Correlated Physical and Mental Health Composite Scores For the RAND-36 and RAND-12 Health Surveys: Can We Keep Them Simple?

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Research

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Abstract

Background

The RAND-36 and RAND-12 (equivalent to versions 1 of the Short-form-36 and Short-form-12 respectively) are widely used measures of health-related quality of life. However, there are diverging views regarding how to create the physical health and mental health composite scores of these questionnaires. We present a simple approach using an unweighted linear combination of subscale scores for constructing composite scores for physical and mental health that assumes these scores should be free to correlate. The aim of this study was to investigate the criterion validity and convergent validity of these scores.

Methods

We investigated oblique and unweighted RAND-36/12 composite scores from a random sample of the general Norwegian population (N=2107). Criterion validity was tested by examining the correlation between unweighted composite scores and weighted scores derived from oblique principal component analysis. Convergent validity was examined by analysing the associations between the different composite scores, age, gender, body mass index, physical activity, rheumatic disease, and depression.

Results

The correlations between the composite scores derived by the two methods were substantial ($r = 0.97$ to 0.99) for both the RAND-36 and RAND-12. The effect sizes of the associations between the oblique versus the unweighted composite scores and other variables had comparable magnitudes.

Conclusion

The unweighted RAND-36 and RAND-12 composite scores demonstrated satisfactory criterion validity and convergent validity. This suggests that if the physical and mental composite scores are free to be correlated, the calculation of these composite scores can be kept simple.

Background

The RAND-36, and its brief version, the RAND-12 (equivalent to version 1 of the Short-form-36 and Short-form-12, respectively), are freely available and widely used measures of generic health-related quality of life (HRQoL) [1–4]. HRQoL refers to “how health impacts on an individual’s ability to function and his or her perceived well-being in physical, mental and social domains of life” [3]. The RAND-36/12 provides data on eight subscale scores and two composite scores of physical and mental health. The use of the composite scores has become quite popular as they can simplify interpretation of the findings [2]. However, despite the widespread use of the RAND-36/12 composite scores, the choice of method for constructing them has been a controversial issue for decades [5–10].

Originally, Ware et al. [2, 11] provided algorithms for constructing composite scores based on orthogonal principal component analysis (PCA) to create a physical composite summary (PCS) and a mental composite summary (MCS) for the RAND-36/12. Their aim was to create pure PCS and MCS scores with little overlapping variance. To achieve this, all the scales/items must be included in the two composite scores but have different weights. However, this orthogonal approach has been criticized for producing inconsistencies between the composite scores and the observed data [5–7, 9].

Thus, a range of alternative scoring algorithms has been developed that do not restrict the correlations between the PCS and MCS [12]. One of the best documented alternatives to the orthogonal PCS and MCS was published by Farivar et al. in 2007, using oblique PCA to create the RAND-36/12 composite scores, which allowed correlations between them [7]. Overall, approaches such as this seem to be less prone to produce inconsistencies with the observed data [5–7].

On the other hand, a correlated PCS and MCS might not be without limitations. For example, a PCS and MCS from oblique PCA tend to be very strongly correlated, inducing multicollinearity [8]. Another issue is that the weights from oblique PCA fluctuate according to sample characteristics, making standardization across samples problematic [12, 13]. Furthermore, several authors have advocated the use of weights from confirmatory factor analysis (CFA) to create a PCS and MCS that are permitted to correlate [14, 15]. However, using CFA to construct composite scores can be problematic from a theoretical point of view, as a composite score, by nature, is a multidimensional construct [13, 16].

Hence, at present there are many different alternatives to an orthogonal PCS and MCS for the RAND-36/12, making it unclear for researchers to decide which one to use [6, 12]. It has been argued that we often tend to make HRQoL scores unnecessarily complicated [17]. Thus, simple unweighted composite scores for the RAND-36/12 have been proposed that show promising criterion validity [5, 18]. This is not surprising given the strong correlations among the indicators of the RAND-36/12 composite scores. Weighting is probably of little value under such conditions [19]. However, data on the convergent validity for the unweighted RAND-36/12 is lacking in studies that have used unweighted composite scores for them [5, 18]. This is a limitation, as convergent validity is a crucial part of evaluating psychometric properties [20].

We present a simple approach that uses an unweighted linear combination of subscale scores to construct composite scores for the RAND-36/12, which implicitly assumes that these scores should be allowed to correlate. The aim of this study was to investigate the criterion and convergent validity of these scores by comparing them to established oblique composite scores.

Methods

Design and study participants

We reused data from a representative survey of the general population of Norwegian adults aged 18–79 years. The methods have been described in detail previously [21]. In brief, the sample consisted of 2107 persons (36% response rate) who completed the Norwegian version of the RAND-36 (equivalent to the SF-36 version 1), as a postal questionnaire in 2015. All the items in the RAND-12 were taken directly from the RAND-36.

Demographic and other variables

We included self-reported data on age (10-year intervals), gender (women, men), marital/cohabitation status (no, yes), education (elementary school, high school, university < 4 years, and university ≥ 4 years), strenuous physical activity habits (never, less than 1 hour per week, 1–2 hours per week, and ≥ 3 hours per week), self-reported height and weight (body mass index), and self-reported history of being diagnosed with a rheumatic disease or depression (no, yes) [21].

RAND-36 measures and scoring

Oblique RAND-36 PCS and MCS composite scores were created using the method described by Farivar et al. [7]. First, all the items were standardized into 0–100 scores, according to the RAND-manual [22]. Then, eight subscales were created based on the mean scores of items belonging to the same scale: physical functioning (10 items), physical role

functioning (4 items), bodily pain (2 items), general health (5 items), vitality (4 items), social functioning (2 items), emotional role functioning (3 items), and mental health (5 items). The subscale scores ranged from 0 to 100, with higher scores indicating better HRQoL. The oblique RAND-36 PCS and MCS composite scores were created based on weights from the oblique PCA analysis using all eight subscores. T-scores were created with a mean score of 50 (SD=10) representing a US reference population, with higher scores indicating better HRQoL.

The unweighted RAND-36 PCS and MCS composite scores were based on the original subscales, ranging from 0 to 100. Previous studies have shown that four subscale scores predominantly reflect physical health, while four others predominantly reflect mental health [6]. Thus, the unweighted RAND-36 PCS was created by adding the subscale scores for physical functioning, physical role functioning, bodily pain, and general health, and dividing the sum by 4. The unweighted RAND-36 MCS was created by adding the subscale scores for vitality, social functioning, emotional role functioning, and mental health, and dividing the sum by 4. This is quite similar to the RAND-HSI scoring, but without weights [6]. The unweighted RAND-36 PCS and MCS ranged from 0 to 100, with higher scores indicating better HRQoL.

RAND-12 measures and scoring

The oblique RAND-12 PCS and MCS composite scores were also created by the method of Farivar et al. [7]. The scoring was based on regressing the oblique RAND-36 PCS and MCS T-scores in separate models for the RAND-12 items. From these results, weighted dummy variables were used to create RAND-12 PCS and MCS T-scores, with higher scores indicating better HRQoL.

The unweighted RAND-12 PCS and MCS composite scores were created by standardizing the 12-items to 0-100 scores, in the same way as done for the RAND-36. Eight subscales were created, based on mean scores of items belonging to the same scale: physical functioning (2 items), physical role functioning (2 items), bodily pain (1 item), general health (1 item), vitality (1 item), social functioning (1 item), emotional role functioning (2 items), and mental health (2 items). Subscale scores ranged from 0 to 100, with higher scores indicating better HRQoL. The unweighted RAND-12 PCS score was created by adding the subscale scores for physical functioning, physical role functioning, bodily pain, and general health, and dividing the sum by 4. The unweighted RAND-12 MCS score was created by adding the subscale scores for vitality, social functioning, emotional role functioning, and mental health, and dividing the sum by 4. The unweighted RAND-12 PCS and MCS scores ranged from 0 to 100, with higher scores indicating better HRQoL.

Statistics

The data are presented as means and standard deviations or raw numbers and percentages. Associations between subscale scores and the PCS and MCS composite scores were examined using Pearson correlations or Spearman rank correlations. Criterion validity was examined by Pearson correlations between unweighted composite scores and scores derived from the oblique factor scoring coefficients [7]. Convergent validity was examined using Spearman rank coefficients between the composite scores and variables known to be related to HRQoL: age (years, continuous); sex (women = 0, men = 1); body mass index (units, continuous); physical activity (strenuous physical activity: never = 0, less than 1 hour per week = 1, 1-2 hours per week = 2, ≥ 3 hours per week = 3), rheumatic disease (no = 0, yes = 1), and depression (no = 0, yes = 1)[2, 11, 23–26]. SPSS version 27 was used to perform the statistical analyses (IBM Corporation).

Results

The characteristics of the study participants are presented in Table 1. We also display RAND-36/12 scores stratified by age and sex (Table 2), and correlations between them and the respective subscale scores (Table 3-4). The correlations

between the composite scores derived from the two methods were very strong ($r = 0.97$ to 0.99) for both the RAND-36 and RAND-12 (Table 5). The correlations between the PCS and MCS derived by the two methods were weaker for the unweighted method than for the oblique method for both the RAND-36 ($r = 0.62$ vs. $r = 0.77$) and RAND-12 ($r = 0.59$ vs. $r = 0.79$). The effect sizes of the associations between the oblique versus unweighted composite scores and other variables had comparable magnitudes, indicating similar convergent validity (Table 6).

Discussion

We found strong correlations between the composite scores derived by the two methods for both the RAND-36 and RAND-12, and that the effect sizes of the associations between the oblique versus the unweighted composite scores and other variables had comparable magnitudes, also indicating similar convergent validity.

To the best of our knowledge, this is the first study to report both the criterion validity and convergent validity of unweighted RAND-36/12 composite scores. However, two prior studies have reported the criterion validity of the RAND-36 or RAND-12 composite scores using two other methods for constructing unweighted scores. Grassi et al. [27] used data from the European Community Respiratory Health Survey and compared SF-36 composite scores derived from oblique PCA with those from an unweighted scoring system. The unweighted PCS was calculated as the sum of 18 items, while the MCS included 19 items. The correlation between the oblique and unweighted PCS was 0.97, and 0.96 between oblique and unweighted MCS. The correlation between the unweighted PCS and MCS was 0.61.

Hagell et al. [5] applied data from people with Parkinson's disease and stroke to compare SF-12 composite scores derived from the RAND-12 HSI algorithm that produced similar results to scores based on oblique PCA. The unweighted PCS was calculated as the raw sum of six items, while the MCS was from six other distinct items. The correlation between the weighted and unweighted PCS was 0.99, and 0.99 between the weighted and unweighted MCS. The correlation between the unweighted PCS and MCS was 0.68.

The scoring methods in these two studies differed slightly from ours by using the sum of items to create raw scores, while we used unweighted linear combinations of subscale scores, based on items that were standardized, ranging from 0 to 100. We think that a two-step method that initially scores the subscales, and then uses them to create composite scores is more intuitive, considering that the subscales have a different number of items. However, the practical difference between our approach and the two other unweighted approaches for scoring composite scores seems to be minor. These findings are not surprising, given the strong correlations between the items that contribute to the RAND-36/12 composite scores.

We found that the correlations between the unweighted RAND-36/12 PCS and MCS were weaker than those created from oblique PCA. A reason for this is that oblique PCA produces weights for creating PCS and MCS that increase the correlation between these scores [7]. In the unweighted approach, no restraints are imposed, and the PCS and MCS are completely free to correlate. This could be a strength favouring unweighted RAND-36/12 composite scores, as correlations approaching 0.80 may induce multicollinearity if the PCS and MCS are used as independent variables in the same model [28].

Regarding convergent validity, the associations between the oblique versus the unweighted RAND-36/12 composite scores and other variables had comparable magnitudes. An exception was that age was more strongly correlated with the unweighted PCS scores, than the oblique ones. This could reflect that the oblique PCS scores were based on all subscales being either negatively, neutral, or positively correlated with age. There also seems to be a subtle tendency for the oblique PCS and MCS to have more similar effect sizes than the unweighted PCS and MCS. This probably reflects the stronger correlations between the oblique PCS and MCS.

The strengths of this study include a sufficiently large sample from a general population and that convergent validity was examined. A limitation of the study is that weight, height, physical activity, rheumatic disease, and depression were assessed by self-reports. However, the included measures have been shown to have acceptable validity [29–31].

The main implication of this study is that we can keep the calculation of the RAND-36/12 composite scores simple. This has several advantages, such as the standardization of scoring across studies and populations. In this paper, we calculated composite scores ranging from 0 to 100, but the data can easily be converted to T-scores, if needed. It might also be possible to merge datasets with composite scores derived from both the RAND-36 and RAND-12 using T-scores. It should be emphasized that our findings do not imply that weighted composite scores of HRQoL are never useful, or that prior studies using different oblique composite scores for the RAND-36/12 have led to erroneous results. However, we propose that when creating composite scores from highly correlated subscale scores, weighting is likely to be redundant. This knowledge should also be useful to consider when developing composite scores for new HRQoL instruments.

Conclusions

In conclusion, the unweighted RAND-36/12 composite scores demonstrated satisfactory validity. Consequently, the calculation of these composite scores can be kept simple when we want them to be free to correlate. Future studies should examine the external validity of our findings, and the sensitivity of changes to the composite scores.

Abbreviations

CFA: Confirmatory Factor Analysis.

HRQoL: Health-Related Quality of Life.

MCS: Mental Composite Summary.

PCA: Principal Component Analysis.

PCS: Physical Composite Summary.

RAND: Research ANd Development.

Declarations

Ethics approval and consent to participate

According to Jacobsen et al [21]: “the survey was conducted according to Norwegian regulations for surveys. The Regional Committee for Medical and Health Research Ethics (REC) South-east Norway approved the survey. Return of the questionnaires was regarded as informed consent. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study at the time of the survey”. Note that before the current study was conducted, all personally identifiable information were permanently deleted from the data set, so that the people whom the data describe are anonymous.

Consent for publication

Not applicable.

Availability of data and materials

The data is owned by a third party: Marianne Jensen Hjermsstad, Kjersti S. Grotmol and Håvard Loge (Regional Advisory Unit for Palliative Care, Dept. of Oncology, Oslo University Hospital, Norway). E-mail: mariajhj@medisin.uio.no. Data are however available from the corresponding author upon reasonable request and with permission of the third party.

Competing interests

The authors declare no conflict of interest.

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Authors' contributions

All authors contributed to the study conception, methods, and the paper outline. Andersen conducted the data analyses and wrote the first draft of the manuscript. The other authors commented and made suggestions for improvements of previous versions to the manuscript. All authors read and approved the final manuscript.

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Tables

Table 1
Characteristics of the study population (n=2107).

Variables	Values
Age in years, n (%)	
18-29	105 (5.0)
30-39	203 (9.6)
40-49	400 (19.0)
50-59	484 (23.0)
60-69	519 (24.6)
70-79	396 (18.8)
Gender, n (%)	
Women	1143 (54.8)
Men	943 (45.2)
Married or cohabiting, n (%)	
Yes	1603 (76.1)
No	504 (23.9)
Education, n (%)	
Elementary school	79 (18.0)
High School	777 (37.0)
University <4 years	457 (21.8)
University $\geq$ 4 years	486 (23.2)
Strenuous physical activity, n (%)	
Never	292 (17.4)
Less than 1 hour per week	375 (22.4)
1-2 hours per week	596 (35.6)
$\geq$ 3 hours per week	410 (24.5)
Body mass index, mean (SD)	26.1 (4.5)
History of rheumatic disease, n (%)	
No	1766 (92.3)
Yes	148 (7.7)
History of depression, n (%)	
No	1656 (86.1)
Yes	268 (13.9)

Note: Variables with fewer than 2017 observations are due to missing data.

Table 2
General Norwegian population scores for unweighted RAND36/12 composite scores (0-100) presented with means (standard deviations) and stratified by age and gender

Women	18-29 y	30-39 y	40-49 y	50-59 y	60-69 y	70-79 y
RAND-36 PCS	80.0 (21.7)	83.5 (16.5)	77.6 (22.0)	75.2 (22.3)	71.5 (24.0)	65.0 (26.0)
RAND-36 MCS	70.4 (20.3)	75.3 (19.8)	77.0 (18.8)	78.2 (16.2)	79.6 (17.5)	77.8 (18.1)
RAND-12 PCS	78.9 (23.1)	82.6 (17.2)	77.0 (23.8)	73.1 (24.6)	68.3 (26.3)	61.6 (27.6)
RAND-12 MCS	64.0 (22.6)	70.7 (20.6)	72.5 (20.3)	73.4 (18.6)	75.0 (20.0)	72.3 (21.7)
Men						
RAND-36 PCS	87.9 (12.6)	84.5 (15.7)	81.4 (18.6)	79.7 (19.8)	76.7 (21.3)	71.0 (22.1)
RAND-36 MCS	75.0 (19.3)	80.1 (15.1)	80.4 (15.8)	81.2 (15.3)	81.9 (16.4)	79.6 (17.0)
RAND-12 PCS	87.5 (13.5)	83.4 (17.3)	80.5 (20.0)	78.3 (21.7)	74.5 (22.7)	67.9 (23.5)
RAND-12 MCS	70.2 (22.1)	75.8 (15.7)	76.1 (18.3)	76.9 (16.7)	78.6 (18.7)	75.9 (19.1)
Note: PCS = Physical Composite Summary; MCS = Mental Composite Summary.						

Table 3
Pearson correlations between RAND-36 subscales and unweighted and oblique composite scores

RAND-36 subscales	PCS unweighted	PCS oblique	MCS unweighted	MCS oblique
Physical functioning	0.80	0.77	0.45	0.47
Physical role functioning	0.90	0.88	0.53	0.56
Bodily pain	0.82	0.81	0.48	0.55
General health	0.80	0.82	0.62	0.71
Vitality	0.61	0.70	0.79	0.86
Social functioning	0.59	0.68	0.85	0.80
Emotional role functioning	0.43	0.48	0.81	0.70
Mental health	0.38	0.46	0.82	0.86

Note: PCS = Physical Composite Summary; MCS = Mental Composite Summary.

Table 4
Spearman rank correlations between the RAND-12 subscales and unweighted and oblique RAND-12 composite scores

RAND-12 subscales	PCS unweighted	PCS oblique	MCS unweighted	MCS oblique
Physical functioning	0.73	0.66	0.41	0.43
Physical role functioning	0.81	0.78	0.48	0.53
Bodily pain	0.79	0.79	0.49	0.56
General health	0.82	0.75	0.52	0.59
Vitality	0.55	0.73	0.86	0.86
Social functioning	0.53	0.63	0.74	0.68
Emotional role functioning	0.38	0.44	0.62	0.56
Mental health	0.33	0.50	0.79	0.83

Note: PCS = Physical Composite Summary; MCS = Mental Composite Summary.

Table 5
Pearson correlations between the RAND-36/12 composite scores

	RAND-36 PCS unweighted	RAND-36 PCS oblique	RAND-12 PCS unweighted	RAND-12 PCS oblique	RAND-36 MCS unweighted	RAND-36 MCS oblique	RAND-12 MCS unweighted	RAND-12 MCS oblique
RAND-36 PCS unweighted	1							
RAND-36 PCS oblique	0.99	1						
RAND-12 PCS unweighted	0.97	0.96	1					
RAND-12 PCS oblique	0.95	0.97	0.98	1				
RAND-36 MCS unweighted	0.62	0.72	0.61	0.73	1			
RAND-36 MCS oblique	0.68	0.77	0.66	0.78	0.97	1		
RAND-12 MCS unweighted	0.59	0.69	0.59	0.72	0.97	0.96	1	
RAND-12 MCS oblique	0.66	0.75	0.66	0.79	0.95	0.97	0.97	1

Note: PCS = Physical Composite Summary; MCS = Mental Composite Summary.

Table 6
Spearman rank correlations between RAND-36/12 composite scores and related variables

	Age	Sex	Body mass index	Physical Activity	Rheumatic disease	Depression
RAND-36 PCS unweighted	-0.22	0.07	-0.21	0.27	-0.27	-0.22
RAND-36 PCS oblique	-0.13	0.08	-0.20	0.27	-0.26	-0.24
RAND-12 PCS unweighted	-0.25	0.07	-0.22	0.30	-0.25	-0.20
RAND-12 PCS oblique	-0.12	0.10	-0.19	0.29	-0.23	-0.25
RAND-36 MCS unweighted	0.09	0.10	-0.08	0.21	-0.15	-0.34
RAND-36 MCS oblique	0.10	0.10	-0.09	0.22	-0.17	-0.33
RAND-12 MCS unweighted	0.09	0.11	-0.07	0.21	-0.14	-0.33
RAND-12 MCS oblique	0.09	0.11	-0.09	0.23	-0.17	-0.32
Note: Age (years, continuous); sex (women = 0, men = 1), body mass index (units, continuous), physical activity (strenuous physical activity: never = 0, less than 1 hour per week = 1, 1-2 hours per week = 2, ≥ 3 hours per week = 3), rheumatic disease (no = 0, yes = 1), depression (no = 0, yes = 1).						