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1 **Exploring the pathways from the Power of Food to food cravings in a sample of**
 2 **Brazilian young adults**

3

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17 Declarations of interest: none

18

19 **Abstract**

20 The present study has three main objectives: a) to analyse, for the first time, the factor
 21 structure of the Control of Eating Questionnaire (CoEQ) in a Brazilian sample; b) to
 22 explore, through in-depth interviews, motivators and consequences of food cravings
 23 among participants with high scores on the CoEQ; and c) to analyse whether and how
 24 the power of food is related to food cravings. The study involved 335 young adults aged
 25 18-30 years, balanced for sex. The CoEQ and the Power of Food Scale (PFS) were used
 26 in an online survey. The CoEQ and PFS were subjected to confirmatory factor analysis.
 27 Semi-structured interviews were also conducted with a subsample (n=20) with high
 28 CoEQ scores. The Socratic questioning method was used for the interviews. The
 29 interviews were transcribed and analysed according to thematic content analysis. The
 30 PFS and the CoEQ showed adequate factor structure with reliable factors. The results of
 31 the qualitative analysis showed that both food availability and seeking relief from
 32 stressors serve as motives for food cravings. Concern for health and weight gain were
 33 cited as consequences of cravings, as was seeking distraction to cope with these
 34 cravings. It was found that the PFS aggregate factor was a significant influencing factor
 35 for craving control ($\beta = 0.604$; $p < 0.001$), craving for savoury ($\beta = 0.382$; $p < 0.001$),
 36 craving for sweet ($\beta = 0.414$; $p < 0.001$) and positive mood ($\beta = -0.198$; $p < 0.001$). The
 37 findings suggest that the relationship between food cravings and the power of food is
 38 significant in today's obesogenic environment.

39

40 **Keywords:** eating behaviours; palatable foods; disordered eating; qualitative research;
 41 structural equation modelling.

42

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43 1 Introduction

44 High food availability and exposure to food cues in the environment are a risk
45 factor for increased food consumption and weight gain in susceptible individuals
46 (Boswell & Kober, 2016). In an obesogenic environment, where the availability of highly
47 palatable foods is ubiquitous, food choices and intake are often motivated by hedonistic
48 rather than homeostatic reasons (Mankad & Gokhale, 2021), such as a *strong desire to*
49 *eat* (Hallam, Boswell, et al., 2016). Food cravings refer to an urge for a particular food or
50 group of foods, which is manifested by intense and intrusive thoughts alongside a strong
51 urge to consume. This feeling is often accompanied by a sense of lack of control and
52 anticipation of pleasure (Taylor, 2019). Increased food cravings have been associated
53 with higher intake of palatable foods (Massicotte et al., 2019). The presence of palatable
54 food can trigger a cue-induced craving or even a state craving if the food is not physically
55 present but easily accessible (Hallam, Boswell, et al., 2016). With this in mind,
56 psychometric tools have been developed to help researchers and practitioners assess
57 individual variability in hedonic hunger aspects and food cravings, such as the Control of
58 Eating Questionnaire (CoEQ) and the Power of Food Scale (PFS).

59 The CoEQ was validated by Dalton *et al.*, (2015) as a scale that measures the
60 frequency, intensity, specificity, and behaviour associated with food cravings by
61 providing information about appetite and affective state. The scale was used in a cross-
62 sectional analysis conducted by Smithson & Hill (2017) to examine the frequency and
63 nature of intense cravings in individuals who participated in weight management
64 programmes. The researchers concluded that feeling control over food was associated
65 with greater weight loss, suggesting that craving behaviour influences weight
66 management. Similar results were also observed by Dalton *et al.* (2017).

67 The PFS was developed by Lowe *et al.*, (2009) and was initially introduced as a
68 scale to analyse parameters related to hedonic hunger, which is characterised by
69 preoccupation with, and consumption of, food for pleasure in the absence of physical
70 hunger (Horwath et al., 2020; Mankad & Gokhale, 2021). The scale assesses self-
71 reported motivation to eat palatable foods, especially in environments where food is
72 constantly available considering three domains: food present, food tasted, and food
73 available (Espel-Huynh et al., 2018; Ulker et al., 2021). In a sample of older adults living

74 with obesity those who scored higher on the PFS were more likely to have increased
75 cravings for palatable foods (Rejeski et al., 2012). This indicates a possible link between
76 motivation to consume palatable foods and food cravings.

77 Of note, both the CoEQ and PFS do not analyse actual food consumption but
78 possible anticipatory factors for it. Nonetheless, the context differs from the parameters
79 of physiological hunger, as this increases in intensity due to the absence of food (Dalton
80 et al., 2017) and can be satisfied with any type of food, whereas intense cravings are
81 usually satisfied with specific foods (Meule, 2020). Therefore, this connection between
82 control over the power of food and food cravings is quite logical, but thus far, little
83 research has been conducted. While the PFS and CoEQ scales used in the present study
84 measure similar traits, such as motivation to eat (Espel-Huynh et al., 2018; Dalton et al.,
85 2015), they differ. The PFS analyses preoccupation with eating in the absence of physical
86 hunger (Horwath et al., 2020) and the CoEQ assesses the intensity of craving for
87 palatable foods and the level of control an individual perceives themselves to have over
88 those cravings (Dalton et al., 2015). Therefore, it remains unknown whether the
89 domains of PFS and CoEQ are related. Is the motivation to eat palatable foods closely
90 related to the control of cravings? How does the power of food correlates the craving
91 for sweet and savoury foods differently?

92 To better answer such questions, special attention should be paid to the role of
93 sex in research on eating behaviour. Women are at greater risk of obesity, body image
94 problems, and having food cravings than men (Hallam, Boswell, et al., 2016; Macedo &
95 Diez-Garcia, 2014; Rodgers et al., 2015). The type of food craved, the level and frequency
96 of cravings, and the ability to regulate food cravings are thought to be key aspects that
97 differentiate men and women (Hallam, Boswell, et al., 2016). Given that cravings vary in
98 men and women, it is important that research on food cravings includes both men and
99 women.

100 In this research we were interested in understanding the environmental
101 determinants of cravings or the triggers related to the presence of palatable foods in the
102 environment. Most research to date in the field has used quantitative data. Research
103 with qualitative or mixed methods approach are scarce in the field. However, qualitative
104 data can contribute to a deeper understanding of the quantitative information, explain
105 the results obtained and give meaning to the numbers (Connelly, 2009). Such in-depth

106 information also offers value when investigating psychometric scale criterion validity.
107 Therefore, in an effort to better understand eating motivations in an urban
108 environment, using a mixed-methods approach, the present study had three main
109 objectives: a) to analyse, for the first time, the factor structure of the CoEQ in a sample
110 of Brazilian adults; b) to explore, through in-depth interviews, motivators and
111 consequences of food cravings among participants with high scores on the CoEQ and c)
112 to analyse whether and how the power of food is related to food cravings.

113

114 **2 Methods**

115 We carried out a mixed methods approach for this study, employing a
116 quantitative approach in the first step and a qualitative approach in the second step, i.e.
117 a sequential explanatory design (Bartholomew & Brown, 2012). There are different
118 definitions and cutoffs to determine adolescence and young adults in Brazil (Fiorini et
119 al., 2017). In this study, young adults were defined as individuals between the ages of
120 18 and 30. They were invited to participate through social media calls. Participation was
121 voluntary, and all participants gave free and informed consent. The study methods were
122 approved by the Research Ethics Committee of the *Universidade Estadual de Campinas*
123 (CAEE: 40026320.3.0000.5404).

124

125 *2.1 First step - Quantitative approach*

126 *2.1.1 - Sample*

127 Data were collected online via Qualtrics from 11th October to 16th November
128 2021. The survey was announced via social media (e.g., Facebook, Instagram and email)
129 and aimed to reach a minimum of 300 participants (150 men and 150 women for
130 balanced groups). According to Kyriazos (Kyriazos, 2018), a sample > 200 would be
131 appropriate for confirmatory factor analysis (CFA), as most factors have more than three
132 indicators. A sample of 300 is recommended for multivariate analysis (Kyriazos, 2018).
133 Participants answered the PFS and CoEQ, in this order, in addition to a socioeconomic
134 questionnaire that included questions on sex, age, city and state they live in, whether
135 they were studying or have a degree in any area of health and education level, weight
136 (kg), height (m), email and mobile phone number.

137 To avoid bias, the recruitment advert stated that the objective was to assess
138 general eating behaviour, and did not include information about the study objective
139 (i.e., food craving assessment). Adults aged 18 to 30 years (both sexes) who were
140 Brazilians living in Brazil were included. Participants with monotonous responses
141 (standard deviation equal zero for any questionnaire) (n=1); incomplete responses in
142 PFS and CoEQ (n=7) were excluded.

143

144 *2.1.2 Measures - CoEQ and PFS*

145 The CoEQ questionnaire consists of 21 indicators of food cravings and mood, and
146 the participants are asked to answer regarding their experience over the last seven days
147 (Dalton et al., 2015). The results are given according to four factors: craving control,
148 craving for sweet, craving for savoury and positive mood. Four items are not included in
149 the subscales; items 1 and 2 provide information on general feelings about appetite, and
150 items 20 and 21 provide information on the person's degree of control over resisting a
151 particular food they identify as being difficult to control their consumption of. Item 20
152 is an open-ended question that allows the participant to specify the food item they are
153 craving. The questions of each indicator are answered using visual analogue scales
154 ranging from 0 to 100 mm, and one item allows the participant to specify a particular
155 food (Dalton et al., 2017). The score for each factor is the mean of the indicators. For
156 Positive Mood, the score for item 6 is inverted; for Craving Control, the higher the value,
157 the lower the craving control. The CoEQ indicators and scales was translated for Brazilian
158 Portuguese by two researchers with a PhD in the field Nutrition and Psychology.

159 The PFS is a scale consisting of 15 indicators. It is divided into 3 factors: food
160 available (food that is available in the environment but not physically present); food
161 present (reactions to a food that is physically present but not yet experienced); and food
162 tasted (reactions to a food that is physically present and being experienced for the first
163 time) (Lowe et al., 2009). The indicators are rated on a scale from '1 - I strongly disagree'
164 to '5 - I strongly agree' (Lowe et al., 2009). The PFS has already been used for the
165 Brazilian population (Paiva et al., 2022), with a slight adaptation of the Portuguese
166 version. The higher the total score, the more strongly the person responds to the food
167 environment (Cappelleri et al., 2009).

168

169 2.1.2 Data analysis

170 For data analysis, first, the theoretical distributions of the variables were
171 analysed using means, variances, skewness, kurtosis and the histogram of the
172 distribution. The Kolmogorov–Smirnov test (with Lilliefors correction) was used to check
173 the normality of the data. CoEQ and PFS were subjected to confirmatory factor analysis
174 (CFA). Although it is a validated instrument already in use in Brazil, we decided to
175 conduct the CFA in the PFS to ensure the quality of the constructs. CFA was performed
176 following the original structure of CoEQ (Dalton et al., 2015) and PFS (Cappelleri et al.,
177 2009) using robust maximum likelihood (ML) and diagonally weighted least squares
178 (DWLS), respectively. The differences between the CFA methods are due to the
179 difference in the scales of both questionnaires, count (COeQ) and ordinal (PFS). The chi-
180 square value (χ^2 with $p < 0.05$), root mean square error of approximation (RMSEA $<$
181 0.08), comparative fit index (CFI > 0.90), standardised root mean square residual (SRMR
182 < 0.08), Tucker–Lewis index (TLI > 0.90), and goodness-of-fit index (GFI > 0.90) were used
183 to check model fit (Kline, 2016). Due to poor fit of CoEQ original structure in the CFA, an
184 Exploratory Factor Analysis (EFA) was conducted for this questionnaire. Valid items were
185 extracted using maximum likelihood. The number of factors to be retained was made
186 using the eigenvalue criteria. EFA was performed with Promax rotation, allowing
187 possible positive correlation among the CoEQ factors. The RMSEA (< 0.08), CFI (> 0.90)
188 and TLI (> 0.90) were used to check the goodness of fit (Brown, 2006). The Kaiser–
189 Meyer–Olkin (KMO > 0.70) and Bartlett's tests ($p < 0.05$) were used to check sampling
190 adequacy. Groups (man x women) were compared using Student's t-test and Cohen's d
191 for effect sizes. These analyses were performed using JASP 0.16.1.

192

193 2.2 Second step - Qualitative approach

194 2.2.1 Sample

195 Only participants with high scores for craving for sweet or for savoury foods were
196 invited (in the 4th quartile of the distribution, i.e. with a mean score of more than 68 for
197 savoury and 71 for sweet foods) to participate in the individual in-depth interviews. For
198 the analyses, four participant lists were created that took into account sexes
199 (men/women) and high craving (sweet/savoury) for a purposeful sampling
200 (Sandelowski, 1995). Participants were invited randomly until we reached the minimum

201 number of participants of 20. The sample was chosen to create homogeneous groups,
 202 i.e., five men with craving for sweets (MSW), five women with craving for sweets (WSW),
 203 five men with craving for savoury (MSV), and five women with craving for savoury
 204 (WSV). With the sample it was possible to reach saturation.

205 For this second step of the project, participants were contacted by telephone or
 206 e-mail (had previously agreed to be contacted) and were reminded about the study and
 207 were invited to an interview with a psychologist for more information. A total of 83
 208 participants were contacted, and 20 agreed to participate.

209

210 2.2.2 Interview and analysis

211 The individual interviews were conducted online via Google Meet by a
 212 psychologist. Each interview lasted an average of 30 minutes. The Socratic questioning
 213 method was used (Paul & Elder, 2007). Participants answered nine open-ended
 214 questions based on four cores: origin, assumption, consequence, and evidence (Table
 215 1). Some additional contextual questions could be included for clarity.

216

217 Table 1 – questions for the interview following the Socratic questioning method.

Core	Question
Warm up	What is your name and age? What is your favorite food? What is your job or study?
Origin	1) When in the presence of food cues (thinking, smell, visual cues...) of tempting foods, what kind of thoughts and feelings do you have? 2) Are there times when you are more likely to experience food cravings (e.g., when hungry, tired etc.): 3) Do you think your emotions (e.g., sad, happy etc.) affect your food cravings?
Assumptions	4) Why do you think it is so difficult to resist any food cravings?
Consequence	5) What is the consequence in your life of not resisting food cravings?
Coping strategies	6) What helps you to resist a food craving? 7) Is it something that you think you are able to change? (food cravings)
Evidence	8) Can you provide an example when you had a food craving?

218

219 The qualitative approach aimed to explore three defined research questions: a)
 220 What motivates participants to have food cravings? b) What impact does food cravings
 221 have on participants' life? c) What coping strategies are used for food cravings? Before
 222 the questions began, a simple definition of food cravings was provided to participants,
 223 i.e. "Food craving is defined as an intense desire to eat a specific food" (Dalton et al.,
 224 2015). In order not to bias the answers, the questions were general.

225

226

The entire content of the in-depth interviews was transcribed and analysed according to Laurence Bardin's qualitative method of content analysis of the thematic

227 type (Bardin, 1977). In this method, speeches are divided into meaning cores, originating
228 nonprioristic categories. The principal researcher determined the category and was later
229 reviewed independently by three other researchers for validation and grouping. A final
230 discussion was made for consensus. The differences between men and women and
231 between those who craved savoury and sweet foods were determined by the count of
232 people in each group who presented the meaning core in their speech. The qualitative
233 data were analysed using MAXQDA© software - VERBI GmbH 2018.

234

235 3.2 Third step – Modelling

236 Structural equation modelling with partial least squares (PLS-SEM) was chosen
237 to analyse the relationship between PFS and CoEQ. PLS-SEM minimises sample size
238 limitations, makes no distributional assumptions and is an appropriate approach to deal
239 with second-order models (Van Riel et al., 2016). The hypotheses were specified *a priori*,
240 *i.e.*, before the data were collected. First, a 1st-order model was tested to examine the
241 individual effects of the PFS factors on the CoEQ factors. Since the results were
242 significant, a 2nd-order model was tested that included an aggregate power of food
243 factor. In both models, all indicators validated in the previous CFA were included to form
244 the latent variables, *i.e.* food tasted, food present, food available for PFS and craving
245 control, craving for sweet, craving for savoury and positive mood for CoEQ. The bias-
246 corrected and accelerated bootstrap procedure with 5,000 samples was used to
247 estimate the t-statistics (significance: $t > 1.96$) and p values (significance: $p < 0.05$) of the
248 estimated loadings. The outer model (part of the model that describes the relationships
249 among the latent variables and their indicators) was assessed using the factor loadings
250 (> 0.40), the composite reliability ($CR > 0.80$) and the average of the variance extracted
251 ($AVE > 0.40$). The inner model (the part of the model that describes the relationships
252 among the latent variables) was assessed using the variance explanation of the
253 endogenous constructs, effect sizes ($f^2 > 0.10$), and predictive relevance (Stone-Geisser's
254 $Q^2 > 0.15$). The values and indicators were used as suggested by Henseler *et al.* (Henseler
255 *et al.*, 2009). The heterotrait-monotrait ratio (HTMT) of correlations was used to assess
256 discriminant validity (< 0.85) (Hair *et al.*, 2016). Multicollinearity was assessed using
257 variance inflation factor (VIF) values (< 3.3) (Henseler *et al.*, 2015). The PLS-SEM was

258 conducted with SmartPLS v3.2.8 (SmartPLS GmbH. Boenningstedt - Germany) (Ringle et
259 al., 2015).

260

261 3. Results

262 3.1 Sample

263 The sample comprised of 335 young adults and 54% females (Table 2). The mean
264 age was 24 years old (standard deviation = 4.02). The overall mean self-reported BMI
265 was 25.5; 6.1 kg/m², (women: 25.3; 7.3 kg/m²; men: 25.8; 4.4 kg/m²). There were no
266 significant differences between sexes regarding age ($p = 0.58$), BMI ($p = 0.53$), and rates
267 of obesity (17% women with obesity and 14% men with obesity, $p = 0.47$).

268

269

Table 2 - Sociodemographic characteristics of the sample (n=335).

Variables	N (%)
Age (years old)	
18-21	83 (24.7)
22-24	84 (25.1)
24-27	84 (25.1)
27-30	84 (25.1)
Sex	
Women	183 (54.6)
Men	152 (45.3)
Education level	
Completed primary education	4 (1.3)
Completed high school	26 (8.0)
Attending higher education	159 (49.1)
Completed higher education	71 (21.9)
Postgraduate	64 (19.7)
BMI classification	
Underweight (<18.4 kg/m ²)	16 (5.2)
Without overweight or obesity (18.5 to 24.9 kg/m ²)	150 (48.7)
Overweight (25.0 to 29.9 kg/m ²)	95 (30.8)
Obese (≥30.0 kg/m ²)	47 (15.3)

270

271 3.2 CoEQ Confirmatory Factor Analysis

272 The original structure of CoEQ showed suboptimal fit in CFA: $\chi^2 = 1243.1$ ($p <$
273 0.001); RMSEA = 0.17; SRMR= 0.10; CFI = 0.91; TLI = 0.89; GFI = 0.98. Based on this poor
274 fit, a EFA was performed for the COeQ. Three indicators (6, 7, and 15) were automatically
275 excluded since they presented low factor loading (< 0.30). Indicators 1 , 2 and 21 were
276 not included, as described in the original model (Dalton et al., 2015). With this, a
277 reasonable fit was observed for EFA: RMSEA = 0.08; CFI = 0.94; TLI = 0.90. The KMO

278 (=0.82) and Bartlett's statistic (=2073.5; $p < 0.001$) of EFA were adequate. Four well-
 279 defined and reliable factors were found in CFA: craving control, craving for savory,
 280 craving for sweet, and positive mood (Table 3). All four factors presented adequate CR
 281 and AVE, explaining 67% of the total variance, and were used in the subsequent analysis.

282

283 **Table 3** – Control of Eating Questionnaire (CoEQ) indicators and factors

CoEQ indicators	Mean; SD	Factor loadings
<i>Craving control (CR= 0.897; AVE= 0.637)</i>	-	-
9 - During the last 7 days how often have you had food cravings?	57.8; 27.3	0.762
10 - How strong have any food cravings been?	60.4; 25.2	0.863
11 - How difficult has it been to resist any food cravings?	54.4; 29.6	0.790
12 - How often have you eaten in response to food cravings?	56.8; 28.9	0.585
19 - Generally, how difficult has it been to control your eating?	59.8; 28.1	0.525
<i>Craving for savoury (CR= 0.813; AVE= 0.593)</i>	-	-
4 - How strong was your desire to eat savoury foods?	65.3; 28.7	0.390
16 - How often have you had cravings for dairy foods (cheese, yoghurt)?	39.9; 28.3	0.543
17 - How often have you had cravings for starchy foods (bread, pasta)?	51.2; 28.7	0.921
18 - How often have you had cravings for savoury foods (fries, crisps, burgers etc.)?	61.8; 27.8	0.340
<i>Craving for sweet (CR= 0.909; AVE= 0.770)</i>	-	-
3 - How strong was your desire to eat sweet foods?	64.2; 29.4	0.868
13 - How often have you had cravings for chocolate and chocolate flavoured foods?	60.0; 33.1	0.708
14 - How often have you had cravings for other sweet foods (cakes, pastries, biscuits, etc.)?	51.0; 32.1	0.659
<i>Positive Mood (CR= 0.918; AVE= 0.849)</i>	-	-
5 - How happy have you felt?	69.0; 23.6	0.860
8 - How contented have you felt?	69.5; 23.9	0.764
<i>Not included items</i>	-	-
1 - How hungry have you felt?*	55.4; 23.9	-
2 - How full have you felt?*	66.3; 21.9	-
6 - How anxious have you felt?	64.0; 28.7	-
7 - How alert have you felt?	50.3; 24.4	-
15 - How often have you had cravings for fruit or fruit juice?	45.1; 28.7	-
21 - How difficult was it to resist consuming this food in the last seven days?*	70.8; 25.8	-

284 *These indicators were also not included in the original model. CR= composite reliability; AVE= average of the
 285 variance; SD= standard deviation.

286

287

288 Foods mentioned by participants in the 20th item of the CoEQ were classified
 289 based on the content of major nutrients or ingredients. Most of the participants (42.3%)
 290 cited food rich in sugar (simple carbohydrates) as craved food item, such as sweets,
 291 chocolate and some traditional Brazilian desserts (Table 4). Fat-rich foods were the
 292 second most cited, including some savoury foods such as fries, hamburger, and hot dogs.

293

294 **Table 4** – Cited craved food on the open item of the CoEQ categorised into groups
 295 according to main nutrient content

Food group	Frequency (%)	Cited foods
Sweet foods rich in sugar	41.3	Sweets in general; chocolate, <i>açaí</i> *, candies, <i>brigadeiro</i> *, and ice-cream
Savoury foods rich in fat	22.5	Fries, hamburguer, penaut, hot-dogs, <i>coxinha</i> *, fried foods and pizza
Mixed	15.9	Cited foods from two or more different groups (e.g., stuffed bread with chocolate, pasta with cheese)
Starchy foods	13.4	Cake, bread, pasta, rice, and crackers
Dairy	2.5	Milk with chocolate, cheese, and cream-cheese
Sweet drinks	2.2	Soft drinks
Alchool	1.9	Beer, wine, and alchool in general
Other	0.3	Coffee and pepper sauce

296 **Açaí* = Sorbet of *açaí* fruit with sugar and sorted candies and fruits as a topping; *Brigadeiro* = Creamy
 297 chocolate balls made of condensed milk, butter and chocolate; *Coxinha* = breaded and fried dough-
 298 based snack filled with chicken.

299

300 A CFA for PFS was performed based on Paiva et al. (2022). PFS presented
 301 adequate fit: $\chi^2 = 234.48$ ($p < 0.001$); RMSEA = 0.07; CFI = 0.98; TLI = 0.98; GFI = 0.98.

302 Three well-defined domains were observed with adequate CR and AVE (Table 5).

303

304 **Table 5** - Mean values, standard deviation, and factor loadings of the Power Food Scale
 305 (PFS) indicators

PFS indicators	Mean; SD*	Factor loadings
Food Available (CR= 0.900; AVE= 0.600)		
PFS 1	2.97; 1.2	0.736
PFS 2	2.40; 1.1	0.698
PFS 5	2.65; 1.4	0.749
PFS 10	2.78; 1.4	0.745
PFS 11	2.24; 1.3	0.805
PFS 13	2.07; 1.2	0.894
Food Tasted (CR= 0.854; AVE= 0.540)		
PFS 8	2.92; 1.3	0.788
PFS 9	3.33; 1.2	0.621
PFS 12	2.69; 1.2	0.799
PFS 14	3.29; 1.2	0.611
PFS 15	2.98; 1.4	0.657
Food Present (CR= 0.863; AVE= 0.614)		
PFS 3	3.53; 1.1	0.649
PFS 4	3.21; 1.3	0.709
PFS 6	3.13; 1.3	0.837
PFS 7	2.81; 1.4	0.750

306 *5-point Likert scale; CR= composite reliability; AVE= average variance extracted; SD= standard deviation; #PFS is
 307 copyrighted by Drexel University, copies of the PFS can be obtained by writing to Prof. Michael Lowe
 308 <lowe@drexel.edu>

309

310 Several differences were observed between the sexes (Table 6). Women had
 311 higher scores for the factors craving control, craving for sweets, food available, food
 312 tasted, and food present power of food aggregated factor. Men showed higher scores

313 for positive mood. All significant differences showed medium to large effect size
314 ($d > 0.40$).

315 **Table 6** – Differences between males and females CoEQ and PFS scores.

Variable	Men (n=152)	Women (n=183)	p^*	d
	Mean; SD	Mean; SD		
CoEQ - Craving control	51.8; 22.2	62.9; 21.0	<0.001	0.51
CoEQ - Craving for savoury	54.9; 18.5	54.3; 20.0	0.767	0.03
CoEQ - Craving for sweet	47.5; 28.0	67.5; 24.0	<0.001	0.76
CoEQ - Positive mood	73.5; 20.4	65.8; 23.0	0.001	0.35
PFS – Food available	2.18; 0.82	2.80; 1.05	<0.001	0.65
PFS – Food tasted	2.81; 0.92	3.22; 0.95	<0.001	0.43
PFS – Food present	2.90; 0.93	3.40; 1.01	<0.001	0.51
PFS – Power of Food aggregated factor	2.58; 0.74	3.10; 0.86	<0.001	0.64

316 *Welch's t test; Bold values = significant difference with $p < 0.05$. CoEQ= Control of Eating Questionnaire; PFS=
317 Power Food Scale; SD = Standard deviation

318 3.3 Qualitative approach

320 We interviewed 20 participants with high scores of food craving for sweet or
321 savoury foods, with average BMI: 26.9; 6.47 kg/m² (range: 19.0 - 45.1kg/m²) and
322 average age: 24; 3.62 years. Ten participants were “without overweight or obesity”, five
323 were with overweight and six were with obesity. No differences were found between
324 those who agreed and those who disagreed with the interview in terms of BMI, age,
325 craving control, craving for sweet and craving for savoury. Table 7 shows the process of
326 qualitative data analysis in which the meaning cores together generated categories for
327 each research question.

328 **Table 7** – Determined categories, meaning cores of interviews, number of occurrences
329 and number of participants.

Category	Meaning core	Occurrence (number of quotes)	Men	Women	Craving	Craving
			(n)	(n)	for savoury (n)	for sweet (n)
Question 1 – What motivates food craving?						
Negative feelings	Relief after a stressful day or situation	39	6	8	8	6
	Anxiety	23	6	6	4	8
	Idleness	12	3	5	4	4
	Being alone or accompanied	6	4	2	4	2
	Being on restrictive diet	4	1	3	3	1
Pleasure to eat	Disordered eating	4	0	2	1	1
	Immediate pleasure	10	4	4	3	5
	Break out of daily routine	11	5	0	4	1
Situational aspects	Uncontrollable feeling of need	7	0	5	3	2
	Moments of celebration	4	1	2	1	2
	Menstrual cycle	3	0	2	0	2
External cues	Food available (in the home)	15	3	7	3	7
	External food advertisements	3	1	1	2	0

Question 2 - What are the consequences of food cravings?						
Negative health aspects	Health problems	13	6	5	5	6
	Weight gain	10	3	5	4	4
Negative feelings	Feel guilty	5	0	5	3	2
	Loss of self esteem	3	1	1	1	1
	Frustration	2	1	1	1	1
	Loss of control (overconsumption)	8	2	3	3	2
No psychological or health aspects	No consequence	4	4	0	2	2
	Increased financial cost	4	2	0	0	2
Question 3 – What are the coping strategies for food cravings?						
Health-related strategies	Choose a healthier food instead	7	3	3	3	3
	Practice physical activities	7	3	4	4	3
	Perceived healthy strategy	4	0	3	2	1
Environmental-related strategies	Look for distractions	6	1	4	4	1
	Adjust daily routine with different activities	10	3	3	4	2
	Avoid having the food available	6	2	3	3	2
Professional support	Therapy	2	1	1	0	2
	Medication	2	0	2	0	2
Negative feelings	Thinking about the negative effects on the body	2	1	1	1	1
No strategy	No strategy	3	2	1	1	2

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The cited motivators for food cravings were 'negative feelings', 'situational aspects' and 'external cues'. All participants cited one or more negative feelings as the reason for food cravings. Most participants (n=18) cited that cravings were triggered by relief after a stressful day or situation. This is evident in the following quotes: *'When I am too stressed or too sad, I always take it out on food (WSV5); sometimes it happens after a situation at work that hurts me, or sometimes after something at home with my husband (WSW3); stress is a strong trigger (for food cravings) (MSV4). Anxiety was a relevant motivator of cravings, cited by 12 participants, especially for those who had cravings for sweets (n=8). Some quotes clearly define the mechanisms of hedonic hunger related to anxiety, e.g. 'Sometimes it's not even hunger, sometimes I am aware that it's not 'hunger', maybe it is... I do not know if it's boredom, idleness or even anxiety, and I end up taking it out on food (MSW1); Also because of anxiety. I want to eat this food so badly, so I want to anticipate everything so I can eat it soon (MSW2).'* Another relevant negative feeling was idleness, e.g. *'But when I am at home, more idle, I find it much harder to resist (MSW1).'*

In contrast, some cravings were reported to be motivated by the pleasure to eat, such as the pleasure for a highly palatable meal e.g. *'I like eating, right? My mouth*

348 *waters when I think of the sensations that eating can bring me, even if it's just a brief*
349 *pleasure (MSV5)'; I do not know... so, what comes to my mind is that eating is very good.*
350 *I love to eat, okay, it's wonderful. And the better the food is, the harder it is for you to*
351 *control it if you feel it too intensely. Yes... I love to eat. (HSW4).'* It is important to
352 differentiate this meaning core from 'uncontrollable feeling of need'. On this second,
353 the craving is not limited to pleasure, but to a situation, e.g. after lunch - *'I like eating*
354 *sweets, for example, after lunch I get a craving for sweets (WSW2), or even a guilty*
355 *conscience (e.g. 'sometimes I feel that I can not control it. But then I think I have it under*
356 *control and feel guilty about it (WSV4).'* This motivator was particularly strong for
357 women (n=5), and not cited by men. Men, on the other hand, seemed to be more
358 inclined to break out of the daily routine, such as eating tasty food on a Friday night or
359 at a happy hour. Finally some external cues were cited as motivators, specially in the
360 context of having the food available. This is evidenced by quotes: *'I think I am one of*
361 *those people who do not stop eating until it ends (WSV3); If I do not see a certain food, I*
362 *do not have much need for it. But when I see it, I eat it. (MSW1); So in my mind it goes*
363 *on and on, you know? "You have it, you can go get it, it's within reach, go get it" (WSW5).'*
364 The food availability seemed to be more of a problem for those with craving for sweets
365 and women.

366 When asked about the consequences of cravings, participants mentioned many
367 negative health aspects and negative feelings. Many health problems were mentioned,
368 many of which were related to weight gain or poorer nutrition, e.g.: *'I think there are*
369 *consequences, especially for health. Cravings do not lead to better health, because you*
370 *always want to eat something fatter, something more calorific and everything else... You*
371 *may be satisfying yourself at the moment, but it's not good for your body, right?'*
372 (MSW1). Despite researchers' efforts to separate independent quotes, there is a clear
373 link between cravings with health problems, body weight and some negative feelings.
374 For example participants cited how gaining weight was bad for their esteem and health
375 e.g., *I have always been a chubby person, but at times when my cravings for food are*
376 *stronger, I usually gain weight, and this eventually affects relationships with others due*
377 *to some insecurity (MSW5); I get fat, and wow. my self-esteem drops, and then I think*
378 *"oh, I am ugly" (MSW1).*

379 In contrast, women showed feelings of guilt related to uncontrolled consumption
380 and not specifically due to weight gain, e.g.: *'when I was in a very difficult moment, I*
381 *knew it was not right, but I had to do it, so I blamed myself at the same time that I knew*
382 *I wanted to, and then a very big feeling of guilt came. And that then got in the way so I*
383 *felt... felt a bit insecure and still do (WSW5); 'The thought that's 100% in my head is "you*
384 *should not eat that' (WSV2); 'Ah, sometimes I feel bad... I feel heavy sometimes when I*
385 *eat these things in excess because we feel right... so sometimes I feel a bit guilty*
386 *(WSW2).'* Still on the topic of negative feelings many participants cited the loss of
387 control, i.e. the craving leading to a overconsumption. According to the speeches, the
388 loss of control eventually leads to other consequences such as guilt, e.g. *'It's not 1*
389 *packet, it's 2 packets (of sweet biscuits). I wanted to be one of those people who can eat*
390 *2 to 3 biscuits, but I do not know how to do that (MSW1); But sometimes I can not, so I*
391 *eat more than one... and then I feel bad because I can not control myself (WSV5); I eat a*
392 *bit more to increase serotonin and then I think, "Why did I eat so much?" (MSW1)'. Some*
393 *menn did not report any consequences of food cravings, while all women cited one or*
394 *more negative consequences.*

395 Different meaning cores and categories were observed regarding coping
396 strategies. For example, some participants referred to physical activity, e.g.: *'One thing*
397 *that helps me is physical activity, because it helps me with my anxiety. And I think a little*
398 *about the issue of satiety. Both of these things together help me not to want to eat,*
399 *because I feel less anxious and more full (WSW1); For example, sometimes I want to live*
400 *healthier, you know, and then when I exercise I kind of remember that and think, "No, I*
401 *do not need that," and then my cravings decrease and at the same time my stress is*
402 *reduced (WSV5); I do not know... maybe I'll look for another activity, like a bike ride or*
403 *something... the urge will go away (MSV1). Some participants reported trying to choose*
404 *a healthier food instead of a highly palatable food e.g., 'Sometimes you can cheat with*
405 *other foods, am I right? Sometimes I put grapes in the freezer, which makes them*
406 *sweeter and I eat them (WSW4); That does not always work, but I try to make better*
407 *choices in that context. So I do not know if I eat 1 or one and a half between 3 chocolate*
408 *bars (WSV4); If I really do not want to eat anything because I want to stick to the diet, I*
409 *try to find an alternative with honey, a sweetener or something else (MSW3)'. Some men*

410 also referred to drinking water to distract themselves and fill their stomach e.g. *'I drink*
411 *a lot of water to make it feel like my stomach is full (MSW3).'*

412 Having an organized, or busy, daily-routine was cited coping strategy for food
413 cravings, evidenced by these quotes: *'When I was working, I had a lot to do, my day was*
414 *very busy, my schedule was very regulated. So I had a proper time to eat, to do everything*
415 *properly (MSW1); A routine, for example, when I am busy, when I am doing other*
416 *things... my attention is on other things than eating (WSV4); For example, when I am*
417 *very busy during the day, I do not think about it (about eating) (MSW1).'* Finally, some
418 participants cited professional support or no strategy at all. Two participants mentioned
419 thinking about the negative effects of a poor diet on the body, e.g. *'Because I want to fit*
420 *into a better outfit. Because I want to wear shorts, because I do not like my legs... so it's*
421 *always about aesthetics (resisting cravings) (WSV2).'* Some environmental-related
422 strategies were also cited like avoiding the food available, e.g. *'Not buying chocolate and*
423 *not having these sweets at home also helps a lot (MSW1); To not eat them (craved food),*
424 *I can not have them in the fridge (MSV1).'* Another strategy was look for distractions e.g.:
425 *'What has helped me is to find something to do... To find a course on the internet, I will*
426 *do something... I am going to help my mother with something (WSW5); I have tried doing*
427 *something else before looking for food... "I am going to take a shower"... and wait for*
428 *some time to see if this tormenting feeling subsides a little... and I can understand what*
429 *is hunger and what is not (WSV4).*

430

431 3.3 Modelling approach

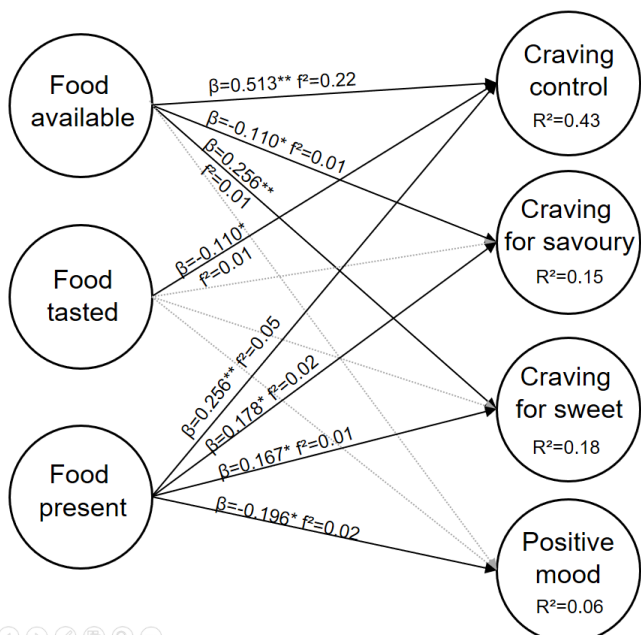
432 First, a first-order model was calculated (Figure 1A). A positive effect of the 'food
433 available' domain on craving control had a high effect size ($f^2 = 0.22$) i.e. the higher the
434 food available score was, the more and stronger craving episodes participants had, as
435 this last variable has an inverted score. All other significant paths between PFS and CoEQ
436 had low effect sizes ($f^2 < 0.10$). For this reason, a second-order model was tested. Since
437 the second-order model showed better effect sizes (f^2) with similar explanatory power
438 than the first-order model, the second-order model would be better suited to predict
439 changes in the CoEQ factors (Figure 1B). All factors had a reasonable effect size with f^2
440 > 0.15 in the second-order model. The only exception is the effect of the power of food
441 aggregated factor on positive mood, which had a small effect size ($f^2 = 0.04$). The craving

control showed high predictive relevance ($Q^2 = 0.22$) and adequate explanatory power ($R^2 = 0.36$). Lower predictive relevance and explanatory power were observed for other CoEQ variables - craving for savoury ($Q^2 = 0.06$; $R^2 = 0.14$); craving for sweet ($Q^2 = 0.12$; $R^2 = 0.17$); positive mood ($Q^2 = 0.02$; $R^2 = 0.04$). A multi-group analysis was tested for men and women. However, the model was not significant. Although the variables vary in strength, the path (or effect) is similar among the sexes.

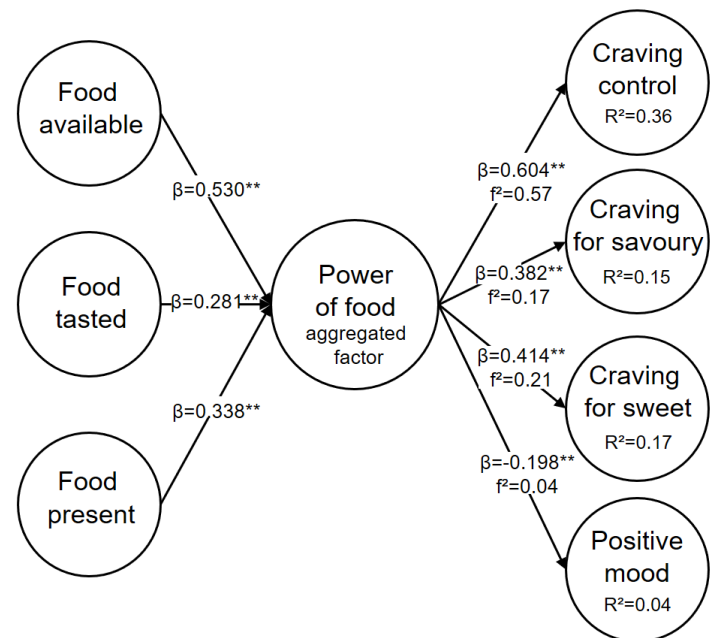
Both models presented adequate discriminant validity with HTMT of correlations < 0.85 . No multicollinearity issues were identified with all VIF < 3.3 .

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A – 1st order model



B – 2nd order model



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453 * $p < 0.05$; ** $p < 0.001$; p -values of the t -statistics (based on bootstraps with 5000 samples); dashed light
454 grey line = non-significant path

455 **Figure 1** – A: first order final inner model; B: Second-order final inner model

456

457 4. Discussion

458 The first objective of this study was to investigate, for the first time, the
459 consistency and reliability of the CoEQ in a Brazilian sample. Consistent with other
460 studies, (Dalton et al., 2015; Dalton et al., 2017a), the CoEQ in Brazil showed a
461 reasonable factorial structure in the EFA. Similar to Dalton et al. (2017a), indicator 15,
462 which refers to fruit juices, was not included in the factor craving for sweets. This is likely
463 because fruit juices are perceived as natural and healthy (Marsola et al., 2021) and are
464 not a common choice for food cravings. The PFS also showed adequate factorial

465 structure during the CFA. This was expected since PFS was already tested in the Brazilian
466 population (Paiva et al., 2022). In both scales, the remained indicators presented high
467 factor loading (>0.50) and the constructs high reliability ($CR > 0.70$). The construct
468 explained most of the indicators ($AVE > 0.50$). When the AVE is less than 0.50, the
469 constructs explain more errors than the variance of the construct (dos Santos & Cirillo,
470 2021).

471 To better understand the motivations behind food cravings and how the
472 environment might relate to these episodes, we conducted a qualitative research phase.
473 Regarding the motivations for food cravings, many negative emotions were cited. Other
474 research has discussed how negative feelings can arise when a craving for a particular
475 food occurs as a relief from stressful days and anxiety (Dalton et al., 2015; Jáuregui-
476 Lobera et al., 2012; Penaforte et al., 2019; Potenza & Grilo, 2014; Reichenberger et al.,
477 2021). For many people, stress alters their food choices, leading to higher caloric intake
478 from highly palatable foods. This change is known as "comfort eating": eating palatable
479 foods to reduce the effects of stress and provide some relief (Ulrich-Lai et al., 2015). For
480 example, carbohydrate cravings are well known in the literature as a form of self-
481 medication to improve mood and overcome unpleasant affective states (Yanovski,
482 2003). Neurobiological mechanisms related to stress are known to potentiate the
483 motivation and reward of highly palatable foods, increasing food cravings and the risk
484 of overeating (Chao et al., 2015; Reichenberger et al., 2021; Sinha et al., 2019).
485 According to Ulrich-Lai et al. (2015), the ingestion of palatable foods as a naturally
486 rewarding behaviour can restrict the activation of the stress system, by acting on the
487 brain's reward circuits. However, although there are physiological and chemical
488 hypotheses that explain the reasons for food craving, individual and cultural factors
489 seem to have significance (Hormes et al., 2014).

490 Most participants cited negative consequences for food cravings, with the most
491 important reasons related to health and negative feelings about body shape and body
492 image. Women reported feelings of guilt, which was not observed in men. It is
493 noteworthy that even when asked directly about the consequences of cravings, some
494 men did not report any, while all women mentioned at least one negative consequence.
495 In addition, some limited coping strategies have been observed, such as drinking water
496 to overcome the urge to eat or reducing energy intake, which has little effect on the

497 feeling of hunger (McKay et al., 2018). Participants reported worries about their health
498 and weight gain as consequences of cravings (Hallam, Boswella, et al., 2016; Lowe &
499 Butryn, 2007; Werthmann et al., 2015). The most important strategy for overcoming
500 cravings was adjusting routines with different activities, confirming some findings that
501 refer to distraction as a good way to avoid the urge to consume certain foods (Forman
502 et al., 2013; Karekla et al., 2020).

503 The third main objective was to investigate the relationship between food
504 cravings and food intake motivation, especially for foods with high palatability. The PFS
505 seems to be related to CoEQ, but there are few detailed analyses of eating behaviour in
506 the literature. Power of food aggregated factor was associated with a high effect size
507 with craving control. In the first-order model, we also observed a high effect size in the
508 path of the factor food available to craving control. This result suggests that low control
509 over palatable food, especially food that is available in the environment, might impair
510 craving control. The factor "power of food" also showed positive paths with high effect
511 size to craving for sweet and savoury foods, i.e. people with low control over palatable
512 food may have more frequent, or stronger, episodes of craving for sweet and savoury
513 foods. This relationship between environmental aspects and food cravings was also
514 found in the qualitative phase.

515 In Brazil, increasing ease of access to food apps and socioeconomic changes such
516 as family composition and food prices are influencing the food environment (Zanetta et
517 al., 2021). The presence of food was already cited as a motivation for increasing food
518 cravings (Forman et al., 2007). For example, meals away from home, increased food
519 portion sizes, and greater availability of palatable foods have increased recently (Rosi et
520 al., 2017). Bakeries, restaurants, takeaways, supermarkets, and food delivery apps are
521 access points for consumption inside and outside the home, promoting the availability
522 of food at all times in urban environments. Along with the increasing development of
523 processed and highly palatable foods, these are factors that tend to promote the
524 consumption of convenience foods, high-energy snacks, and sugary beverages in
525 addition to physiological needs (Blechert et al., 2016; Lake & Townshend, 2006). This
526 can be confirmed when analysing question 20th of CoEQ. The most frequently mentioned
527 food groups in the CoEQ open-ended question were foods high in sugar (chocolate, ice
528 cream) and salty foods high in fat and carbohydrates (French fries, pizza), confirming

529 data from the literature linking cravings to high-energy foods (Meule, 2020; Taylor,
530 2019). It is possible to consider food craving as a precursor of excessive food
531 consumption (Buscemi et al., 2017), as a consequence of the abundance of cheap, high-
532 calorie, and highly palatable foods.

533 Women scored higher on craving control, craving for sweets, and all PFS
534 domains, whereas men scored higher on positive mood. These results were expected
535 and are consistent with the literature which indicates that the nature, frequency and
536 magnitude of craving (un)control is different between sexes (Aliasghari et al., 2020;
537 Hallam, Boswell, et al., 2016; Paiva et al., 2022; Potenza & Grilo, 2014; Rodríguez-Martín
538 & Meule, 2015). These differences may be due to a number of factors, including
539 hormonal and social differences between men and women. Studies demonstrating
540 increased food cravings during premenstrual and the prenatal period (Rodríguez-Martín
541 & Meule, 2015) as well as a greater craving for sweets in women who have a high stress
542 response, explained by increased basal leptin and waist circumference, support the
543 hormonal hypotheses (Macedo & Diez-Garcia, 2014). Nevertheless, the role of social
544 determinants in sex differences must be considered, as it is a complex and multifactorial
545 phenomenon. There is strong evidence of the link between body image dissatisfaction
546 and the development and maintenance of eating disorders, and it has been
547 demonstrated that women and girls are at high risk for body image problems due to
548 internalisation of the media ideal and comparison of appearance (Rodgers et al., 2015).
549 However, although the results for the female population are very consistent, there are still
550 different results in the literature for food craving, with some studies showing no differences in
551 PFS (Serier et al., 2019; Andreeva et al., 2019) and CoEQ scores (Dalton et al., 2015).

552 As a theoretical implication, the association between PFS and CoEQ was
553 significant and with an acceptable effect size. It will be beneficial for future studies to
554 assess whether the available, tasted and present food influences food craving and which
555 factors mediate these pathways. Finally, the qualitative step was important for a deeper
556 understanding of the perceptions of people with food cravings. Qualitative methods
557 allow the researcher to capture the meanings within the data and a contextualised
558 understanding of the subjective experiences (Crowe et al., 2015). To our knowledge, this
559 is the first study to attempt to interview people with food cravings.

560 The study has many practical implications. Practitioners should be vigilant, as
561 women might have less control over food cravings, especially for sweet food, and have
562 less control over palatable foods. However, men also showed some relevant values for
563 food cravings, especially for savoury foods. The qualitative section has shown that the
564 motivators for food cravings can be different for men and women but affect both.
565 Regardless of sex, people need to know how to deal with cravings because many
566 negative feelings are the trigger or consequence of cravings. It will be beneficial for
567 consumers to know how to modulate their environment to reduce cravings, as
568 recommended by professionals in the field. These include, for example, appropriate
569 dietary orientation, controlling the presence of palatable foods in the environment,
570 removing barriers to healthy food intake and psychological orientation to improve
571 emotional regulation strategies.

572 Limitations of the study include that it is a cross-sectional research, so it is not
573 possible to infer causality concerning food cravings. Another limitation is that the CoEQ
574 has not been validated for the Brazilian population. One problem was that the factor
575 "mood" in the EFA retained only two indicators. A factor with two indicators can be
576 problematic for many statistical reasons. We conducted various quality controls (e.g.
577 composite reliability, variance extracted, etc.) to ensure the quality of the instrument.
578 Nevertheless, this factor needs to be further investigated with other populations and an
579 update of the CoEQ might be needed to improve this specific factor. Finally, the sample
580 of the quantitative step was purposive, but not stratified or randomised. Like many
581 studies in this area, the results cannot be generalised to other age groups and cultures.
582 Therefore, studies with other life cycles and populations are needed for a better
583 understanding of the phenomenon.

584

585 **Conclusions**

586 The CoEQ scale had an appropriate factor structure in this Brazilian sample.
587 Women had higher scores in the craving control and craving for sweets domains and in
588 all PFS domains, indicating sex differences. In the qualitative stage, food craving was
589 associated with the routine, so the craved food has the function of relieving stress and
590 anxiety. Food availability was also considered as a factor motivating food cravings. It was
591 quite evident that most of the interviewees, especially woman, had negative feelings

592 about their body shape as a result of food cravings. The power of food was a positive
 593 driver (i.e., the higher one, the higher the other) for craving control, craving for savoury,
 594 and craving for sweet.

595 The results suggest that the relationship between food cravings and the power
 596 of food is relevant in the current obesogenic environment. Understanding the feelings,
 597 perceptions and factors associated with food craving are necessary to inform
 598 interventions and guidelines for the population.

599

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605

606 **Data availability**

607 Data will be available on request to the corresponding author.

608

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