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A comparative analysis of the Work Ability Index

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Background The Work Ability Index (WAI) is a well-established instrument to measure work ability. However, the dimensionality of the WAI remains controversial.

Aims To identify the dimensionality of the WAI and to investigate dependencies of factors and subscales.

Methods The sample analysed in this study consisted of 371 subjects of different occupational groups (teachers, office workers, nursery school teachers and managers). The WAI was measured for all subgroups. Psychometric characteristics of the WAI were investigated using factor analyses with different numbers and different patterns of dependency among the factors. Chi-square analysis and the Comparative Fit Index were used to statistically assess fit quality.

Results The group of managers had to be excluded from the analysis as their results were probably overoptimistic due to reporting bias; thus, 324 subjects entered. The one-factor model and an orthogonal two-factor model did not fit the observed correlational structures. A satisfactory fit was obtained using a two-dimensional model with correlated factors. These factors could be interpreted as subjectively estimated work ability and objective health status. Only five of seven items of the WAI could be related unambiguously to one of both factors.

Conclusions From our study, we conclude that using only the total score of the WAI is not adequate for population analysis of and assessment of work ability to individuals. Instead, the two-dimensional structure of the instrument must be taken into account.

Key words Confirmatory factor analysis; factor analysis; factor structure; health status; WAI; work ability.

Introduction

The Work Ability Index (WAI) is a widely used questionnaire in occupational health and research that takes into consideration the demands of work, the worker's health status and resources. It consists of seven subscales regarding work ability compared with the lifetime best in relation to the demands of the job, the number of diseases, the work impairment and the absence from work due to disease and finally subjects' own prognosis of work ability and mental resources. The WAI was developed in Finland [1] but it has been translated into 25 languages and has been used in different European countries, China and Brazil [2].

The question of whether the WAI may be treated as a one-dimensional or as a two- or more dimensional instrument is controversial [3]. One could postulate that Subscales 1, 2, 6 and 7 relate to subjective estimations of work ability, whereas Subscales 3 and 5 are health related and Subscale 4 refers to both work ability and health status.

Recent studies on the reliability of WAI point to a two-dimensional structure. Reliability was assessed by correlation analysis in the first cross-sectional study in 1981 [4]. In later cross-sectional studies [5], Cronbach's alphas were calculated for assessing the reliability of the instrument. The Subscales 1, 2, 4 and 7 had the strongest effect on the extent of reliability. These variables were interpreted to have the highest internal consistency. Subscales 3, 5 and 6 had the weakest effect on WAI.

However, the use of Cronbach's alpha might be misleading if the underlying factor structure contains more than one dimension and especially if the number of subscales influencing each factor is different. In general, the larger group of subscales will achieve better Cronbach's alpha.

This could explain the seemingly smaller validity in Subscales 3 and 5 of the WAI.

In a large follow-up study among employees aged 15–64 years in the metal industry and in the retail trade, the reliability coefficients were between 0.72 and 0.80 [6]. In another study, the test–retest reliability was also studied among elderly construction workers. At the group level, the mean WAI score and classification into WAI categories were found to be stable over a 4-week interval [7].

This study combines data from several studies in Germany into a secondary analysis. All the studies were undertaken using similar multidimensional methods based on objective physiological measures (Vitality Measurement Station [8]) and subjective instruments (questionnaires and structured interviews) including the WAI. The data were collected in the following projects: 'Work ability and vitality of teachers in different age groups' [9], 'Workplace health promotion and work ability in day-care facilities' [10] and 'Work- and health-related determinants on work ability and vitality' [11]. An analysis of predictors for biological age in the pooled sample has been published recently [12].

The issue of whether there are several dimensions in the WAI instrument is crucial for both the validation of subscales using statistical methods based on correlations and the interpretation of results for individuals and populations. In our study, we asked the following questions:

1. What is the dimensionality of the WAI?
2. If there is more than one dimension, how can we interpret the multi-dimensionality?
3. Are the results stable in different subpopulations?

Methods

In this analysis, we focused on the WAI; the entire programme of measurements has been described elsewhere [9,11]. Other measurements were health-related outcomes (Vitality Measurement Station and Relaxation Inability Questionnaire [13]) and the effort–reward imbalance [14,15] questionnaire.

The WAI describes how capable an employee is of doing his/her job [16–20] and the questionnaire consists of seven subscales referring to these aspects of work ability:

- WAI 1: current work ability compared with lifetime best;
- WAI 2: work ability in relation to job demands;
- WAI 3: number of current diseases;
- WAI 4: estimated work impairment due to diseases;
- WAI 5: sick leave during the past year (12 months);
- WAI 6: own prognosis of work ability 2 years from now and
- WAI 7: mental resources.

The cumulative index of WAI ranges from 7 to 49 points. It is divided into the categories: poor (7–27 points), moderate (28–36 points), good (37–43 points) and excellent work ability (44–49 points). We did not use this classification in our analyses.

Descriptive analysis included means and standard deviations and medians and ranges. Comparisons between subsamples were done using analysis of variance with correction for multiplicity of pair wise comparisons (Tukeys B). For our primary scientific question, we used confirmatory factor analysis. The method of estimation was Maximum Likelihood, and only standardized path coefficients are reported. To statistically assess fit quality, we present discrepancy chi-square values, degrees of freedom and the Comparative Fit Index (CFI). This index, introduced by Bentler [21], compares the model under investigation to the model assuming independent subscales. It ranges between zero and one, and values >0.90 or 0.95 indicate a satisfactory fit [21]. A further detailed justification of this index has been given by Byrne [22].

Results

The sample consisted of 371 subjects belonging to five subgroups: female teachers ($n = 100$) [9], female office workers ($n = 60$) [9], female nursery school teachers ($n = 65$) [10], male teachers ($n = 99$) [9] and male managers ($n = 47$) [11]. For Subscales 4 and 6, the managers documented only the best possible values. Thus, there was no variation in this subgroup and we excluded the managers from the psychometrical analysis, leaving 324 subjects for our analysis. Table 1 shows the demographic data and a descriptive analysis of the samples. Except for the nursery teachers, all employees worked >35 h/week. The majority of subjects were married (80%).

The one-factor model is motivated by the idea that the different subscales of the WAI are all measurement tools for the same underlying construct 'work ability', which does not have any substructure. The higher the inter-subscale correlation of one subscale, the larger is the validity of this subscale. If the one-factor model is correct, the reduction of the seven subscales to only one overall score is justified without loss of relevant information. In Figure 1 (four populations and seven subscales), the factor loadings of the one-factor model are displayed for the several groups (x-axis) and the subscales of the WAI (lines). In accordance with the observation in [5], Subscales 3, 5 and 6 show smaller factor loadings as compared to Subscales 1, 2, 4 and 7. Subscale 3 shows a marked peak in Group 2 (office workers), whereas the other lines show comparable profiles. Cronbach's alpha varied between 0.58 and 0.77 for the four populations.

The two-factor model is motivated by the idea that the seven subscales of the WAI are measurement tools for two different underlying constructs. The analysis showed that these constructs might be labelled as health-related work ability and (subjectively) non-health-related work ability.

Table 1. Description of the sample, including management personnel

	Total (n = 371)	Teachers (female) (n = 100)	Office workers (female) (n = 60)	Nursery school teachers (female) (n = 65)	Teachers (male) (n = 99)	Management personnel (male) (n = 47)
Participation rate (%)	–	58	57	86	28	70
Age						
Mean ± SD	**45.6 ± 8.1**	44.6 ± 7.7	42.6 ± 8.7	43.9 ± 9.2	47.9 ± 6.4	49.2 ± 7.5
Median	**46**	45	43	44	48	50
Range	**20–64**	25–61	20–60	22–61	35–61	35–64
Education (%)						
University		100			77	49
High school		100			78	81
Secondary school			67	91		
Vocational training			75	100		
WAI						
Mean ± SD	**40.1 ± 5.5**	37.6 ± 5.9	41.0 ± 4.1	39.7 ± 5.4	39.3 ± 4.7	46.3 ± 2.1
Median	**41**	38	41	41	38	46
Range	**19–49**	20.5–47.5	29.5–48	19–49	25–47	40.5–49
WAI 1						
Mean ± SD	**8.0 ± 1.5**	7.2 ± 1.5	8.2 ± 1.1	8.0 ± 1.7	7.8 ± 1.2	9.6 ± 0.7
Median	**8**	7	8	8	8	10
Range	**0–10.0**	3–10	5–10	0–10	4–10	8–10
WAI 2						
Mean ± SD	**8.0 ± 1.3**	7.3 ± 1.2	8.3 ± 1.2	8.0 ± 1.0	7.6 ± 1.1	9.7 ± 0.7
Median	**8**	8	8	8	8	10
Range	**4.5–10**	4.5–10	4.5–10	6–10	4.5–10	8–10
WAI 3						
Mean ± SD	**4.5 ± 2.0**	4.0 ± 2.1	4.2 ± 2.0	4.3 ± 2.1	4.7 ± 1.9	5.3 ± 1.6
Median	**5**	4	4	5	5	5
Range	**1–7**	1–7	1–7	1–7	1–7	3–7
WAI 4						
Mean ± SD	**5.4 ± 1.0**	5.2 ± 1.1	5.7 ± 0.6	5.2 ± 1.0	5.4 ± 0.8	6.0 ± 0.0
Median	**6**	6	6	5	6	6
Range	**1–6**	2–6	3–6	1–6	2–6	6–6
WAI 5						
Mean ± SD	**4.0 ± 1.0**	3.9 ± 0.9	3.9 ± 1.0	3.6 ± 1.1	4.2 ± 0.8	4.7 ± 0.5
Median	**4**	4	4	4	4	5
Range	**1–5**	1–5	1–5	1–5	2–5	3–5
WAI 6						
Mean ± SD	**6.8 ± 0.8**	6.7 ± 1.0	7.0 ± 0.4	6.8 ± 0.7	6.7 ± 1.0	7.0 ± 0.0
Median	**7**	7	7	7	7	7
Range	**1–7**	1–7	4–7	4–7	1–7	7–7
WAI 7						
Mean ± SD	**3.4 ± 0.7**	3.3 ± 0.6	3.6 ± 0.6	3.8 ± 0.4	2.9 ± 0.7	4.0 ± 0.2
Median	**4**	3	4	4	3	4
Range	**1–4**	2–4	2–4	2–4	1–4	3–4

Entries are mean ± standard deviations, medians and ranges. Results for total sample are given in bold. We found significant differences for each of the seven subscales of the WAI ($P < 0.01$) except for Subscale 6 ($P = 0.06$) with managers showing significantly higher values than each other group for the WAI 1, WAI 2, WAI 4, WAI 5 and WAI 7. Both groups of teachers consistently showed the worst results for WAI 1, WAI 2, WAI 6 and WAI 7. This was not true for WAI 3 (worst results for office workers and nursery teachers). For WAI 4 and WAI 5, female teachers (but not male teachers) and nursery teachers showed the worst results. WAI 1: current work ability compared with lifetime best; WAI 2: work ability in relation to the demands of the job; WAI 3: number of current diseases diagnosed by a physician; WAI 4: estimated work impairment due to diseases; WAI 5: sick leave during the past year (12 months); WAI 6: own prognosis of work ability 2 years from now and WAI 7: mental resources.

The assumption of orthogonality means that correlations between the health-related subscales and the non-health-related subscales are irrelevant or occurred by chance only. This means that the overall score might not adequately describe the work ability and should be broken down into two subscores. This analysis showed a very clear structure: Subscales 1, 2 and 7 were related to one factor, whereas Subscales 5 and 3 were related to factor two in all subpopulations. Subscales 4 and 6 were not clearly related to one of both factors and the loadings varied largely between the subpopulations. Thus, the structure postulated in the introduction (Scales 1, 2, 6 and 7: subjective work ability; Scales 3 and 5: health status and Scale 4: both) was confirmed. However, in our data, Subscale 6 (own prognosis of work ability) was influenced by health status too; even so, the wording of this scale did not contain a direct relation to the health status. The results are not shown in detail as this model provided a much worse fit as compared to a model with correlated factors (section confirmatory factor analysis Table 2).

The non-orthogonally rotated two-factor model is a compromise between the one-factor approach and the orthogonal two-factor approach. It still assumes that the subscales of the WAI are measurement tools for two different underlying constructs. However, these constructs may be correlated. In the case of a positive correlation as in our study (see below), subjects with a better health status will on average also show a better subjectively estimated work ability. If the correlation between both factors approaches 1, the model becomes similar to the one-factor model; if the correlation is zero, the model is equivalent to the orthogonal factor analysis.

The two models analysed here differed in that the first one gave an unambiguous relationship between both correlated factors and the several subscales. In view of the analysis with orthogonal factors (preceding section), this assumption was doubtful for Subscale (4) 'Estimated work impairment due to diseases' and also for Subscale (6) 'Own prognosis of

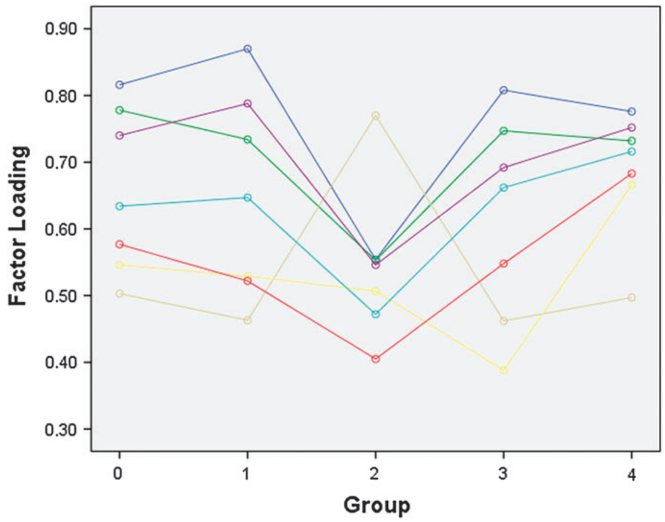

Figure 1. Exploratory factor analysis: structure of models I–IV. Groups—0: total sample, 1: female nursery teachers, 2: female office workers, 3: male school teachers and 4: female school teachers. Cronbach's Alpha was 0.77 for female teachers, 0.69 for male teachers, 0.58 for office workers and 0.72 for nursery teachers. Subscales—WAI 1: current work ability compared with the lifetime best (dark blue); WAI 2: work ability in relation to the demands of the job (green); WAI 3: number of current diseases diagnosed by a physician (grey); WAI 4: estimated work impairment due to diseases (violet); WAI 5: sick leave during the past year (12 months) (yellow); WAI 6: own prognosis of work ability 2 years from now (red) and WAI 7: mental resources (light blue).

Table 2. Results of confirmatory factor analysis, seven subscales, four populations, fit of models

	Total	Female office workers	Female nursery teachers	Male teachers	Female teachers
I One-factor model					
Chi-square, df = 14	89.1	46.7	24.1	9.5	41.7
P	<0.001	<0.001	<0.05	0.80	<0.001
CFI	0.85	0.49	0.92	1.00	0.87
II Two-factor model, orthogonal factors					
Chi-square, df = 15	115.0	51.8	27.6	21.4	69.4
P	<0.001	<0.001	<0.05	0.13	<0.001
CFI	0.80	0.42	0.90	0.95	0.74
III Two-factor model, correlated factors					
Chi-square, df = 13	38.6	48.0	18.6	8.6	38.6
P	<0.001	<0.001	0.14	0.80	<0.001
CFI	0.88	0.45	0.95	1.00	0.88
IV Two-factor model, correlated factors, Subscales 4 and 6 loading on both factors					
Chi-square, df = 11	25.8	21.3	9.8	6.5	19.5
P	<0.01	<0.05	0.55	0.83	0.053
CFI	0.97	0.84	1.00	1.00	0.96

The subgroup of managers was excluded as their results were probably overoptimistic due to reporting bias cf. Table 1). Models I–IV are displayed graphically in Figure 2a–d. Comparative fit indices should be >0.90 for a satisfactorily fit.

work ability 2 years from now'. Thus, in the second model, Subscales 4 and 6 were related to both factors. The question which of all the four models is adequate was answered by the method of confirmatory factor analysis.

In confirmatory factor analysis, the observed correlation structure among subscales was compared to the one predicted by the model. Mathematically, this approach lead to a specific type of chi-square test with degrees of freedom determined by the number of pair wise correlations and the number of estimated parameters in the factor analyses. Different models were compared by calculating the difference of degrees of freedom and chi-square values. This, however, was only allowed if one model was a special case of the other one, i.e. the models were hierarchically ordered. We investigated the two models from the preceding paragraphs and two additional models including correlations between both factors and allowing Subscales 4 and 6 to load on both factors. The structures of all four models are shown in Figure 2a–d. In these figures, directed arrows show the influence of the underlying factors on the measurement scales, and undirected arrows indicate correlations between factors. The empty circles indicate that each scale is influenced not only by the underlying factors but also by the other random and/or unknown systematic influences. The absence of undirected arrows between empty circles indicates that the correlation between subscales is entirely due to the factors.

Table 2 shows the goodness of fit for Models I–IV in the total population and the four subpopulations.

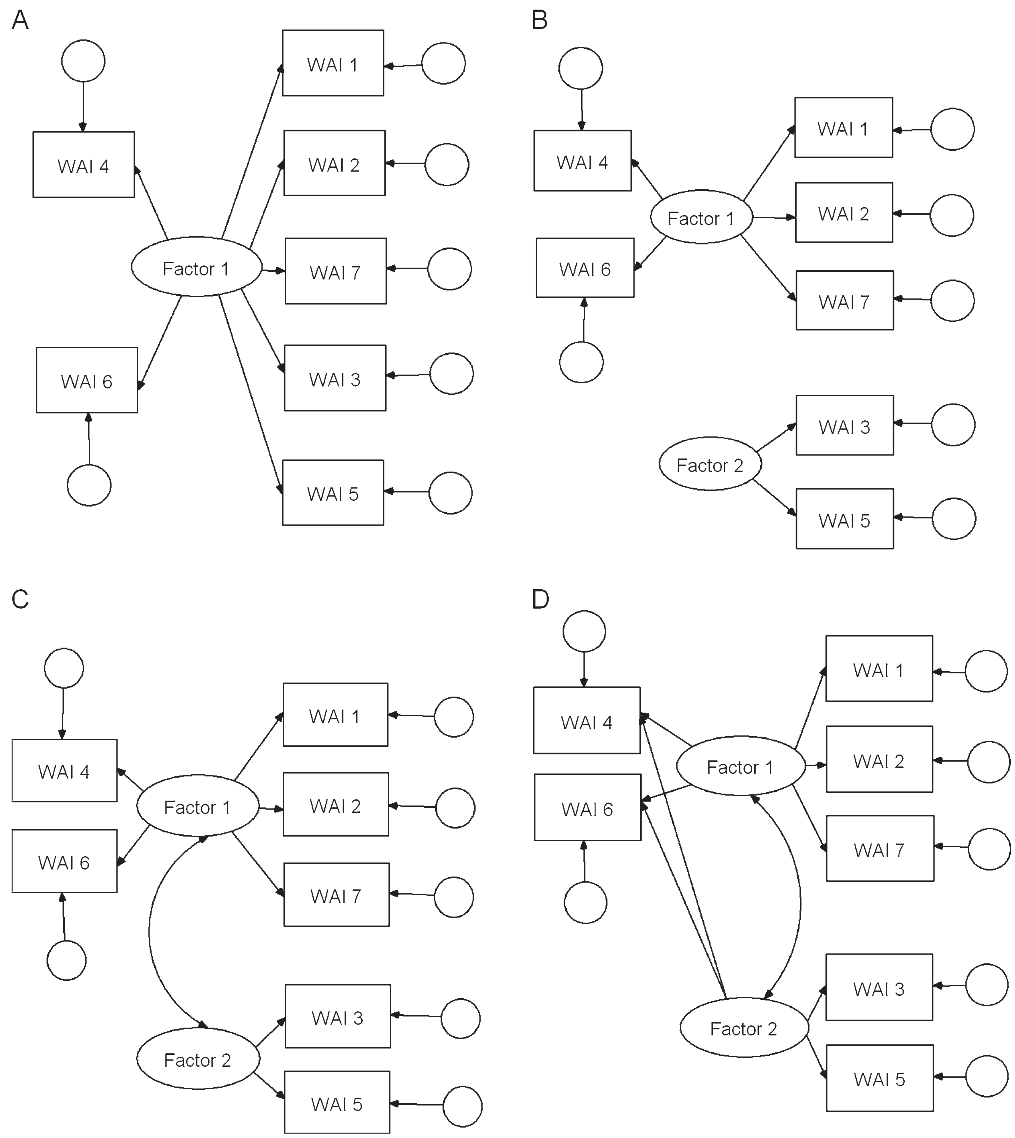

Figure 2. Confirmatory factor analysis: structure of models I–IV. Rectangles correspond to observed measurements, ovals correspond to the unobserved factors of the WAI and circles correspond to unobserved measurement errors or unknown influential variables. Directed arrows represent the loading of subscales on factors and bidirectional arrows represent correlations.

Except for II versus I, all model pairs were hierarchically ordered and thus might be compared by differences of chi-square statistics. Except for male teachers, Model IV clearly gave the best fit in the overall population and the subpopulations. Except for female office workers, we obtained CFI >0.95. For female office workers, the CFI was 0.84 for Model IV and <0.50 for each other model. For male teachers, the one-factor model gave a satisfying fit. The parameters of the one-factor model are shown in Figure 1; the parameters for the proposed Model IV can be found in Table 3. In Model IV, loadings of Subscales 1 and 2 on factor 1 were >0.73 with one exception (female office workers, Subscale 2, path coefficient = 0.48). For Subscale 7, loadings ranged between 0.40 and 0.68. Loadings of Subscales 3 and 5 on factor 2 were between 0.42 and 0.64. Subscales 4 and 6 showed a very heterogeneous pattern of path coefficients over the populations with Subscale 4 loading predominantly on Factor 2. The correlations between both factors were highly significant between 0.38 and 0.73.

Discussion

Our study found that work ability as measured by the WAI was not a one-dimensional construct. Except for the subpopulation of male teachers, we observed results that favoured a two-dimensional structure. There was a clear grouping of five of the seven subscales of the WAI in the two-dimensional rotated model: Subscales 1, 2 and 7 constituted a factor that could be termed 'subjectively estimated work ability and resources' and Subscales 3 and 5 might constitute an 'ill-health-related factor'. For Subscales 4 and 6, the situation was less clear.

The confirmatory analysis supported the use of a two-factor model and the special role of Subscales 4 and 6. For the total population and most of the subpopulations, the two-factor model with Subscales 4 and 6 loading on both factors improved the fit highly significantly.

Both factors appeared to be strongly correlated; thus, neither the one-factor model nor the orthogonal two-factor model seems to describe the data well. The data do not suggest that the grouping of Subscales 1, 2 and 7 versus Subscales 3 and 5 occurred by chance. Additionally, because in four of five subpopulations the fit of the one-factor model was inadequate, the one-factor model should be dismissed. Our data does not allow determinations of whether the construct of work ability underlying the WAI is more complex, with three or four dimensions.

Concerning the stability of the results in different populations, we found at least one exceptional population, the male managers. This population was so different from the others that it could not be included in the analysis. In two subscales, only the best possible values were documented, interestingly exactly those subscales (4 and 6) that did not fit well to the two-factor structure in the other populations. In our study, 94% of the managers showed excellent work ability (WAI > 43 points).This contradicts the results of Feldt *et al.* [23], who found in a longitudinal analysis only 662 of 1033 managers (64%) with excellent work ability throughout the follow-up. Restricted to the upper managerial level, this percentage was 71. Gould and Polvinen [24] showed an age-adjusted mean of 41.9 for male managers compared to 46.3 in our sample (unadjusted). Thus, we conclude that either our sample of managers or their responses were biased towards a higher work ability.

Our results contribute to the ongoing debate about the structure of the WAI. Radkiewicz [3] analysed psychometric properties of the WAI in a very large population of nurses (Nurses Early Exit Study) with 38 000 participants from 10 European countries. In country-specific analyses, they found Cronbach's alpha between 0.54 and 0.79. Comparing the different subscales of the

Table 3. Results of confirmatory factor analysis, seven subscales, four populations, factor loadings and between factor correlations

	Total	Female office workers	Female nursery teachers	Male teachers	Female teachers
WAI 1, Factor 1	0.82	0.79	0.97	0.82	0.81
WAI 2, Factor 1	0.74	0.48	0.73	0.73	0.76
WAI 3, Factor 2	0.52	0.66	0.58	0.42	0.44
WAI 4, Factor 1	0.28	0.41	0.46	0.33	0.14
WAI 4, Factor 2	0.56	0.98	0.36	0.36	0.94
WAI 5, Factor 2	0.58	0.50	0.64	0.41	0.62
WAI 6, Factor 1	0.33	0.46	0.19	0.23	0.13
WAI 6, Factor 2	0.25	0.03	0.33	0.26	0.53
WAI 7, Factor 1	0.54	0.40	0.58	0.56	0.68
Correlation Factors 1–2	0.46	0.38	0.47	0.66	0.73
Chi-square (covariance Factors 1–2)	63.3	25.4	14.3	3.0	22.2
P	<0.001	<0.001	0.003	0.39	<0.001

The subgroup of managers was excluded due to lack of variation for two subscales. Explanation of subscales cf. legend of Table 1.

WAI, they found the lowest discriminant power for Subscales 3 and 5 in nearly all the 10 populations. They found, over all subpopulations, that Subscales 1 and 2 had the highest discriminant power, whereas Subscales 4, 6 and 7 showed intermediate discriminant power as measured by the correlation with the total score, which is very close to the factor loadings in the one-factor model. Inspection of Figure 1, total group, reveals very similar results in our study. Moreover, they found two-factor structures of subjective and objective work ability in the majority of the 10 European countries but not in Germany. We found a two-factor structure in four of five German samples. In contrast to our work, Radkiewicz concluded that Item 5 should be excluded from the instrument. This, however, would only be reasonable if the WAI instrument had a one-factor structure. It is clear from theory that if a two-factor model is true but data are fitted to a one-factor model items loading on the factor with less items will show less discriminant power. Moreover, the specific role of Subscale 6 (own prognosis) has not been identified in the study of Radkiewicz. Thus, our interpretation differs from theirs, as we postulate a health-related factor and a factor related to the subjectively estimated work ability. Accordingly, we cannot support the proposal in their study to exclude Subscale 5 (sick leave during the past year) from the instrument.

One strength of our study is the fact that a standardized examination was done in different populations that led to consistent results in four of five populations. Another strength is the use of confirmatory factor analysis that allows a rigid evaluation of scales in contrast to exploratory factor analysis. Moreover, our results supporting a two-factor structure of the WAI are coherent with a regression analysis in a large population study that showed that health (39%) and work (33%) explained most of the variance of the WAI [25]. In the same paper, a structural equation modelling approach has been used to investigate dimensions of work ability. In a large overview (20 studies with a total of ~10 000 subjects, median 224 subjects), van den Berg *et al.* [26] found individual and work-related determinants of WAI. The authors, however, pointed out that associations between work-related determinants and WAI may be spurious when subjects with a poor WAI overestimate their physical and mental workload in the workplace relative to those with an excellent WAI.

There is obviously one weakness in our study which is the small sample size. With 324 subjects in the four populations (managers excluded), results may be affected strongly by random variation. This weakness is more pronounced in the subgroup analyses. Taking this into account, the results of the confirmatory analysis are more important than those from the exploratory analyses. However, we note that the latter analysis was not strictly confirmatory as we modified our model to increase the fit.

Moreover, we emphasize that our results concerning dimensionality refer to the specific instrument 'WAI'. The WAI has been developed as a simple tool that can be used in very different populations of working people. The full-dimensional structure of the underlying concept 'work ability' might not be analysed adequately by factor analysis of seven subscales.

In summary, we conclude that our study supports two hypotheses: (i) the WAI is at least a two-dimensional instrument and (ii) both dimensions correlate and some of the subscales load on both dimensions.

Key points

- In a psychometric analysis, the Working Ability Index showed a two-dimensional structure.
- The two dimensions could be interpreted as 'subjectively estimated work ability' and 'objective health status'.
- This structure was consistently observed in several German populations with different occupations.

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Conflicts of interest

None declared.

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