‘Paper and pencil’ *vs*. ‘online’ assessment: exploring measurement invariance of the Yale Food Addiction Scale 2.0 in inpatients with severe obesity and the general population

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Abstract.

During the last few years, food addiction (FA) increased its popularity both in clinical and research practice. To date, the gold standard for the assessment of FA is the Yale Food Addiction Scale 2.0 (YFAS2.0) – that conceptualizes FA as a substance-related and addictive disorder (SRAD), according to the DSM-5 diagnostic criteria. Despite an intensive worldwide use across heterogeneous populations, to date, no studies assessed the factorial validity and measurement invariance (MI) of the YFAS2.0 across samples that filled out the questionnaire with different assessment methods. The present study aimed to: extend evidence of YFAS2.0 factorial validity and explore its MI across four different groups. Participants (N = 470) completed the Italian YFAS2.0. Participants were grouped on the basis of their recruitment (inpatients with severe obesity *vs*. the general population) and the assessment methodologies (‘paper and pencil’ assessment *vs*. ‘online’ assessment). The CFA showed good fit indexes for the overall sample as well as for each of the different groups. Also, configural, metric, and strong invariance were achieved across the four groups. Findings suggested that the Italian YFAS2.0 can be considered a good psychometrically-based and structural invariant instrument for the assessment of FA in different samples and across different methods of assessment.

Keywords: Food addiction, severe obesity, confirmatory factor analysis, measurement invariance, assessment, online survey.

1 Introduction

Food addiction (FA) has become more and more popular [1-3] and has received increasing interest in both clinical and research practice [3, 4]. Its popularity could be due to its dual nature [2-4]. Indeed, on one hand, FA seems to share the clinical characteristics of some eating disorders [4-6]. On the other hand, some individuals seem to be addicted to certain kinds of food [7, 8]: neuroscience showed a neural activation in response to high-caloric palatable foods (*e.g.*: sweetened foods, foods with high levels of refined carbohydrates, and food with added fat) comparable to what found in response to addictive drugs [8-10].

Considering this background, to date, the gold standard for the assessment of FA at the light of DSM-5 SRAD criteria is the second version of the Yale Food Addiction Scale (YFAS 2.0 [11, 12]). The YFAS 2.0 concerns the key behavioral features of addiction-like eating behaviors over the previous year: (A) 'Substance taken in larger amount and for a longer period than intended'; (B) 'Persistent desire or repeated unsuccessful attempts to quit'; (C) 'Much time/activity to obtain, use, recover'; (D) 'Important social, occupational, or recreational activities given up or reduced'; (E) 'Use continues despite knowledge of adverse consequences (*e.g.*, emotional problems, physical problems)'; (F) 'Tolerance'; (G) 'Characteristic withdrawal symptoms; substance taken to relieve withdrawal'; (H) 'Continued use despite social or interpersonal problems'; (I) 'Failure to fulfill major role obligation (*e.g.*, work, school, home)'; (J) 'Use in physically hazardous situations'; (K) 'Craving, or a strong desire or urge to use'; (L) 'Significant distress/impairment'.

Simultaneously, during the last few years, several studies underlined the need for an evolution of psychological interventions as well as psychological assessment, suggesting increasing the use of technology-based tools – such as online psychotherapy and/or online surveys [13-18].

In this context, despite a large number of studies tested psychometrical properties of the YFAS 2.0, none of them explored its measurement invariance (MI) across samples of individuals who filled out the YFAS 2.0 with different methodologies – namely, the classical method ('paper and pencil' assessment) and a computer-based one ('online' survey/online assessment).

Thus, the present study aimed to assess for the first time the structural validity and MI of the YFAS 2.0 in four samples of subjects assessed with different methodologies.

2 Material and Methods

2.1 Sample size

Considering the statistical analyses necessary for this study, the sample size was calculated a priori according to the "*n*:*q* criterion": *n* is the number of participants and *q* is the number of (free) model parameters to be estimated [19]. Consequently, five subjects per free parameter (5:22; $n_{\text{minimum}} = 110$) were guaranteed.

2.2 Procedure and Participants

Four groups of individuals were enrolled: (A) a first sample of inpatients with severe obesity who filled out the YFAS 2.0 with the 'paper and pencil' assessment; a second sample of (B) inpatients with severe obesity who compiled the YFAS 2.0 with an 'online' assessment; a third sample of (C) individuals from the general population who filled out the YFAS 2.0 with the 'paper and pencil' assessment; a fourth sample of (D) individuals from the general population who compiled the YFAS 2.0 with an 'online' assessment. Exclusion criteria were: (A) illiteracy; (B) inability to complete or finish the assessment. All participants signed informed consent.

Concerning the 'paper and pencil' assessment method, the sample of inpatients with severe obesity (Body Mass Index; BMI $\geq$ 35) was recruited at the San Giuseppe Hospital, IRCCS, Istituto Auxologico Italiano, Verbania (Italy) whether individuals from the general population were enrolled in Padua (Italy).

Regarding the 'online' assessment method, an online survey was developed and disseminated using the Qualtrics software for data collection. Moreover, the *'snowball sampling method'* was used to recruit participants through personal invitations or materials advertised via social media platforms (*i.e.*, Facebook, Twitter).

The final sample comprised 470 participants [171 males (36.4%) and 299 females (63.6%) aged from 18 to 84 years (*mean* = 45.02, *SD* = 17.715)].

More in detail, the first sample was composed of (A) *inpatients with severe obesity* who filled out the YFAS 2.0 with the *'paper and pencil' assessment*: *n* = 121; 43 males (35.5%) and 78 females (64.5%) aged from 20 to 78 years (*mean* = 56.59, *SD* = 12.43), with a BMI ranged from 35.06 to 65.82 (*mean* = 42.66, *SD* = 6.05).

The second sample was composed of (B) *inpatients with severe obesity* who compiled the YFAS 2.0 with an *'online' assessment*: *n* = 114; 56 males (49.1%) and 58 females (50.9%) aged from 18 to 77 years (*mean* = 54.89, *SD* = 12.16), with a BMI ranged from 35.16 to 80.11 (*mean* = 43.12, *SD* = 6.79).

The third sample was composed of (C) individuals from the *general population* who filled out the YFAS 2.0 with the *'paper and pencil' assessment*: *n* = 118; 39 males (33.1%) and 79 females (66.9%) aged from 19 to 84 years (*mean* = 36.03, *SD* = 16.09), with a BMI ranged from 15.37 to 34.37 (*mean* = 23.08, *SD* = 3.70).

The fourth sample was composed of (D) individuals from the *general population* who compiled the YFAS 2.0 with an *'online' assessment*: *n* = 117; 33 males (28.2%) and 84 females (71.8%) aged from 22 to 79 years (*mean* = 33.32, *SD* = 15.64), with a BMI ranged from 17.04 to 31.25 (*mean* = 22.38, *SD* = 3.54).

2.3 Measure

The Yale Food Addiction Scale 2.0 (YFAS2.0)

The Italian version of the YFAS 2.0 [4, 11, 12] is a 35-item self-report questionnaire assessing FA symptoms in both general and clinical populations. The YFAS 2.0 assesses the 11 DSM-5 diagnostic criteria for SRAD and the significant impairment and/or distress related to food. The scale is scored on an 8-point Likert type scale (ranging from 0 = *"never"* to 7 = *"every day"*). According to an item-specific cutoff, each

of the 35 items has to be dichotomized (0 = "*non*-endorsed" *vs*. 1 = "endorsed") to compute the two scoring options: the *symptom count* score and the *diagnostic score* [11]. The first one is the *symptom count* score – namely – the number of FA criteria (ranging from 0 to 11) experienced during the previous year. The 'impairment/distress' criterion should not be considered in this count [14]. The second one is the diagnostic score: FA could be diagnosed as mild if there are 2 or 3 symptoms and clinically significant impairment/distress, moderate if there are 4 or 5 symptoms and significant impairment/distress, or severe if there are 6 or more symptoms and significant impairment/distress [14].

2.4 Statistical Analyses

Statistical analyses were performed with R software and the following packages: 'lavaan', 'semTools', and 'semPlot'.

A confirmatory factor analysis (CFA) was performed using the diagonally weighted least square (DWLS) estimator. A single-factor first-order structure was specified [4, 11]: each of the eleven symptoms (from 'Criterion A' to 'Criterion K') loaded onto a latent dimension.

Factorial validity was assessed using the Satorra-Bentler χ^2 (a non-significant χ^2 indicating a better model fit). Goodness-of-fit indices were also used, with the following criteria as cutoffs for ideal fit [20]: the Root-Mean-Square Error of Approximation (RMSEA < 0.05); the Comparative Fit Index (CFI > 0.95); and the ratio of χ^2 to the degrees of freedom ($\chi^2/df < 3$).

As reported in Figure 1, measurement invariance (MI) analysis was computed to evaluate whether the aforementioned structure of the Italian version of the YFAS 2.0 was invariant between (A) a sample of inpatients with severe obesity who filled out the YFAS 2.0 with the 'paper and pencil' assessment; (B) a sample of inpatients with severe obesity who compiled the YFAS 2.0 with an 'online' assessment; (C) a sample of individuals from the general population who filled out the YFAS 2.0 with the 'paper and pencil' assessment; (D) a sample of individuals from the general population who compiled the YFAS 2.0 with an 'online' assessment.

The "standard" procedure for structural models with categorical indicators was followed [21]. First, the first-order model was constrained to equality between the four groups (*Configural* Invariance). Second, both the factor loadings and items' thresholds were simultaneously constrained to equality across groups (*Metric+Strong* Invariance). Third, the latent factor means (*Latent Means* Invariance) were constrained to equality between groups.

Measurement invariance was assessed by using test differences in three fit indices and with the following criteria as cutoffs for model equivalence: DIFFTEST (equal to $\Delta\chi^2$; *p*-value > 0.050), ΔCFI (< 0.010), ΔRMSEA (< 0.015) [21]. An excess of the cutoff in two out of these three indices, combined with worse fit indices, was considered as the evidence of model *non*-invariance.

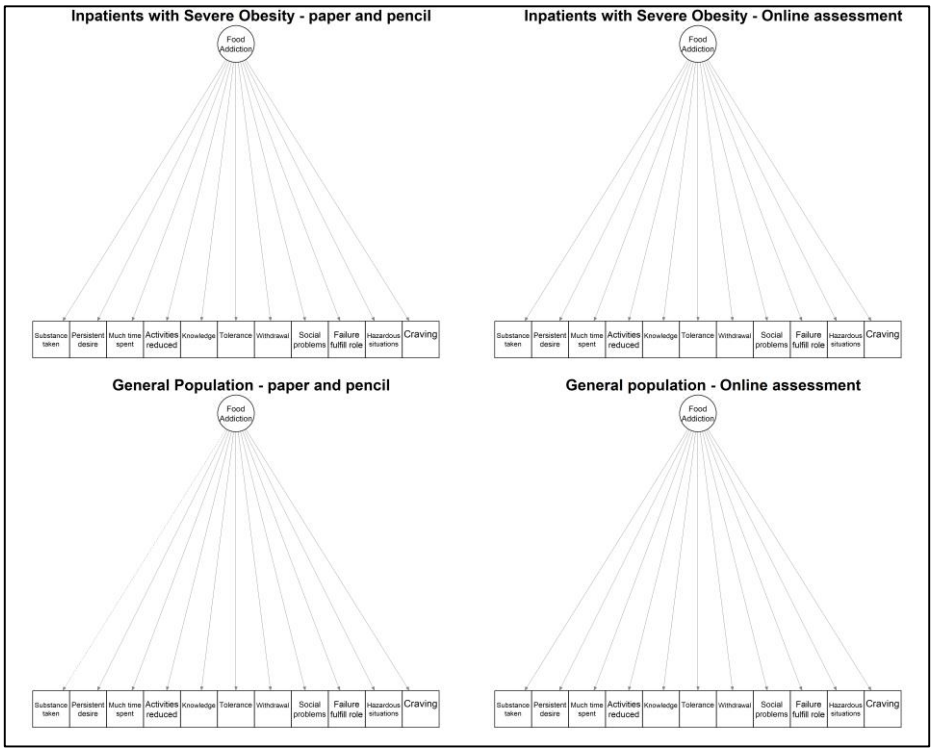

Figure 1. conceptual models for the four groups tested.

3 Results

3.1 Structural validity

The single-factor model showed a good fit to the data for the overall sample. Despite the Chi-square statistic resulted to be statistically significant [$\chi 2$ (44) = 89.241; p < 0.001], all the other fit indices revealed a good fit to the data: the RMSEA = 0.047; 90%CI 0.033–0.061; p(RMSEA < 0.05) = 0.063, the CFI = 0.995, and the χ^2/df = 2.028. As reported in Table 1, all the items' loadings were statistically significant and ranged from 0.745 (Criterion A) to 0.911 (Criterion E); *mean* = 0.835; *SD* = 0.055.

Regarding (A) the sample of *inpatients with severe obesity* who filled out the YFAS 2.0 with the *'paper and pencil'* assessment, all of the fit indices revealed a good fit to the data: χ^2 (44) = 26.588; p = 0.982 *ns*, the RMSEA = 0.000 [90%CI 0.000–0.000; p(RMSEA < 0.05) = 0.999], the CFI = 1.000, and the χ^2/df = 0.604. Items' loadings ranged from 0.754 (Criterion A) to 0.931 (Criterion K); *mean* = 0.833; *SD* = 0.071.

Regarding (B) the sample of *inpatients* with *severe obesity* who compiled the YFAS 2.0 with an *'online'* assessment, all of the fit indices revealed a good fit to the data: χ^2 (44) = 55.081; p = 0.122 *ns*, the RMSEA = 0.047 [90%CI 0.000–0.083; p(RMSEA <

0.05) = 0.519], the CFI = 0.995, and the χ^2/df = 1.252. Items' loadings ranged from 0.477 (Criterion H) to 0.919 (Criterion K); *mean* = 0.790; *SD* = 0.136.

Regarding (C) the sample of individuals from the *general population* who filled out the YFAS 2.0 with the *'paper and pencil'* assessment, all of the fit indices revealed a good fit to the data: χ^2 (44) = 38.999; p = 0.685 *ns*, the RMSEA = 0.000 [90%CI 0.000–0.050; p(RMSEA < 0.05) = 0.949], the CFI = 1.000, and the χ^2/df = 0.886. Items' loadings ranged from 0.602 (Criterion B) to 0.982 (Criterion E); *mean* = 0.782; *SD* = 0.120.

Regarding (D) the sample of individuals from the *general population* who compiled the YFAS 2.0 with an '*online'* assessment, all of the fit indices revealed a good fit to the data: χ^2 (44) = 35.813; p = 0.805 *ns*, the RMSEA = 0.000 [90%CI 0.000–0.041; p(RMSEA < 0.05) = 0.976], the CFI = 1.000, and the χ^2/df = 0.814. Items' loadings ranged from 0.695 (Criterion A) to 0.952 (Criterion K); *mean* = 0.867; *SD* = 0.092.

	Overall sample	Sample A	Sample B	Sample C	Sample D
Criterion A	0.745	0.754	0.880	0.683	0.695
Criterion B	0.795	0.855	0.790	0.602	0.735
Criterion C	0.883	0.856	0.883	0.900	0.933
Criterion D	0.818	0.900	0.601	0.712	0.913
Criterion E	0.911	0.882	0.856	0.982	0.934
Criterion F	0.864	0.870	0.871	0.907	0.772
Criterion G	0.809	0.779	0.844	0.766	0.944
Criterion H	0.759	0.695	0.477	0.821	0.842
Criterion I	0.857	0.862	0.735	0.786	0.903
Criterion J	0.844	0.781	0.832	0.623	0.917
Criterion K	0.901	0.931	0.919	0.818	0.952

Table 1. Standardized factor loadings for each sample.

3.2 Measurement invariance

Configural Invariance. A first-order configural invariance model was specified between groups. Good model fit indices were found (χ^2 (176) = 156.48, p = 0.852 *ns*; the RMSEA = 0.000; the CFI = 1.000; and the χ^2/df = 0.998), suggesting that the factor structure was similar between the four groups.

Metric+Strong Invariance. Also the first-order metric plus strong invariance model still fitted data well: χ^2 (203) = 201.02, p = 0.526 *ns*; the RMSEA = 0.000; the CFI = 1.000; and the χ^2/df = 0.990. *Non*-significant decreases – in two out of three fit indices – were found (DIFTEST = 44.54; p = 0.018; ΔRMSEA = 0.000; ΔCFI = 0.001), indicating that items were equivalently related to the latent factor between groups.

Latent Means Invariance. Finally, also the first-order latent means invariance model revealed adequate fit indices: χ^2 (206) = 274.34, p = 0.001; the RMSEA = 0.053; the CFI = 0.993; and the χ^2/df = 1.332. Moreover, statistically significant decreases in fit indices compared to the previous invariance model were found (DIFTEST = 73.32, p < 0.001; ΔRMSEA = 0.053; ΔCFI = -0.007), suggesting that groups had not the same expected item response at the same absolute level of the trait.

4 Discussion

To date, an increasing number of studies underline the necessity of an evolution of psychological interventions as well as psychological assessment toward the use of technology-based tools – such as online psychotherapies and/or online surveys [13, 14, 17]. This necessity for technology-based change may be fostered by a significant number of people avoid seeking psychological help and (social) support [22, 23] despite maladaptive behaviors as well as several related psychological issues [24-37]. On one hand, some of these people may be reluctant to seek professional help due to the associated stigma [38-41]. On the other hand, some individuals may deny the problem, leading them to think that it will probably resolve itself naturally [23, 42, 43], thus choosing to manage the psychological issue on their own instead of starting a structured psychological intervention [23, 44]. Moreover, the urgency to improve technology-based assessment and psychological intervention could be due to the new categories of patients who often struggle to turn to clinical services in person – such as people with an infective disease or chronic progressively disabling disease (*i.e.* severe obesity). Also, people with severe obesity may show the comorbidity of unhealthy behavior and/or psychopathological ones that exacerbate their illness – *i.e.* emotional eating and/or FA.

In this context, the YFAS 2.0 could be considered as the 'gold standard' for the assessment of FA in both clinical and the general population [11, 12, 45]. However, no previous study compared the factorial structure of YFAS 2.0 among samples that complied this scale with different assessment methodologies – such as the classical 'paper and pencil' assessment or a technology-based assessment (online survey). The present study aimed to fill this gap assessing the MI of the YFAS 2.0 across four groups.

The CFA revealed that the Italian YFAS 2.0 showed a good fit to the data for the overall sample. Also, the CFA showed that each aforementioned single group provided good fit indices, in line with Italian validation studies. Statistical analyses successfully replicated the original factorial structure of the YFAS 2.0 – suggesting that it could be considered as a good psychometrically-based instrument for the assessment of FA.

Moreover, configural, metric, and scalar invariance were achieved across the four abovementioned samples. These results are in line with previous research [4] and suggest that individuals in the four samples interpreted the YFAS 2.0 items in the same way, with the same strength, and with the same starting point – the factorial structure was equal across samples and items were equally related to the latent construct with equal thresholds. However, the latent trait was not equally distributed between groups: latent means were different across samples.

Despite these interesting findings, some limitations have to be highlighted. First, although the sample size was adequate to perform a CFA and MI, the number of individuals in each group was small. Also, this study lacks a second administration of the scale – thus not allowing to perform longitudinal analyses.

Overall, these findings suggest that the comparisons between these samples should be taken with caution (different latent means), but these groups were comparable (due to equal items threshold). Finally, these results suggest Italian YFAS 2.0 should be considered as a starting point for the assessment of FA and in the planning of psychological treatments in different samples and across different methods of assessment.

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