMÍNGUEZ and Elena FERNÁNDEZ-GARCÍA. All authors reviewed the results and approved the final version of the manuscript.

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Conflicts of interest

All authors have no conflicts of interest to declare.

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