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The Validation of the Persian Version of Sugar Addiction Questionnaire: Factor Structure, Item Analysis and Model Fit

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Abstract

Objective: Excessive sugar consumption is a growing public health concern, with research suggesting it may function as an addictive substance. However, the lack of standardized tools to assess sugar addiction, particularly across cultures, remains a challenge. This study aims to validate the Persian version of the Sugar Addiction Questionnaire (SAQ) for use in Iran.

Method: In this cross-sectional psychometric validation study, 504 Persian-speaking adults (59.1% female, mean age = 29.8 ± 19.5 years) were recruited using convenience sampling from Tehran health centers. Participants completed the SAQ and Yale Food Addiction Scale (YFAS 2.0), and participated in DSM-5-based semi-structured interviews for sugar addiction. Factor analysis and reliability measures (Cronbach's alpha, test-retest, split-half) were used to assess the SAQ's validity and reliability.

Results: The Persian SAQ demonstrated strong psychometric properties. Factor analysis revealed a five-factor structure explaining 45.08% of the variance. Concurrent validity was confirmed by significant correlations with the YFAS 2.0 ($r = 0.51$, $P < 0.001$) and BMI ($r = 0.55$, $P < 0.001$). The scale showed a good model fit (CFI = 0.91, RMSEA = 0.08), with acceptable reliability (Cronbach's alpha = 0.79) and a test-retest correlation of 0.54. The optimal cutoff for diagnosing sugar addiction was 9, with the Area-Under-the-Curve (AUC) of 98%.

Conclusion: The Persian version of the SAQ is a reliable and valid tool for assessing sugar addiction in Iran. This validated instrument can improve the diagnosis and understanding of sugar-related behavioral issues, supporting better public health strategies for managing excessive sugar consumption.

Key words: *Addictive; Behavioral Addiction; Psychometrics; Questionnaires; Sugars; Validation Study*

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Excessive sugar consumption has emerged as a major public health concern in the 21st century. Global data show alarming trends in sugar intake, with many countries exceeding WHO recommendations (1, 2). According to research, Iranians consume 38% more sugar than the average food basket and more calories than is advised.(3). This overconsumption strongly correlates with a range of health conditions: from direct impacts like obesity and dental disease to more complex disorders including cardiovascular disease (4), type 2 diabetes, certain cancers (5), and mental health conditions (6, 7).

Recent research has sparked debate about whether excessive sugar consumption might be better understood through the lens of addiction. This perspective stems from three key lines of evidence. First, animal studies have demonstrated addiction-like behaviors with sugar consumption, including binging patterns, withdrawal symptoms, and craving responses (8, 9)—particularly when sugar access is intermittent rather than continuous (10). Second, human neuroimaging studies have shown that consuming sugary foods activates reward-related brain regions, similar to patterns seen with addictive substances. Third, clinical observations have revealed that some individuals struggle with sugar consumption despite understanding its negative health consequences, displaying patterns that mirror substance use disorders (9, 11).

However, the "sugar addiction" model faces several significant challenges. While brain imaging studies show some overlap between sugar and drug responses in reward pathways, these findings often lack consistency across studies (12). This inconsistency makes it difficult to establish sugar as an addictive substance definitively.

The current classification systems, including the DSM-5, do not recognize sugar addiction as a distinct disorder (13). Yet, excessive sugar consumption shares several characteristics with recognized behavioral addictions like gambling disorder, including loss of control, continued use despite negative consequences, and withdrawal-like symptoms when sugar intake is reduced. This parallel has led researchers to propose viewing problematic sugar consumption through the framework of behavioral addiction rather than substance addiction (9, 14, 15).

A significant barrier to advancing our understanding of sugar addiction is the lack of standardized assessment tools. While various questionnaires and scales exist for measuring food addiction broadly, few validated instruments specifically target sugar consumption patterns. This measurement gap has hindered both research efforts and clinical interventions, making it difficult to establish consistent diagnostic criteria or evaluate treatment effectiveness.

These challenges point to a critical need for systematic research addressing three key areas: development of validated sugar addiction assessment tools, establishment of clear diagnostic criteria, and investigation of potential treatment approaches. Understanding the precise nature of sugar's effects on behavior and biology—whether through an addiction model or alternative frameworks—remains crucial for addressing its impact on public health.

While these insights have been made, the controversy surrounding sugar addiction continues, partly because of inconsistencies in the criteria for diagnosis and the lack of targeted assessment tools.

Although several instruments are available to measure eating behaviors and food frequency, such as the MINI Plus "L" Module (16) and the Dietary Fat and Free Sugar-Short Questionnaire (DFS) (17), these tools are not specifically designed to measure sugar addiction or are based on outdated criteria. The DFS evaluates general dietary patterns, such as fat and sugar intake, but does not assess addiction-related behaviors like cravings or withdrawal (17, 18). Meanwhile, the MINI Plus "L" module, adapted for sugar dependence, is based on the outdated DSM-IV criteria, which have since been revised in the DSM-5 (16).

Despite being widely used, the Food Frequency Questionnaire (FFQ) primarily assesses eating patterns rather than the psychological elements associated with addiction (19). Also, other assessments, such as the Yale Food Addiction Scale (YFAS), concentrate on food addiction in general rather than sugar-related behaviors in particular (20). To get over these restrictions, the Sugar Addiction Questionnaire (SAQ) was created, which takes into account both the psychological and behavioural aspects of sugar addiction (21). However, cultural and dietary differences among various populations require thorough validation of such tools in multiple settings.

In Iran, certain unique cultural factors influence diet and sugar consumption. These include traditional dietary practices, economic challenges such as inflation and sanctions, and varying levels of health literacy, particularly affecting women and young age groups (22, 23).

Creating a culturally appropriate tool to measure sugar addiction is important for research and clinical use. The SAQ meets many criteria from the DSM-5, which is used to diagnose substance use disorders. This makes it a helpful starting point for comparing sugar addiction to other substance-related disorders (21). A valid Persian version of the SAQ would help researchers in Iran understand the difference between normal sugar use and sugar dependency. It would also provide valuable insight into the psychological symptoms of excessive sugar consumption among the Iranian population.

This study focuses on two main goals: the first one is the translation of the SAQ into Persian through standard procedures, and the second is evaluating this tool's effectiveness on the Iranian population. In this validation study, attention has been given to being in line with the DSM-5 criteria for behavioral addiction, as well as

consideration of local dietary habits. Results could help develop programs and public health strategies to reduce negative health consequences from excessive sugar intake.

Materials and Methods

Study Design

This psychometric validation study was conducted using a cross-sectional design to evaluate the validity and reliability of instruments used for assessing sugar addiction in an Iranian population.

Participants

Participants included 504 Persian-speaking adults aged between 18 and 65 years, recruited using convenience sampling from various health centers in Tehran city. The study was approved by the Psychiatry and Psychology Research Center (Grant Number: 66395) and the Research Ethics Committee of Tehran University of Medical Sciences (IR.TUMS.MEDICINE.REC.1402.547). Data collection occurred from March 2024 to July 2024.

Inclusion and Exclusion Criteria

Inclusion criteria:

- Adults aged 18–65 years.
- Residents of Tehran during the study period.
- Willingness to participate in the study and provide informed consent.

Exclusion criteria:

- Individuals with severe mental or physical health issues, defined as conditions requiring intensive medical or psychological treatment that would interfere with participation (e.g., psychosis, advanced cancer).
- Inability to complete the questionnaires or participate in the interviews (e.g., illiteracy, cognitive impairment).
- Individuals who do not consume sugar in any form, during a day or following a no-suger diet or sugar-free diet, a dietary approach that involves eliminating the intake of all added sugars, including common sweeteners like sucrose, fructose, and high-fructose corn syrup.

Sampling Method

Convenience sampling was employed, wherein participants were recruited from selected health centers across different areas of Tehran. This non-probabilistic sampling approach may introduce bias due to the reliance on volunteers. To mitigate this, recruitment was conducted across diverse locations to ensure variability in participant demographics.

Data Collection Procedures

Participants were approached at three medical wards and health centers by trained interviewers (PhD holders or PhD candidates in clinical psychology). The study objectives, procedures, inclusion and exclusion criteria, and confidentiality measures were thoroughly explained to the participants—those who met the inclusion criteria and voluntarily agreed to participate provided written informed consent before proceeding.

The data collection process consisted of two main steps:

1. Questionnaire Completion**:**
   Participants were asked to complete a paper-based, self-reported questionnaire in a private setting to ensure confidentiality. This questionnaire included items on socio-demographic variables such as gender, age, education, and body mass index (BMI), as well as validated tools to assess sugar addiction (e.g., the SAQ and the YFAS). Interviewers provided assistance if participants had any questions or needed clarification while completing the forms.
2. Semi-Structured Interviews**:**
   Semi-structured interviews were conducted by two experienced clinical psychologists to diagnose sugar addiction based on DSM-5 criteria for behavioral addiction. These interviews lasted approximately 20–30 minutes and were performed in private rooms within the data collection centers to maintain the confidentiality of the information. The interviews included questions related to sugar consumption patterns, compulsive behaviors, tolerance, withdrawal symptoms, and the impact of sugar consumption on daily life.

An effort was made to ensure that all participants completed the questionnaires and participated in the interviews in a private and comfortable environment to encourage honest and accurate responses.

Thirty participants were excluded from the analysis due to incomplete data, resulting in a final sample size of 504. The response rate was approximately 94%.

Measures

1. Socio-Demographic Variables

Participants completed a questionnaire that collected information on gender, marital status, age, education level, and BMI. Mean age and BMI were calculated and reported (see Table 1).

2. Sugar Addiction Questionnaire (SAQ)

The SAQ was developed and validated by Fawzy and Salah El-Deen (2018), based on a scientific literature review and DSM-5. It consists of 20 items assessing sugar-related behaviors and reactions in daily life, with responses scored as "Yes" (1 point) or "No" (0 points). The total score ranges from 0 to 20, with higher scores indicating greater sugar addiction tendencies (21).

Psychometric Properties:

- Original validation studies reported high reliability (Cronbach's alpha = 0.805) and content validity.
- In the current study, the SAQ was translated into Persian and adapted for cultural relevance. Content validity was assessed by a panel of experts in behavioral addiction, and pilot testing was conducted with 20 participants to ensure clarity.

- Internal consistency (Cronbach's alpha), construct validity (factor analysis), and test-retest reliability were calculated.

3. Yale Food Addiction Scale (YFAS 2.0)

The YFAS Version 2.0 (YFAS 2.0) was developed and validated by Gearhardt, Corbin, and Brownell in 2016. This scale is an updated version of the original YFAS, which was first introduced in 2009 (20). It is a 35-item instrument designed to assess food addiction based on DSM-5 substance use disorder criteria.

Psychometric Properties:

- The YFAS 2.0 has demonstrated appropriate internal consistency (Cronbach's alpha = 0.86–0.92), as well as convergent, discriminant, and incremental validity in prior studies.
- Elevated scores on the YFAS 2.0 are associated with higher rates of obesity and more severe pathological eating behaviors, such as binge eating (24).
- In the Persian culture, the Persian version of the scale (PYFAS 2.0) has been validated and shown to be a psychometrically sound instrument used in Iranian non-clinical populations. Previous studies confirmed its validity and reliability, with internal consistency for the 11 diagnostic symptoms reported as 0.813 (25, 26).
- In the present study, the PYFAS 2.0, validated for Iranian populations, was administered to assess the potential role of addictive processes in problematic eating behaviors.

This instrument provides a robust measure for understanding food addiction and its relationship with eating behaviors in diverse populations.

Semi-Structured Interview for Diagnosing Sugar Addiction

The semi-structured interview for diagnosing sugar addiction was developed based on DSM-5 criteria for behavioral addiction (13). Its content was designed to assess key aspects of sugar addiction, including compulsive sugar use, tolerance, withdrawal symptoms, and interference with daily life. The interview framework drew on diagnostic criteria for behavioral addiction widely discussed in scientific literature and was guided by Peele's theory, which identifies the following diagnostic criteria:

1. The activity (sugar use) becomes the most important aspect of the person's life.
2. Repeated unsuccessful attempts to reduce, control, or stop the behavior.
3. Persistent engagement in the behavior, with relapse occurring after unsuccessful cessation attempts.
4. Neglect of responsibilities (e.g., marital, educational, family, or social) due to obsessive engagement in the behavior.
5. Decreased participation in important social, occupational, or recreational activities.
6. Continuation of the behavior despite awareness of its physical, psychological, economic, or social consequences.
7. Tolerance: The need to increase the frequency or amount of the behavior to achieve the desired effect or experiencing a diminished effect with the same level of behavior.
8. Withdrawal: The presence of restlessness or other withdrawal symptoms when the behavior is not performed, persisting for at least one month or longer (27-29).

The content of the interview was reviewed and approved by specialists in clinical psychology and addiction studies to ensure its suitability and relevance for diagnosing sugar addiction.

Training of Interviewers

To ensure the consistency and accuracy of the semi-structured interviews, interviewers participated in a three-day training workshop. The training covered the theoretical framework of behavioral addiction, the application of DSM-based criteria, and the structured format of the interviews. Additionally, interviewers were trained in maintaining neutrality while probing into sensitive topics and ensuring participant comfort during the interview process.

Regular supervision sessions were conducted throughout the data collection period to address any challenges faced by the interviewers, ensure adherence to the interview protocol, and maintain inter-rater reliability.

This structured approach ensured that the interviews were conducted systematically and consistently, providing reliable and comprehensive data on sugar addiction tendencies.

Ethical Considerations

The study protocol was approved by the Psychiatry and Psychology Research Center and the Research Ethics Committee of Tehran University of Medical Sciences. Ethical considerations included:

- Ensuring participant confidentiality and anonymity.
- Storing data securely and limiting access to authorized personnel only.
- Obtaining written informed consent from all participants.
- No financial compensation was provided, but participants were thanked for their time and effort.

Data Analysis

Data were analyzed using SPSS software. The following statistical methods were applied:

- Construct Validity: Factor analysis was conducted to assess the underlying structure of the SAQ. Sample adequacy was confirmed using the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity.

- Reliability: Internal consistency (Cronbach's alpha), split-half reliability, and test-retest reliability were calculated.
- Normality Assessment: The normality of SAQ scores was evaluated using skewness (< 2) and kurtosis (< 7) criteria (Kim, 2013). In the present study, skewness = 0.74 and kurtosis = 0.39, indicating a normal distribution (30).
- Sample Size Justification: Guidelines for factor analysis recommend a subject-to-item ratio of 10:1 to 5:1. A sample size of 504 was considered adequate, exceeding the recommended minimum for good psychometric analysis (31).

Results

Table 1 presents the demographic characteristics of the samples, including gender, education, marital status, mean age and BMI.

Table 1. Demographic Characteristics of the Samples

Variables	N (%)
Gender	
Male	206 (40.9)
Female	298 (59.1)
Education	
Diploma or less	163 (32.3)
Bachelor's degree	267 (53.0)
Master's degree	63 (12.5)
PhD or higher	11 (2.2)
Marital Status	
Single	331 (65.7)
Married	173 (34.3)
Mean Age (years)	29.8, SD = 10.53
Mean BMI (kg/m²)	24.1, SD = 5.7

Translation and Cultural Adaptation

The SAQ was translated into Persian by an expert clinical psychologist. A bilingual psychologist back-translated the questionnaire into English to assess the accuracy of the initial translation. The research team reviewed the back-translated version and resolved discrepancies and cultural differences through discussions with the translators. This process ensured the questionnaire was culturally relevant and linguistically appropriate.

The preliminary Persian version was pilot-tested with 20 individuals from the general population in Tehran to evaluate clarity and understandability. Feedback from these participants indicated no significant issues, confirming the items were comprehensible and culturally appropriate.

Face Validity

Face validity was assessed by administering the modified questionnaire to 40 participants from the general population. Participants were asked to evaluate each item for relevance, clarity, ambiguity, and structure using a 2-point Likert scale (0 = disagreement, 1 = agreement). The impact score for each item was calculated using the formula:

Impact Score = Frequency (%) × Importance

The results showed that all items had impact scores above 1.5, indicating acceptable face validity. Participants noted that the items were simple, clear, and aligned with the study objectives.

Content Validity

Ten experts (PhD holders in clinical psychology) familiar with psychometric validation were invited to assess the content validity of the SAQ. Experts were required to meet specific inclusion criteria: holding a PhD or being a PhD candidate, at least two years of research experience, and familiarity with the questionnaire validation process. Of the invited experts, 5 met these criteria and participated in the evaluation.

Experts were asked to review the SAQ items for grammar, wording, understandability, and cultural relevance. Feedback was incorporated to refine the questionnaire. In the quantitative assessment, experts rated the items for necessity (Content Validity Ratio, CVR) and relevance (Content Validity Index, CVI).

- **Content Validity Ratio (CVR)**: Calculated using Lawshe's formula, where only items with CVR ≥ 0.7 were retained. All items met this threshold (32).
- **Content Validity Index (CVI)**: Computed for individual items and the overall scale. The CVI for each item exceeded 0.7, and the overall CVI for the questionnaire was acceptable.

Concurrent Validity

Concurrent validity was assessed by examining the relationship between the SAQ, the YFAS 2.0**,** and participants' BMI.

- **Food Addiction**: A positive and significant correlation was observed between the SAQ and the YFAS 2.0 ($r = 0.51$, $P < 0.001$).
- **BMI**: SAQ scores were also significantly correlated with participants' BMI ($r = 0.55$, $P < 0.001$). BMI was chosen as a correlate due to its established relationship with addictive eating behaviors and sugar consumption in prior studies.

Factor Analysis

Exploratory factor analysis (EFA) was conducted using principal component analysis (PCA) to analyze the structure of the SAQ for factor extraction. Several criteria guided the decision to extract factors: (1) eigenvalues greater than 1.0 (Kaiser's criterion), (2) a scree plot to identify the "elbow" point, and (3) the cumulative percentage of variance explained. Items were retained based on a factor loading threshold of ≥ 0.40, as

loadings below this value were considered insufficiently representative of any factor.

Varimax rotation was employed to achieve a simpler and more interpretable structure while maintaining orthogonality of factors. This rotation method was chosen because it is widely used in social sciences, facilitating a clearer interpretation by maximizing the variance of loadings within each factor. While Varimax assumes factors are uncorrelated, it was selected in this study due to its utility in revealing distinct dimensions of sugar addiction. Additionally, although the components (e.g., salience, tolerance, preoccupation) are conceptually interrelated, the goal was to identify orthogonal factors for clarity in interpreting the results.

The Kaiser–Meyer–Olkin (KMO) index for sampling adequacy was 0.86, indicating that the data were appropriate for factor analysis. Bartlett's test of sphericity was significant ($\chi^2 = 1536.36$, df = 190, $P < 0.0001$), confirming the suitability of the correlation matrix for factorization.

The analysis revealed five factors with eigenvalues exceeding 1.0, collectively explaining 45.08% of the total variance. Factor loadings, eigenvalues, and variances are summarized in Table 2. The scree plot (Figure 1) supports the retention of these five factors.

Factor Structure and Interpretation

- Factor 1: Salience (nine items) explained the greatest variance (22.24%) and included items reflecting the prominence of sugar dependency in daily life.
- Factor 2: Tolerance (three items) described an increased threshold for sugar consumption.
- Factor 3: Excessive Use (four items) captured behaviors indicative of overconsumption.
- Factor 4: Preoccupation (two items) represented thoughts or behaviors dominated by sugar dependency.
- Factor 5: Mood Modification (seven items) included items indicating emotional regulation through sugar intake.

Item-Level Results and Factor Loadings

A complete list of factor loadings for all items is presented in Table 3, ensuring transparency regardless of whether items met the ≥ 0.40 threshold. Notably, the factors were interpreted based on theoretical relevance and empirical loading patterns, supporting the construct validity of the questionnaire. The full factor loadings for all 20 items are presented in Table 3.

Table 2. Total Variance Explained by Factors in the Sugar Addiction Questionnaire

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.448	22.241	22.241	4.448	22.241	22.241	2.354	11.768	11.768
2	1.306	6.529	28.770	1.306	6.529	28.770	1.906	9.532	21.300
3	1.128	5.640	34.409	1.128	5.640	34.409	1.882	9.409	30.709
4	1.104	5.518	39.928	1.104	5.518	39.928	1.693	8.466	39.175
5	1.026	5.130	45.058	1.026	5.130	45.058	1.176	5.882	45.058

Extraction Method: Principal Component Analysis.

Table 3. Results of Factor Analysis with Varimax Rotation on 20 Items of Sugar Addiction Questionnaire (Structure Matrix)

Structure Matrix					
	Component				
	1	2	3	4	5
suger.addiction.Item.1					0.671
suger.addiction.Item.2					0.562
suger.addiction.Item.3					0.701
suger.addiction.Item.4	0.484				0.412
suger.addiction.Item.5		0.712			
suger.addiction.Item.6			0.566		
suger.addiction.Item.7	0.684				

suger.addiction.Item.8			0.417			
suger.addiction.Item.9	0.453					0.419
suger.addiction.Item.10						
suger.addiction.Item.11	0.547					
suger.addiction.Item.12	0.655					
suger.addiction.Item.13	0.657					
suger.addiction.Item.14		0.428	0.438			0.455
suger.addiction.Item.15	0.509					
suger.addiction.Item.16				0.812		
suger.addiction.Item.17	0.472			0.453		
suger.addiction.Item.18						0.465
suger.addiction.Item.19			0.558			
suger.addiction.Item.20	0.453	0.404				

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization

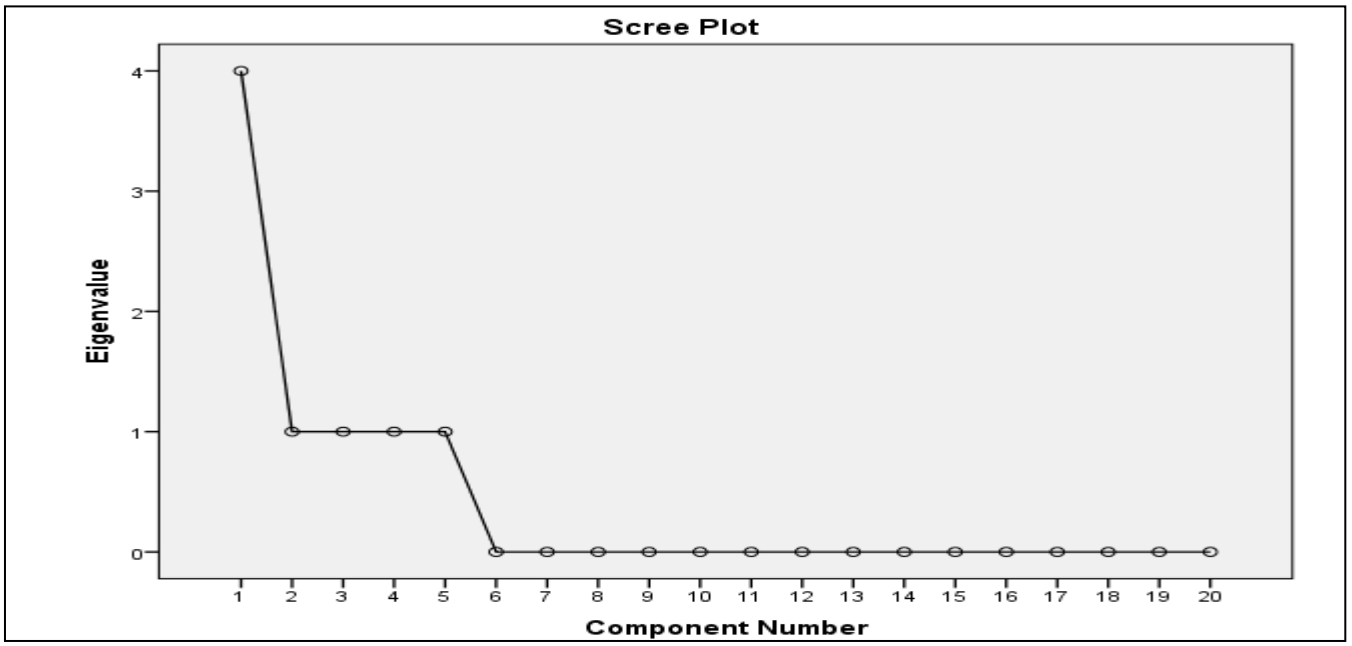

Figure 1. Factors that are Extracted via the Scree Plot of Sugar Addiction Questionnaire

Confirmatory Factor Analysis (CFA)

To confirm the factor structure identified through EFA, a Confirmatory Factor Analysis (CFA) was conducted. The CFA tested the adequacy of the proposed five-factor model and the fit of the SAQ to the collected data.

Model Fit Statistics

The following goodness-of-fit indices were obtained for the CFA model:

- $\chi^2/df = 1716/262 = 6.55$, $P < 0.001$ (indicating model fit but a sensitive test due to large sample size).
- Root Mean Square Error of Approximation (RMSEA) = 0.08 (acceptable; < 0.10).
- Comparative Fit Index (CFI) = 0.91 (satisfactory; ≥ 0.90).
- Tucker-Lewis Index (TLI) = 0.95 (satisfactory; ≥ 0.90).
- Goodness-of-Fit Index (GFI) = 0.91 (satisfactory; ≥ 0.90).
- Composite Reliability (CR) = 0.77.
- HOELTER Index = 209 (indicating adequate sample size for model reliability) (Table 4).

These indices collectively demonstrate an acceptable to strong fit of the five-factor model to the data. The KMO test value of 0.86 and the significance of Bartlett's test of sphericity ($P < 0.001$) further confirmed the adequacy of the sample for CFA. Figure 2 presents a graphical representation of the confirmed five-factor model. The diagram visually demonstrates the relationships between the latent variables (factors) and the observed items,

providing further evidence of the robustness of the factor structure.

Factor Reliability

The Cronbach's alpha coefficient for the global questionnaire was 0.79, reflecting strong internal consistency. The reliability coefficients for each factor were as follows:

- Salience: 0.71
- Tolerance: 0.63
- Excessive Use of Sugar: 0.77
- Preoccupation: 0.67
- Mood Modification: 0.74

These values indicate acceptable to strong reliability across all dimensions of the SAQ.

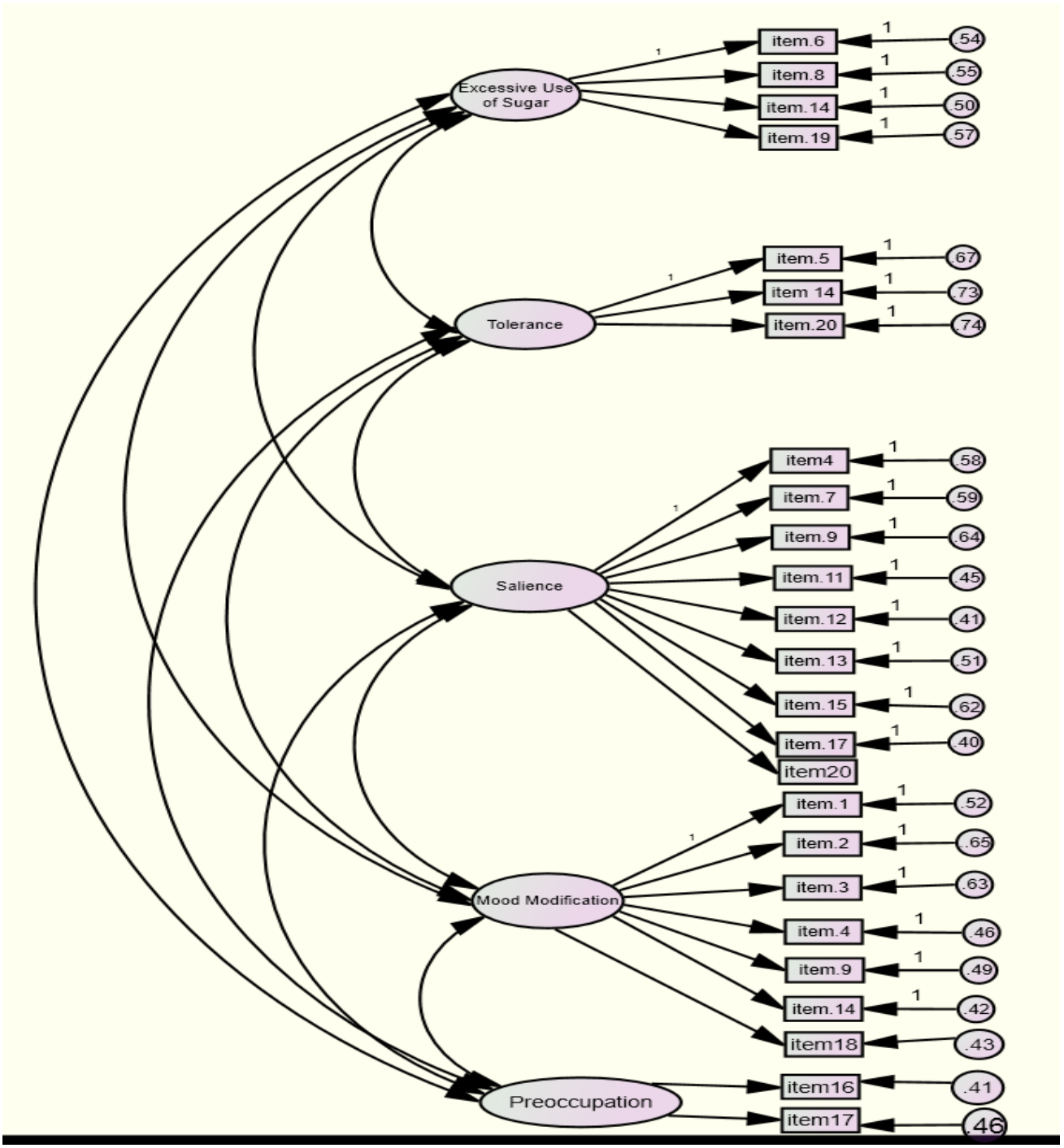

Figure 2. Graphical Representation of the Confirmed Five-Factor Model of Sugar Addiction Questionnaire

Table 4. Goodness-of-Fit Indices for the Sugar Addiction Questionnaire

Goodness-of-Fit Index	Expected Value	Calculated Value
χ^2	P < 0.05	< 0.0001
χ^2/df	< 3	6.55
RMSEA (Root mean square error of approximation)	< 0.10	0.08
CFI (Comparative fit index)	≥ 0.90	0.91
TLI (Tucker-Lewis Index)	≥ 0.90	0.95
GFI (goodness-of-fit index)	≥ 0.90	0.91
CR (Composite Reliability)	> 0.50	0.77

Reliability

Analysis of the internal consistency of the SAQ was conducted using several statistical methods according to the characteristics of the data (continuous or categorical) and the context of testing variables. Pre-survey and post-survey responses were coded and entered into SPSS24 software for analysis. Cronbach's α was calculated to measure the internal consistency of the Likert-type scale items. The reliability of the questionnaire was assessed using internal consistency, which indicates the homogeneity of the items. In this method, Cronbach's α coefficients of > 0.7 represent acceptable reliability (33). The reliability of the SAQ is presented in Table 5.

Table 5. Internal Consistency of the Sugar Addiction Questionnaire (Cronbach's Alpha)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Cronbach's Alpha if Item Deleted
suger.addiction.Item.1	6.7302	14.448	0.782
suger.addiction.Item.2	7.0357	13.871	0.780
suger.addiction.Item.3	7.1151	13.502	0.772
suger.addiction.Item.4	7.3988	13.954	0.774
suger.addiction.Item.5	7.2103	14.302	0.787
suger.addiction.Item.6	7.1528	13.780	0.778
suger.addiction.Item.7	7.3948	13.746	0.770
suger.addiction.Item.8	7.2976	13.657	0.772
suger.addiction.Item.9	7.3095	13.737	0.773
suger.addiction.Item.10	7.2063	14.275	0.787
suger.addiction.Item.11	7.3373	13.556	0.768
suger.addiction.Item.12	7.3849	13.756	0.771
suger.addiction.Item.13	7.4266	14.213	0.778
suger.addiction.Item.14	7.0675	13.447	0.771
suger.addiction.Item.15	7.4266	14.030	0.774
suger.addiction.Item.16	7.3413	14.635	0.789
suger.addiction.Item.17	7.3452	13.952	0.776
suger.addiction.Item.18	6.9921	13.646	0.775
suger.addiction.Item.19	6.7421	15.484	0.801
suger.addiction.Item.20	7.0556	13.818	0.779

Analysis of External Reliability of the Sugar Addiction Questionnaire

The test-retest reliability of the SAQ was evaluated using Pearson correlation, revealing a consistency of 0.54 (P < 0.001) between the two administrations. The time interval (two weeks) between test-retest was in line with literature suggestions (34). Additionally, the split-half reliability of the questionnaire was calculated, with a correlation of 0.55. Statistical significance was set at the 0.05 level.

Determination of the Cutoff Point

Using psychological interviews based on DSM-5 criteria as the gold standard, participants were classified into

two groups: sugar-addicted (n = 142, 28.2%) and non-addicted (n = 362).

The Receiver Operating Characteristic (ROC) curve was used to validate the diagnostic efficiency of the SAQ. The ROC curve plots sensitivity (true positive rate) against 1-specificity (false positive rate) at different cutoff points. A high Area-Under-the-Curve (AUC) indicates strong diagnostic ability. The SAQ achieved an AUC of 98%, suggesting excellent performance in distinguishing between sugar addicts and normal consumers. The optimal cutoff point for the SAQ was determined to be 9, balancing sensitivity and specificity. At this cutoff, the SAQ effectively identifies sugar addiction while minimizing false positives (Table 6).

Table 6. The Receiver Operating Characteristic Curve Analysis. Sensitivity and Specificity of Total Scores of Sugar Addiction Questionnaire

Cut off Point	Sensitivity	1 - Specificity
7	1.000	0.243
8	1.000	0.099
9	1.000	0.000
10	0.704	0.000
11	0.563	0.000
12	0.373	0.000

As the cutoff point increases, sensitivity decreases, leading to more false negatives (missed cases of sugar addiction). However, 1-specificity remains low at cutoff points of 9 and above, minimizing false positives. The cutoff point of 9 offers the best balance, ensuring high sensitivity and acceptable specificity. The trade-off between sensitivity and specificity is typical in diagnostic testing. Lower cutoff points (e.g., 7 and 8) maximize sensitivity but may misclassify many non-addicted individuals as addicted. Higher cutoff points (e.g., 10, 11, 12) improve specificity but decrease sensitivity, leading to missed addiction cases. The cutoff of 9 is optimal, as it identifies most true cases of sugar addiction without over-diagnosing normal consumers.

Discussion

This study represents the first effort to evaluate the psychometric properties of the SAQ in a general population aged 18 to 65 years, the primary aim was to adapt and validate this innovative questionnaire for assessing sugar addiction in the Persian-speaking population, ensuring its cultural appropriateness. The SAQ, originally developed to measure behavioral addiction symptoms based on DSM-5 criteria, includes 20 items that assess various aspects of sugar intake dependency (21). Through a rigorous process of translation, cultural adaptation, and psychometric testing, we ensured that the Persian version of the SAQ is reliable and valid.

Cultural Adaptation and Validity

The translation and cultural adaptation of the SAQ ensured its relevance to the Iranian population. Content validity assessments confirmed that the items were reflective of sugar consumption behaviors in the Persian society. Strong face and content validity were demonstrated, consistent with findings from the original study conducted in Egypt (21). This cross-cultural consistency suggests that the SAQ requires minimal adjustments for use across different populations.

Reliability

The internal consistency of the questionnaire was satisfactory, with Cronbach's alpha coefficients ranging from 0.63 to 0.77 for individual factors and 0.79 for the overall questionnaire. These values indicate acceptable reliability for the five extracted factors. The temporal stability of the measure was demonstrated through test-retest reliability ($r = 0.54$, $P < 0.001$) over a two-week interval, suggesting moderate stability. Additionally, the internal consistency was further supported by split-half reliability ($r = 0.55$), indicating that the items within the questionnaire were consistent in measuring the intended construct. The reliability coefficients in this study align closely with those reported in the original research (Cronbach's alpha = 0.805) (21). Minor differences in reliability coefficients may be attributed to variations in sample size, cultural differences, or methodological approaches. Despite these differences, the results consistently demonstrate the reliability of the SAQ. These findings are consistent with the original study conducted in Egypt.

Construct Validity

The results from the factor analysis and CFA strongly support the construct validity of the SAQ. Using principal component analysis with Varimax rotation, five distinct factors were identified: salience, tolerance, excessive sugar use, preoccupation, and mood modification. These factors align with theoretical frameworks of sugar addiction, reflecting its multidimensional nature and overlap with behavioral addiction symptoms as outlined in the DSM-5 criteria.

The KMO index was 0.86, and Bartlett's test of sphericity was significant ($P < 0.001$), confirming the dataset's suitability for factor analysis. The five factors explained 45.08% of the total variance, with salience being the most significant at 22.24%. This shows that salience plays a key role in sugar addiction by highlighting how sugar affects thoughts and behaviors. The factor loadings showed coherent groupings of items within their factors, confirming that the questionnaire items matched their intended concepts.

The CFA further supported this factor structure, demonstrating an acceptable model fit (CFI = 0.91, TLI = 0.95, RMSEA = 0.08). These findings confirm that the Persian version of the SAQ retains the theoretical integrity of the original scale while effectively adapting to the Persian cultural context. Additionally, the total SAQ score showed a strong positive correlation with the

YFAS, supporting the SAQ's ability to measure behaviors associated with food addiction.

Interpretation of the Five-Factor Structure

The five-factor structure—salience, tolerance, excessive use, preoccupation, and mood modification—provides insights into the multidimensional nature of sugar addiction. Salience (22.24% of the variance) aligns with substance addiction research, reflecting the central role of sugar in an individual's cognitive and emotional life. The mood modification factor, distinct from tolerance, highlights emotional regulation as a unique component of sugar addiction. While tolerance indicates a greater need for sugar to achieve satisfaction, mood modification highlights sugar's role in boosting positive emotions and reducing stress, illustrating its emotional impact.

Comparison to Traditional Food Addiction Models

The SAQ's factor structure diverges from traditional food addiction models, such as the YFAS, which primarily focus on loss of control and withdrawal symptoms. The SAQ highlights both reward-based processes (salience and mood modification) and habitual pathways (tolerance and excessive use). This dual-process model explains sugar addiction's complexity, combining immediate emotional reinforcement with ingrained, automatic behaviors. This dual model provides a framework for understanding why sugar addiction presents unique challenges in treatment and prevention, as effective interventions must address both the neurochemical drivers of addiction and the habitual patterns sustaining it.

Concurrent Validity

The SAQ demonstrated strong concurrent validity through significant correlations with both the YFAS ($r = 0.51$) and BMI ($r = 0.55$). These findings suggest that higher SAQ scores are associated with greater food addiction symptoms and higher BMI, which are well-documented consequences of excessive sugar consumption. The correlation between sugar addiction and BMI can be explained by the role of sugar in activating the brain's reward system, particularly dopamine pathways (18), which reinforces consumption despite negative health outcomes such as weight gain (35). Additionally, excessive sugar intake can disrupt metabolic processes, causing insulin resistance and promoting fat storage, further contributing to weight gain (36). These findings highlight the clinical significance of the SAQ in identifying individuals at risk for obesity and related health complications, supporting its role as a valuable tool for early intervention and prevention strategies targeting problematic sugar consumption.

Cutoff Point

Based on the findings, a cutoff score of 9 on the SAQ was proposed to differentiate between normal sugar users and those with sugar addiction. This threshold demonstrated high diagnostic efficiency (AUC = 0.98, 95% CI [0.96-0.99]), with excellent sensitivity (1.00) and 1- specificity (0.000) This indicates that the cutoff score of 9 is optimal for accurately identifying sugar addiction cases without misclassifying normal sugar users. In screening contexts, the perfect sensitivity ensures that all potential cases are identified, while the perfect specificity eliminates the risk of false positives. These results suggest that this cutoff is highly effective for both identifying and confirming cases of sugar addiction.

However, no cutoff is perfectly accurate, and errors are inevitable, especially in culturally diverse populations where sugar consumption habits vary. While this threshold performs exceptionally well in the current population, its generalizability to other groups and settings should be evaluated further. Additionally, despite its strong performance, clinical judgment and comprehensive assessments remain important to account for contextual factors that may influence SAQ responses. False positives could lead to unnecessary interventions, wasted resources, or stress for individuals wrongly identified as addicted. However, the perfect sensitivity ensures no false negatives, meaning no cases of sugar addiction are missed. This is important because undiagnosed addiction can contribute to problems like obesity and metabolic issues. Overall, while the cutoff is effective for identifying potential cases, follow-up assessments are essential to confirm the diagnosis and avoid overdiagnosis.

Gender Differences

A significant gender difference was observed, with females scoring higher on average (Cohen's $d = 0.58$, 95% CI [0.42, 0.74]). While hormonal influences, particularly estrogen's role in sweet cravings during the menstrual cycle, contribute to this difference (37), sociocultural factors in the Iranian society also play crucial roles. These include women's primary responsibility for food preparation, greater exposure to sweet foods through social gatherings, and cultural norms (38). Additionally, biological differences in taste perception and reward processing, along with gender-specific stress-coping mechanisms, further explain these variations. These findings align with previous research linking gender differences to both physiological and psychosocial factors in sugar consumption patterns (39-42).

Implications for Public Health and Clinical Practice

The validated Persian version of the SAQ is a reliable tool for assessing sugar addiction in the Iranian population, where excessive sugar consumption poses a significant public health challenge. With per capita sugar intake exceeding recommended levels by 38% (3), the SAQ can help identify at-risk individuals and support interventions. The SAQ's multidimensional structure, based on DSM-5 behavioral addiction criteria, underscores its potential as a diagnostic tool. Its correlations with BMI and food addiction highlight its clinical utility in addressing health issues related to sugar

dependency like obesity, diabetes, and other health complications linked to excessive sugar consumption.

As the first self-reported tool based on DSM-5 criteria to evaluate sugar addiction, the SAQ provides a comprehensive diagnostic profile for researchers and practitioners. Its concise structure makes it suitable for research and clinical use, enabling the identification and management of sugar consumption issues. Additionally, the SAQ's utility extends to studying the overlap between substance and non-substance addictions, given their shared effects on behavior, social interactions, and mental health.

In this study, demographic variations may have influenced the results. To reduce the risk of false positives, a higher cutoff score was applied, reflecting cultural sensitivities regarding sugar addiction. Overall, the SAQ is a valid, reliable, and concise instrument for assessing subclinical sugar addiction, making it a valuable resource for research and public health efforts.

Limitation

Strengths and Limitations

In addition to the unequal gender distribution (75% males), which may have biased the findings, several other limitations must be acknowledged. The cross-sectional design prevents establishing causal relationships, limiting the ability to determine whether excessive sugar consumption leads to addiction-like behaviors or vice versa. The reliance on self-reported data introduces potential biases, such as underreporting due to stigma or social desirability, which may have affected the accuracy of sugar consumption and addiction-related responses. Additionally, the study excluded diabetic individuals, meaning the findings cannot be generalized to populations with diabetes, who may exhibit distinct behaviors and physiological responses to sugar. Finally, while the cultural adaptation of the SAQ ensured relevance to Iranian dietary habits, the findings may not be directly applicable to other cultural contexts, highlighting the need for cross-cultural validation.

Strengths

Despite these limitations, the study has notable strengths. The large sample size (n = 504) enhances the statistical power and reliability of the results, and the comprehensive psychometric analyses confirm the validity and reliability of the SAQ. The cultural adaptation of the questionnaire ensured its relevance to Iranian dietary and social behaviors, and the use of DSM-5 guidelines for diagnosing sugar dependency improved diagnostic accuracy and aligned the study with internationally recognized frameworks.

Future Directions

Future studies should include more diverse and representative samples to enhance generalizability. Longitudinal studies are needed to establish the predictive validity of the SAQ, particularly in predicting outcomes like obesity, diabetes, and metabolic syndrome. Additionally, the application of the SAQ in clinical settings should be explored to assess its diagnostic utility.

Conclusion

The Persian version of the SAQ was successfully validated and shown to be a reliable tool for assessing sugar addiction in the Iranian population. By aligning with DSM-5 criteria, the SAQ fills an important gap in measuring sugar-related behavioral addictions. This study makes a valuable contribution to addiction research by providing a tool that helps better identify and examine sugar-related behavior issues. The validated SAQ may lead to better diagnostics, treatments, and prevention methods, ultimately helping to improve public health by addressing excessive sugar consumption.

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Conflict of Interest

None.

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