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**The European Heart Failure Self-care Behaviour Scale: New insights into factorial structure,
reliability, precision and scoring procedure**

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Abstract

Objective. To evaluate a new factorial structure of the European Heart Failure Self-care Behaviour Scale 9-item version (EHFScBS-9), and to test its reliability, floor and ceiling effect, and precision. To propose a new 0-100 score with a higher score meaning better self-care.

Methods. A sample of 1,192 Heart Failure (HF) patients (mean age 72 years, 58% male) was enrolled. Psychometric properties of the EHFScBS-9 were tested with confirmative factor analysis, factor score determinacy, determining the floor and ceiling effect, and evaluating the precision with the standard error of measurement (SEM) and the smallest real difference (SRD).

Results. We identified three well-fitting factors: consulting behaviour, autonomy-based adherence, and provider-based adherence (comparative fit index=0.96). Reliability ranged between 0.77 to 0.95. The EHFScBS-9 showed no floor and ceiling effect except for the provider-based adherence which had an expected ceiling effect. The SEM and the SRD indicated good precision of the EHFScBS-9.

Conclusion. The new factorial structure of the EHFScBS-9 showed supportive psychometric properties.

Practice implications. The EHFScBS-9 can be used to compute a total and specific scores for each identified factor. This may allow more detailed assessment and tailored interventions to improve self-care. The new score makes interpretation of the EHFScBS-9 easier.

KEY WORDS

Heart Failure, Self-care, Psychometrics, Instrument validity and reliability.

1. Introduction

It is estimated that 15 million people are affected by HF in Europe [1], and this figure is enlarging due to the improved treatment of acute coronary events and aging of the population. HF is associated with frequent hospital admissions, emergency department visits, and low quality of life but better self-care has been shown to improve patients outcomes [2, 3].

To evaluate HF self-care and interventions to improve self-care reliable and valid instruments are needed. To date, only two tools are available in the literature: the European Heart Failure Self-care Behaviour Scale (EHFScBS) [4] and the Self-Care of Heart Failure Index v.6.2 (SCHFI v.6.2) [5, 6] which has also a caregiver version [7]. The EHFScBS was developed in 2003 [4] and was reduced to a 9-item scale (EHFScBS-9) in 2009. It consists of two factors: consulting behaviours and adherence to regimen [8].

Examining the factorial structure of an instrument is very important to test its internal validity. In fact, EFA and CFA determine if the theoretical dimensionality of a tool is supported and whether items designed to measure each dimension do so as expected [11].

So far, the factorial structure and the reliability of the EHFScBS-9 have shown less than optimal psychometric properties. In the 2009 study [8] Confirmatory Factor Analysis (CFA) showed poor normed fit index (NFI) and comparative fit indices (CFI) (0.76 and 0.77, respectively). Reliability testing demonstrated an adequate Cronbach's alpha for the total scale and the consulting behaviours factor (both > 0.80), yet with a Cronbach's alpha of 0.56 for the adherence to regimen factor. The EHFScBS-9 was also tested in Germany and United States [9, 10]. In both studies construct validity was not supportive for all fit indices and reliability was adequate for the total scale and the consulting behaviours factor but not for the other extracted factors.

A recent study [12] testing the psychometric properties of the SCHFI v.6.2, that is very similar in content to the EHFSBS-9, has shown that the items pertaining the adherence to treatment loaded on an “autonomous” and a “provider-directed” factor. This new factorial structure of the SCHFI v.6.2 has shown more supportive fit indices than prior analyses and has provided with a new insight in the dimensions of HF self-care.

The reliability of the EHFSBS-9 for the total scale and the consulting behaviours factor is supportive but it is not for the adherence with the regimen factor. However, psychometric literature has demonstrated that Cronbach’s alpha is not a consistent estimator of scale reliability [14, 15]. An alternative option to test reliability is the factor score determinacy coefficient [16], successfully used also on the SCHFI v.6.2 [12], which has never been used on the EHFSBS-9. In addition, the floor and ceiling effect as well as the responsiveness to change of the EHFSBS-9 have never been determined. These three characteristics can give insight into the precision of the scale. The EHFSBS-9 currently has a score from 9 to 45 with a higher score indicating worse self-care. A standardised score from 0 to 100 with a higher score indicating better self-care can make interpretation of the score easier. Therefore, the aims of this study were to: 1) evaluate a new factorial structure of the EHFSBS-9 based on the factorial structure of the SCHFI v.6.2; 2) evaluate the reliability of the EHFSBS-9 by factor score determinacy coefficient; 3) evaluate the floor and ceiling effect of the EHFSBS-9 and its responsiveness to change; and 4) propose a 0 – 100 standardised score of the EHFSBS-9, where a higher score means better self-care.

2. Methods

2.1. Design

A cross-sectional design was used.

2.2. Sample and setting

A sample of 1,192 patients with HF was enrolled in this study. Patients were recruited from cardiovascular outpatient clinics located in 28 provinces located in the North, Centre, and South of Italy. To be eligible in the study patients had to speak and understand the Italian language, had to have a confirmed diagnosis of HF, and had not had an acute coronary event in the previous 3 months.

2.3. Instruments

The EHFSBS-9 was employed [8]. Each item uses a 5-point Likert scale from 1 (“completely agree”) to 5 (“completely disagree”). The nine items can be grouped in two dimensions: consulting behaviours and adherence with the regimen. The consulting behaviours dimension investigates how often people with HF call their doctor/nurse in case of shortness of breath, ankle swelling, weight gain, and fatigue, whereas the adherence with the regimen dimension groups items that investigate how often patients weigh themselves, try to drink less water, follow a low-sodium diet, regularly take their medications, and exercise. The possible score is 9 – 45, with a lower score indicating better self-care. For reasons of interpretation we introduced a standardised score from 0 – 100 for the EHFSBS-9. The score was also reversed such that a higher score means better self-care. The translation and back-translation of the EHFSBS-9 into Italian language was performed in a prior study [8].

We also employed a sociodemographic and clinical questionnaire designed by the research team to collect sociodemographic (age, gender, marital status, and education) and clinical variables [New York Heart Association (NYHA) class, ejection fraction, and illness duration].

2.4. Procedure

This study was approved by the Institutional Review Boards of each centre where patients were recruited. Patients were approached during ambulatory visits, and nurses trained on the research protocol administered the instruments after informed consent was obtained.

2.5. Statistical Analysis

Sociodemographic and clinical variables were analysed with descriptive statistics (frequencies, means, standard deviations, medians, and interquartile ranges). Each of the nine items of the EHFSBS-9 underwent item analysis with computation of the median and interquartile range. CFA was performed to establish the construct validity of the scale considering the following fit indices: Chi square, RMSEA, CFI, NNFI, and standardised root mean square residual (SRMR) [17].

According to Hu and Bentler [18] a model has a good fit if the RMSEA is up to 0.06 and in the lower bound of the 90% confidence interval, the CFI and NNFI are ≥ 95 , and the SRMRs are below 0.08. CFA was initially used to test the one-factor model of the EHFSBS-9, but because this analysis resulted in an inadequate fit [Chi square (27, 1192) = 551.17; $p < 0.000$; CFI = 0.86; NNFI = 0.81; RMSEA = 0.13 (90% CI 0.12 – 0.14); and SRMR = 0.08], CFA was performed taking into consideration the factorial structure of the SCHFI v.6.2 that showed recently excellent fit indices [12]. As described above, the SCHFI v.6.2 [5] is a 22-item instrument that measures self-care of HF with three scales: self-care maintenance, self-care management, and self-care confidence. The first two of these scales are very similar in their content to the EHFSBS-9, and within each, a recent study [12] identified factors pertaining to “autonomous” self-care maintenance and management and factors pertaining to “provider-directed” self-care maintenance and management. The SCHFI v.6.2 item asking about salt restriction (corresponding to item number 7 of the EHFSBS-9) had a loading on the “provider-directed” self-care maintenance. The items of the EHFSBS-9 were similarly aggregated taking into consideration the factorial structure of the SCHFI v.6.2. Specifically, item numbers 1, 5, and 9 were hypothesised to be in a factor that we called “autonomous-based adherence” item numbers 2, 3, 4, and 6 were hypothesised to be in the factor

“consulting behaviours” (already identified in prior studies [4, 8], and item numbers 7 and 8 were hypothesised to be in the factor that we called “provider-based adherence” (Table 1).

Extracted factors from the CFA were tested for their internal consistency reliability by factor score determinacy (FSD) [16], which is the certainty with which factor axes are fixed in the variable space and represents the squared multiple correlations of factor scores predicted from scores on observed variables. A factor is considered stable and with adequate internal consistency when the FSD has a value ≥ 0.70 [16].

The floor and ceiling effect of the EHFSBS-9 overall and of its individual factors were evaluated determining the percentage of the patients who obtained the minimum and the maximum possible score, respectively. An instrument is considered acceptable if both percentages are $< 15\%$ [19].

The responsiveness to changes (that is a measure of an instrument’s precision) of the EHFSBS-9 overall and of its individual factors was computed with the standard error of measurement (SEM) and the smallest real differences (SRD). The SEM is an indication of the dispersion of the measurement errors when trying to estimate individual true scores from their observed test scores [20]. This was computed with the following formula: $SD \times \sqrt{1 - \text{reliability coefficient}}$, whereby the reliability coefficient considered for this computation was the FSD. An instrument with a $SEM < SD/2$ is considered precise to measure a variable [21]. The SRD is the smallest variation in an instrument score that can be interpreted as a real difference [22] and was calculated with the following formula: $1.96 \times \sqrt{2} \times SEM$. The smaller the SEM and the SRD, the more precise is the scale.

The SPSS 19.0 and Mplus 6.0 were the statistical software used to analyse the data.

3. Results

3.1. Sociodemographic and clinical characteristics of the sample

Participants had a mean age of 72 years (SD = 11) and were mostly male (58%). Education was quite low, as only 20% of the sample had completed high school or university studies. Most patients were married (57%) and unemployed (82%). NYHA functional classes were all represented in the sample. The mean ejection fraction was 45% and the median duration of illness was 38 months (Table 2).

3.2. Item analysis of the EHFScBS-9

Item analysis (Table 3) showed that the most frequently performed self-care behaviours (score 1) were taking the medicines regularly, eating a low-salt diet, and limiting fluid intake, whereas the less frequent self-care behaviours (score 5) were contacting provider in case of gaining weight, exercising regularly, and contacting provider if dyspnoea occurred. The mean of the “classic” total score of the EHFScBS-9 was 23.9. We also computed the reversed and standardised 0 – 100 score with a higher score meaning better self-care, which was 58.3. The two above scores had a perfect negative correlation (-1.0 , $p < 0.000$) meaning that the two scores are identical in the measurement properties.

3.3. Construct validity of the EHFScBS-9

The hypothesised measurement model including three factors was supported in the CFA with the following fit indices: $\chi^2(23) = 168.06$, $p < 0.000$, RMSEA = 0.073 (90% C.I. 0.06 – 0.08); CFI = 0.96; NNFI = 0.95; SRMR = 0.04 (Figure 1).

3.4. Reliability of the EHFScBS-9

Internal consistency reliability computed by factor score determinacy showed that the three factors resulting from the CFA exhibited good coefficients: 0.95 for the consulting behaviours factor, 0.82 for the autonomous-based adherence, and 0.77 for the provider-based adherence.

3.5. Floor, ceiling effect and responsiveness to change of the EHFSBS-9

Table 4 shows that the floor and ceiling effect of the EHFSBS-9 overall and its three factors were below 15%, except for the provider-based adherence that showed a ceiling effect of 33.5%. The highest SEM and SRD were observed for the autonomous-based adherence and the provider-based adherence, whereas the lower were observed for the EHFSBS-9 overall and the consulting behaviours factor.

4. Discussion and Conclusion

4.1 Discussion

This study is a step forward in the measurement of patient-reported outcomes of self-care. Firstly, in addition to confirming the existence of the consulting behaviours factor also in this study, we identified two other factors that we named autonomous-based adherence and provider-based adherence. This novel factorial structure gives new insights into the EHFSBS-9, resulting in the possibility to evaluate in patients a total self-care as well as three separate sub-dimensions of self-care which have valid and reliable properties. It was interesting to note that similar to the factorial structure of the SCHFI v.6.2, in the EHFSBS-9 we identified an "autonomous" adherence consisting of healthy behaviours endorsed by patients (e.g. weighing every day or exercising) and an adherence based on the provider's "prescription" (e.g., taking medicines). These findings reinforce prior theoretical orientation which states that self-care is a broader dimension and not

merely the adherence to treatment [23-25]. Interestingly, the SCHFI v.6.2 and the EHFSBS-9, that were seen in prior studies as measuring different constructs [26], resulted in a very similar factorial structure in this study. Compared to prior studies where the factorial structure of the EHFSBS-9 has been tested, in ours the fit indices were even better.

The factor score determinacy resulted in adequate coefficients which demonstrated three reliable factors within the EHFSBS-9. Prior studies had found that the adherence to regimen factor had poor reliability, thus it was advised not to be used separately [8-10]. Instead, we found two factors measuring adherence (the autonomous-based adherence and the provider-based adherence) which had good reliability, and can be used to measure these two dimensions.

Another novel finding that we identified was through measurement of the precision of the EHFSBS-9. We found that only the provider-based adherence exhibited a ceiling effect above the range of 15%. This result was expected because it has been shown that the adherence to pharmacological treatment is the most frequent behaviour in people with HF [27]. Moreover, the SEM was very small for the scale and its factors since it was below half of the SD. The SRD is another new insight into the EHFSBS-9 because it gives the amount of points the scale should increase or decrease to be sure that a real difference in self-care has occurred in patients.

This is the first time that a reversed standardised score of the EHFSBS-9 is presented, with a higher score on a scale of 0 - 100 meaning better self-care. We think this modification would allow for a better understanding of the EHFSBS-9 score and easier comparison with the SCHFI v.6.2, which uses the same standardised score. In fact, in a recent study carried out in 15 countries worldwide where both instruments were used [27], the investigators could only select specific items from the two instruments to compare and could not attempt a comparison of the total score. Therefore, comparisons of “global” self-care were limited. With this new scoring procedure the two instruments have the same range (0 – 100) and the same meaning in score (higher score = better

self-care), which we think may be useful for international and cross-cultural comparisons. In the Appendix we give the SPSS syntax for the computation of the 0 - 100 score of the EHFSBS-9.

This study has several limitations. Even though patients were recruited in 28 provinces across Italy a convenience sample was used. Since these provinces were mainly located in central Italy, individuals living in Northern and Southern Italy were less represented and therefore, differences in healthcare access or clinical care in those areas need to be further studied. Another limitation is that the sample was heterogeneous in term of sociodemographic (e.g. age or gender) and clinical characteristics (e.g. NYHA functional class or comorbidity), factors known to affect self-care. However sample heterogeneity may be considered a strength in this study and may increase generalizability of psychometric properties of the EHFSBS-9 within the Italian population. In addition, this study used a cross-sectional design, so we could only test the internal consistency reliability of the EHFSBS-9. Future research should use a longitudinal study design to evaluate the test-retest reliability in order to give an estimate of the stability of the measure.

The factorial structure of the EHFSBS-9 identified in this study should be generalised with caution in other populations. For instance, while the consulting behaviours factor seems stable across populations as found in prior studies, the adherence to regimen varies [8-10], so we recommend users to test the factorial structure of the EHFSBS-9 before its use in clinical practice and research in specific populations.

4.2. Conclusion

In conclusion, we showed in this study that the EHFSBS-9 has supportive psychometric properties of validity, reliability, and precision, and its use is recommended to measure self-care behaviours in clinical practice and research.

4.3. Practice implication

The number of patients suffering from HF is increasing worldwide with an impact on health care costs. Education to improve self-care in HF has been found to be effective to reduce its burden on individuals, families and society [28, 29]. This study reinforces prior validity and reliability testing of the EHFSBS-9 and expand on practice implications for its use. According to the results of this study researchers and clinicians can measure patient's self-care by computing a total score, but also by computing scores for each sub-dimension of self-care: consulting behaviour, autonomy-based adherence, and provider-based adherence. Use of these subscale scores would allow more detailed assessment of self-care and more tailored interventions to improve self-care, that, for example, might focus on autonomous-based adherence over provider-based adherence. Another practice implication of this study is computation of the SRD for the EHFSBS-9: we should see at least an increase of 5.75 points in the total standardised 0 - 100 score to state that a modification in a patient's self-care has occurred. Finally, the standardized 0 – 100 score proposed in this study provides a better understanding of the EHFSBS-9 score.

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Conflict of Interest:

None declared.

We confirm all patient identifiers have been removed or disguised so the patients described are not identifiable and cannot be identified through the details of the story.

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Appendix

SPSS syntax to compute the 0 – 100 standardised and reversed score of the EHFSBS-9, where a higher score means better self-care.

Syntax to reverse each item:

RECODE

item_n (1=5) (2=4) (3=3) (4=2) (5=1) INTO R_item_n.

EXECUTE.

Syntax to compute the 0 – 100 standardised score (after item reverse):

COMPUTE

EHFSBS_9=(SUM(R_item_1,R_item_2,R_item_3,R_item_4,R_item_5,R_item_6,R_item_7,R_item_8,R_item_9)-9)*2.7777. EXECUTE.

Table 1. The hypothesised factorial structure of the EHFS CBS-9 used to perform confirmatory factor analysis

Items	Factors
1. I weigh myself every day	Autonomous-based adherence
5. I limit the amount of fluids	
9. I exercise regularly	
2. If SOB increases I contact my doctor or nurse	Consulting behaviour
3. If legs/feet are more swollen, I contact my doctor or nurse	
4. If I gain weight more than 2 kg in 7 days I contact my doctor or nurse	
6. If I experience fatigue I contact my doctor or nurse	
7. I eat a low-salt diet	Provider-based adherence
8. I take my medication as prescribed	
SOB, shortness of breath	

Table 2. Sociodemographic and Clinical Characteristics of the Sample (N = 1192)

Variables	N (%)
Age (mean, SD)	72.36 (11.2)
Gender	
Male	694 (58.2)
Female	498 (41.8)
Education	
Elementary	546 (45.8)
Middle School	294 (24.7)
Professional School	110 (9.3)
High School	171 (14.3)
University Degree	71 (6.0)
Marital Status	
Married	677 (56.8)
Single	80 (6.7)
Widowed	358 (30.0)
Divorced	77 (6.5)
Profession	
Employed	214 (18.0)
Unemployed or retired	978 (82.0)
NYHA Class	
I	197 (16.6)
II	508 (42.6)
III	394 (33.0)
IV	93 (7.8)
Ejection Fraction (Mean, SD)	44.66 (10.8)
Months since diagnosis (Median, Interquartile range)	38 (24 – 68)

NYHA, New York Heart Association; SD, standard deviation

Table 3. Item analysis of the EHFSBS-9 (n = 1192)

Item	Median (interquartile range)	Percentages of responses per each Likert point				
		1	2	3	4	5
1. I weigh myself every day	3 (2 – 4)	13.7	21.5	29.4	19.5	16.0
2. If SOB increases I contact my doctor or nurse	3 (2 – 4)	22.3	24.2	21.4	12.5	19.5
3. If legs/feet are more swollen, I contact my doctor or nurse	3 (2 – 4)	21.8	25.4	21.3	13.4	18.1
4. If I gain weight more than 2 kg in 7 days I contact my doctor or nurse	3 (2 – 5)	14.9	21.1	20.5	16.6	26.9
5. I limit the amount of fluids	3 (2 – 4)	24.5	24.3	23.6	14.0	13.6
6. If I experience fatigue I contact my doctor or nurse	3 (2 – 4)	23.2	22.6	21.8	13.6	18.9
7. I eat a low-salt diet	2 (1 – 3)	39.6	26.5	21.4	8.2	4.3
8. I take my medication as prescribed	1 (1 – 2)	69.1	17.7	10.0	2.4	0.8
9. I exercise regularly	3 (2 – 4)	19.2	17.5	23.3	19.5	20.6
Total “Classic” score (Mean, SD)	23.9 (6.9)					
Total “Reversed and Standardised” score (Mean, SD)	58.3 (19.2)					

Note. The total “Classic” score reports the mean (and SD) of the usual score computed for the EHFSBS-9 where higher score means worse self-care (possible range 9 – 45). The total “Reversed and Standardised” score reports the mean (and SD) computed for the EHFSBS-9 on a 0 – 100 scale where higher score means better self-care. SOB, shortness of breath

Figure 1. Confirmatory factor analysis of the EHFScBS-9 (n = 1192)

Table 4. Floor, ceiling effect and responsiveness to change of the EHFScBS-9

Scale/Factor	M (SD)	Floor effect (%)	Ceiling effect (%)	SEM	SRD
EHFScBS overall	58.3 (19.2)	0	1.2	4.3	5.7
Autonomous-based adherence	51.93 (23.)	2.1	2.7	10	8.8
Provider-based adherence	80.05 (19.4)	0.2	33.5	9.3	8.4
Consulting behaviours	49.98 (16.8)	0.2	0.1	3.8	5.4

Note. All scale and factors' scores are standardised to 0 – 100 points with higher scores meaning better self-care. The floor and the ceiling effect are the percentage of the patients who obtained the minimum and the maximum possible score respectively. SEM = Standard error of measurement; SRD = smallest real difference.