PREPRINT

The CRAVE and ARGE Scales for motivation states for physical activity and sedentarism: Brazilian Portuguese translation and single-item versions

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ABSTRACT

According to the WANT model, motivation states for physical activity and sedentarism vary moment to moment. The CRAVE scale (Cravings for Rest and Volitional Energy Expenditure) was developed to assess wants and desires to move. The major aims of the current studies are to: translate and validate the scale in Brazilian Portuguese and determine the best single-item for Move and Rest subscales. Six bilingual speakers translated the scale from English to Brazilian Portuguese (named *Anseios por Repouso e Gastos com Energia* [ARGE]). The ARGE had excellent content validity coefficients across three dimensions (.89-.91), as determined by three independent, bilingual referees. 1,168 participants (mean age = 30.6, SD = 12.2; 71.6% female) from across Brazil completed an online version of the ARGE. An Exploratory Factor Analysis found two, very clear, oblique and inversely related factors (Move and Rest; GFI = 1.00, RMSR = .03). Reliability was good (Cronbach α's: .93 and .92). Two models of the scale (10 versus 13 items) were compared with Confirmatory Factor Analysis. The previously validated version using 10 scored items (GFI = 1.00, RMSEA = .07, RMSR = .02) outperformed the version scored with 13 items. State anxiety and exercise behavior had small associations with Move and Rest (-.20 to .26). ARGE Move scores had high correspondence post-session for 9 women performing short Sprint Interval Training (sSIT; 6 sessions). Large effects were detected for changes in motivation states with sSIT, but due to the small sample size they were not significant. IRT analyses found that for the USA sample, "be physically active" and "be still" were the most representative items for Move and Rest, respectively, while for the Brazil sample they were "exert my muscles" and "be a couch potato". Overall, it was found that: A) the ARGE scale demonstrated excellent psychometric properties, B) the original scoring (with 10 items) resulted in the best model, C) it had small associations with exercise behavior, and D) the sub-scales were reduced to single items that varied by country, indicating potential cultural differences in the concept of motivation states for physical activity.

KEY WORDS

Affectively charged motivation states, motivation, physical activity, exercise, sedentary behavior, psychometrics, sprint interval training, depression

INTRODUCTION

Physical inactivity and sedentarism are problems of worldwide proportions (1), leading to numerous health problems (2). In the USA, small improvements have been made but, overall, the percentage of the population meeting activity guidelines is low (3, 4). There is also a growing physical inactivity pandemic in Brazil (5), which has the highest rate of physical inactivity in Latin America at 47% (1). It also one of five countries in the world where physical inactivity is increasing the fastest (> 15% from 2001 to 2016), perhaps due to rapid urbanization (1). Physical inactivity and sedentarism result from many factors, including environmental, social, and intra- and inter-personal factors (6). While cognitive explanations have dominated the literature, there has been a turn to affective/emotion-based theories (7, 8), as well as motivational theory (9, 10). Indeed, one of the strongest predictors of physical inactivity / sedentarism is motivation (11). Motivation for physical activity, exercise and sedentary behavior has typically been measured as a stable trait, often in light of self-determination theory (12-14). However, newer models of behavior view motivation as a state that varies from moment to moment (15-19).

The concepts of affect, emotion and motivation intersect within the theory of affectively-charged motivation states (ACMS) (20) it applies to movement and sedentarism (10, 21). In short, humans possess transient desires (or wants) to move and be active, and sometimes these are felt subjectively as tension, such as a "pressing readiness" (10). According to the WANT model (Wants and Aversions for Neuromuscular Tasks model) (10, 22), strong feelings of wanting to move are characterized as urges or cravings, which can vary from moment to moment. Typically, these have been studied in clinical populations, such as those with exercise addiction, anorexia nervosa, or with conditions, such as akathisia or Restless Legs Syndrome (23, 24). However, there is recent evidence that these are common in healthy populations (22), vary similar to a biorhythm (21) and may be stimulated endogenously (e.g., a drive) (10) or by an environmental stimulus, such as music (25, 26). Motivation states are influenced by recent activity behaviors (27) and current activities (e.g., sitting, standing, walking) (21). Moreover, they predict activity in the next 30 minutes (21) and affective responses during subsequent physical activity (28). Until recently, the study of motivation states for physical activity, such as desire, wants, urges and craving, has been stymied by a lack of instrumentation to measures these phenomena (29).

Some progress was made in the area of measurement of ACMS with the creation of the CRAVE scale (Cravings for Rest and Volitional Energy Expenditure) (27). This 13-item instrument measures wants and desires to both move (i.e., be active) and rest (i.e., be sedentary), 10 of which are scored (5 each for move and rest subscales), while 3 are fillers. Stults-Kolehmainen and colleagues (27) conducted a series of 5 studies to validate the scale, concluding that it had excellent psychometric properties, including good reliability and stability over time, as well as good discriminant and convergent validity. The instrument, however, needs further development. Psychological assessments developed in North American undergraduate samples (i.e., WEIRD populations - Western, Educated, Industrialized, Rich, and Democratic), such as the CRAVE, are often not applicable to the larger human population (30). Major deficits include: a) lack of cross-cultural adaptation and translations, b) few data corresponding the CRAVE to exercise behavior, c) comparisons of 10 and 1-item versions and d) shorter versions (e.g., 2 items) that can be used in-task (i.e., during bouts of vigorous exercise).

The present study has 5 general aims, with data collected from 3 studies.
Aim 1 – To translate the CRAVE into Brazilian Portuguese and determine adequacy of this translation (i.e., with content validity coefficients) (Study 1).

Aim 2 – To establish psychometrics of the new, adapted scale (i.e., Descriptives and cut offs, reliability, test/retest reliability, exploratory and confirmatory factor analyses, convergent and discriminant validity) (Studies 1 and 2).
Aim 3 – To compare the validated 10-item version of the CRAVE scale to a full 13-item version of the scale (Study 1).
Aim 4 – To determine if the translated scale is associated with exercise behavior (Study 1).
Aim 5 – To shorten both the CRAVE (original American version) and the new translated scale to single-item versions (Study 3).

STUDY 1

INTRODUCTION

Exercise and sport participation, as well as interest for specific physical activities, varies across the globe (31). According to the Social Ecological Model (32), health behaviors, such as physical activity and sedentarism, vary by many factors, including culture. Furthermore, discrete psychological factors, such as social support for physical activity, are additionally known to differ between countries and cultures (6). At the current time, however, there is a lack of data on cultural differences in psychological, cognitive, and affective variables impacting PA in low- and middle-income countries, such as in Latin America (6). Our previous research (10) suggested that Brazil may be a good place to start, due to numerous cultural and linguistic differences between the USA and Brazil (33-35). Moreover, to our knowledge, there has never been a cross-cultural comparison between Brazil and the USA for motivation for physical activity, exercise or sedentarism.

Bauman (6) concluded that this dearth of information is due to the lack of psychological instruments adapted to different cultures and contexts. However, adaptation of an instrument, such as the CRAVE, is not a matter of simply translating the scale with automated translation software. This process requires understanding cultural aspects of each of the constructs involved in the instrument in addition to the translation of words. According to Markus (36), motivation is a “culturally constructed phenomenon”, with large differences between North America and non-Western countries. Motivation constructs, such as desires, wants, urges and cravings have imprecise translations in Brazilian Portuguese, but might be best translated as “desejos”/ “vontades” (desires), quereres (wants), impulsos (urges), necessisdades, compulsões, ânsias (cravings), or anseios (longings). Portuguese also contains motivational constructs that are rarely used or may not exist in English. Common in Brazilian culture, for instance, is the idea of intense longings for someone or something (“saudades”) (37), a concept perhaps less expressed or understood in North American society.

Given the arguments above, it is important to adapt the CRAVE scale to promote motivation research and practice in Brazil. Therefore, the primary purpose of Study 1 is to translate and validate the scale in Brazilian Portuguese. This study also affords the opportunity to collect additional psychometric information for the CRAVE scale to address unresolved issues. For instance, some evidence exists (27) (Study 4) that the scale has better psychometric properties when scored with all 13 items (6 for move and 7 for rest). Therefore, a secondary purpose of this study is to analyze alternative models to determine if the 10-item scored scale exhibits advantages over the 13-item scale. A further aim is generate new data for convergent and discriminate validation of the scale (27, 38, 39); by comparing motivation states with a mental health factor (i.e., state anxiety), as well as exercise behavior, both of which have not been attempted.

METHODS AND MATERIALS

Participants

Volunteers in this study were 1,168 adult participants (71.6% female) with age range between 18 and 82 years of age (*M* = 30.56; SD = 12.2). They were dispersed across the country: Southeast region = 868, South = 168, Northeast = 66, Midwest = 58, and North = 8. All volunteers agreed to participate by digitally checking the option of agreement right after reading the Consent Terms.

Procedures for cross-cultural adaptation

The CRAVE cross-cultural adaptation followed the International Test Commission (ITC) guidelines (40, 41) for translating and adapting tests. This was to minimize semantic misinterpretations and misunderstandings and to provide the optimal adaptation for Brazilian culture (42). First, two Brazilian-Portuguese native speakers with fluent English translated all items from English to Brazilian-Portuguese. A panel of five specialists formed by the authors developed a synthesis of the two versions to create the first translated version. Instructions were amended to reflect states (e.g., estar, ficar) and not traits (e.g., ser). This translated version was back-translated to English by a native English-speaker fluent in Brazilian-Portuguese. The back-translated version was sent to the main author of the original CRAVE for review. Additional modifications were made for clarity, precision, simplicity, and alignment with the WANT model. The panel of specialists, then, evaluated and incorporated all suggestions leading to the final Brazilian-translated version of CRAVE. The scale was renamed from CRAVE to "Anseios por Repouso e Gastos com Energia" (i.e., ARGE).

The last Brazilian-version of the CRAVE was sent to four bilingual experts in motivation and physical activity (i.e., three psychologists and one kinesiologist) to be assessed using the Content Validity Coefficient (CVC) (43, 44). The CVC retrieves a score ranging from 0.0 and 1.0 that comprises the amount of validity the variable holds. If CVC is above .80, then the variable is considered adequate. Experts had to rate each CRAVE-adapted item in three categories (i.e., clarity of the item, adequacy of the item for the construct, and quality of the translation) using a 5-point Likert-type scale (1 – poor; 5 – excellent). *Fit for the construct* (adequacy of the item for the construct) entails how much the translated version kept the original content when compared to original and back-translated versions. *Clarity of the item* comprises how much an item is understandable for the broad Brazilian population. *Quality of the translated version* assesses in which extent the translation was adequate in a language point of view, not necessarily in a construct perspective. They also rated instructions and rating categories. Based on their answer, each Brazilian-adapted CRAVE item had three CVC scores and CRAVE had one CVC. All CVC scores were above .80 which showed that the Brazilian-version of the CRAVE was adequate and well-adapted.

Procedures for human data collection

The project of this research was submitted to the Rio de Janeiro State University Ethics Committee and obtained the approval through the consubstantiated report #2.990.087, which was part of a larger project looking at exercise and health factors during the COVID-19 crisis (45-47). After approval, we recruited participants using the main researchers' (AF and MSK) social media, the Rio de Janeiro State University social media and the local press. We asked volunteers to spread the recruitment advertisement as well, which led to a snow-ball method of recruitment reaching the total number of participants. Among those who connected to the link provided in our recruitment advertisement, 89 individuals (approximately 7.6%) did not agree with the Consent Term; thus, being redirected to a *thank you* webpage and not participating.

We used the Google Forms platform for data collection and the Open Science Framework (OSF) for database repository. The questionnaires were adapted to the Google Docs format. The first form page

consisted of a sociodemographic questionnaire (age, education level, height, weight and self-reported number of days of exercise during last week). The second page comprised the state subscale of the Brazilian-adapted version of the Spielberg's State and Trait Anxiety (STAI) questionnaire (48, 49). Page three provided the 13 Brazilian-adapted items of CRAVE in the same order of presentation of the original instrument (27). Page four provided the Brazilian-adapted version of the Godin-Shephard Leisure-Time Physical Activity Questionnaire (GSLTPAQ) (50, 51). Finally, the fifth page was a *thank you* notification.

We built our database in Microsoft Excel, after exporting these data from Google Docs and processing some variables based on participants' responses. Height and weight were used to calculate the Body-Mass index (BMI), whereas the three metabolic equivalents of task (MET) were measured based on the participants' answers regarding items 1, 2 and 3 of the GSLTPAQ (respectively, strenuous, moderate and mild).

Instruments

Sociodemographic questionnaire

A demographic questionnaire collected age (in years), gender, education (i.e., elementary school, high school, college/graduate degree or post-graduate certificate or diploma), self-reported weight (in kilograms), height (in centimetres), and self-reported number of days of exercise in the past week before answering the research.

Spielberg's State and Trait Anxiety (STAI) questionnaire

This instrument comprises two subscales, one that refers to how generally a person feels and assesses trait anxiety, whereas the other entails how the person is feeling *right now* or *at this moment* and measures state anxiety. This study used the state subscale that comprises 20 items that respondents must answer according to how they feel *right now*. Items depict emotional statements to which participants rated using a 4-point Likert-type scale ranging from "1 – not at all" to "4 – very much so". Example of items are "1 – I feel calm" and "12 – I feel nervous" (48). The Brazilian-adapted version was adopted in this study (49).

Cravings for Rest and Volitional Energy Expenditure (CRAVE)

This questionnaire measures motivation states to move and rest. It entails a 13-item statements divided in two dimensions: move and rest—5 items each—and three filler items not considered when scoring. Examples from the move factor items are "I want/desire to move my body" and "I want/desire to expend some energy". Examples from the rest factor are "I want/desire to do nothing active." and "I want/desire to be a couch potato." Whereas one example from the filler items is "I want/desire to burn some calories." Participants rated the statements on a 10-category rating scale from "0 – not at all" to "10 – more than ever" according to their own motivation to either move or rest *right now* or *at this very moment*. The scale has excellent psychometric properties (27). Reliability of the scale is very high (McDonald's ω for both Move and Rest = .97). The CRAVE reliably measures state-like properties of motivation and has good test-retest reliability. Across-session interclass correlations (ICC) for Rest (ICC = 0.69–0.88) and Move (ICC = 0.72–0.95) are greater than those measured across 2-years' time (Rest: ICC = 0.49; Move: ICC = 0.53). Respondents report large changes in CRAVE with maximal aerobic fitness testing, with Move decreasing (Cohen's d_{av} = 1.05) and Rest increasing (Cohen's d_{av} = 0.82). It has small to moderate associations with psychosomatic sensations, such as energy, fatigue, tiredness and deactivation. The process of translation was described above.

Godin-Shephard Leisure-Time Physical Activity Questionnaire (GSLTPAQ)

We used the Brazilian-adapted version of GSLTPAQ (51). This measure is a 4-item instrument to which participants answered how many times in a 7-day period (a week) they engaged in mild/light, moderate or strenuous exercise practices *for more than 15 minutes* (50). Item one takes into account strenuous exercise (e.g., running, jogging, hockey, football, soccer, etc.). Item two entails moderate exercise (e.g., fast walking, baseball, tennis, easy bicycling, volleyball, etc.). Item three queries about mild/light exercise (e.g., yoga, archery, fishing from a riverbank, bowling, etc.), and item 4 asks how many days within a 7-day period (a week), the participant engages in exercise or physical activity that accelerates their heart-rate. To calculate an index of exercise volume, we calculated the Leisure Score Index (50), which is the number of exercise bouts reported in items 1, 2 and 3 multiplied by 9, 5 and 3 (METs, or metabolic equivalence of task values for vigorous, moderate and light exercise), respectively (52). For example, a participant who only engages in mild exercise four times in a week has a Leisure Score Index (LSI) of "4 x 3 = 12".

Statistical Analysis

As descriptive statistics, we calculated arithmetic mean, standard deviation (SD), skewness and kurtosis. Those last two indexes were adopted to assess normality, we considered normal data whenever both skewness and kurtosis statistics remained inside -2.0 and +2.0. Standardized norms based on percentiles were calculated for the two CRAVE factors: move and rest. Interpretation of standardized bands was as follows: below percentile 10 – low cravings, between percentiles 10 and 25 – cravings below average, between percentiles 25 and 75 – average cravings, between percentiles 75 and 90 – cravings above average, and above percentile 90 – high cravings.

We developed a product-moment correlation matrix with demographic variables, scores for the STAI-State, CRAVE move and rest (both the 10-item and 13-item versions), MET mild/light, moderate and strenuous, BMI and self-reported number of days of exercise in the past week (# days of exercise) for convergent validity purposes. Additionally, we calculated internal consistency using three indexes: Cronbach's alpha, Guttman's Lambda (53) and Mislevy and Bock`s (54) reliability index. All reliability indexes were expected to retrieve values above .70.

Regarding the factor analysis, first, we divided the sample in two subsamples with the same number of participants using the randomization tool of the Microsoft Excel. Thus, a sample of 1168 participants yielded two subsamples of 584 participants each. With the first sample we conducted the exploratory factor analysis (EFA), whereas we performed the confirmatory factor analysis (CFA) with the second sample.

Due to the nature of our CRAVE data, i.e., an ordinal Likert-type rating scale, we followed recommendations from Timmerman and Lorenzo-Seva (55) to conduct the EFA using the polychoric correlation matrix with the Optimal implementation of Parallel Analysis (PA) as procedure for determining the number of dimensions, the Unweighted Least Squares (ULS) for factor extraction and Promax rotation to achieve factor simplicity. To assess the adequacy of the correlation matrix we adopted the Bartlett test—expecting significance of $p < .05$—and the Kaiser-Meyer-Olkin (KMO) test that should retrieve result above .80. Explained variance of factors, items' factor loadings and fit statistics (i.e., goodness-of-fit [GFI] and Root Mean Square of Residuals [RMSR]) followed the recommendations of Kelley (56) and Lorenzo-Seva (57). We considered that an item belonged to a factor if factor loading was above .30, whereas GFI expected should be above .90 and RMSR below .04 (56, 57).

We conducted the CFA using Jöreskog and Moustaki (58) recommendations for ordinal variables: we used Unweighted Least Squares (ULS) as the method of estimation, leaving all parameters on default. We tested two models: the 13-item version of CRAVE and the 10-item model based on the structure found by Stults-Kolehmainen et al. (27). We evaluated the models via five fit indexes, two error indexes and two information criteria for model comparison. Fit indexes were goodness-of-fit (GFI), the adjusted goodness-of-fit (AGFI), the normed fit index (NFI), the parsimony normed fit index (PNFI) and the comparative fit index (CFI). The first two are fit indexes to compare empirical data and the hypothesized model, the other two verify the fit between normed hypothesis and the empirical data; finally, the CFI was accounted for revealing the comparison between the null-hypothesis and the tested model in regard of the empirical data. All fit indexes were expected to be above .90 (57). Error indexes were the Root Mean Square Error of Approximation (RMSEA) and the Standardized Root Mean Square Residual (SRMR), both should be below .05. Finally, we used the Aikake Information Criterion (AIC) and the Consistent AIC (CAIC) as information statistics to establish the best model, the lowest results correspond to the best model (58).

Descriptive statistics, normative data and correlation matrix were performed using R, packages *psych* and *corrplot*. We used the application Factor 9.2 (59) to perform the EFA and LISREL 8.80 (60) for CFA.

RESULTS

Descriptive statistics, skewness and kurtosis are presented for the whole sample (N = 1168; 71.5% female) in Table 1. Normative data (i.e., percentiles / cut-offs) are provided in the Supplemental Material. After separating randomly, the Exploratory Factor Analysis (EFA) and the Confirmatory Factor Analysis (CFA) samples in two subsamples of 584 participants each, we found, in the 584 EFA sample (71.8% female), an age average of 30.84 years-old (SD = 12.63), averaged BMI of 25.27 (SD = 5.12), and reported average of 2.16 days of exercise per week (SD = 2.18). The CFA sample was equally composed by 584 participants (71.2% female) with age average of 30.27 years of age (SD = 11.78), average BMI of 25.24% (SD = 5.40%), and reported average of 2.31 days of exercise per week (SD = 2.30). The Leisure Score Index for the entire sample was 47.49, indicating that this group was, on average, sufficiently active (52).

To ensure non-significant statistical differences between CFA and EFA samples, we conducted a t-test using the three basic sample characteristic variables: age, BMI and the average number of days of exercise per week reported by participants. Results of the age t-test revealed no significance for $t(583) = .83$; $p = .41$; Cohen's $d = .05$; power = .54. Similar results were retrieved for BMI: $t(583) = .12$; $p = .907$; Cohen's $d = .006$; power = .91; and for reported average days of exercise per week: $t(583) = 1.05$; $p = .29$; Cohen's $d = .07$; power = .55.

368 TABLE 1. Descriptive statistics for the whole Brazilian sample (*N*=1,168) including Mean, Standard
369 Deviation (SD), Skewness and Kurtosis.

Variable	Mean	SD	Skewness	Kurtosis
ARGE (CRAVE in Portuguese)				
Move - 10 items	29.82	14.58	-.316	-1.053
Move - 13 items	35.64	17.25	-.330	-.991
Rest - 10 items	21.52	14.64	.282	-1.128
Rest - 13 items	33.18	20.10	.134	-1.190
MET exercise scores*				
Light or Mild	11.95	18.06	.356	-1.250
Moderate	9.54	10.56	.841	-.404
Strenuous	26.00	22.56	1.363	.654
Leisure Score Index (LSI)**	47.49	39.22	.984	-.267
Exercise frequency/week	2.23	2.24	.584	-.925
BMI	25.26	5.26	.966	1.370
State Anxiety	53.55	12.04	-.279	-.629

* Frequency of activity per week for light, moderate, or strenuous
MET intensities x 3, 5, or 9, respectively
** Sum of MET exercise scores

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SUPPLEMENTAL MATERIAL 1. Brazilian normative data (ARGE scale) with raw score, standardized score, percentile and interpretation.

Std Score	Percentile	Raw Score		Interpretation
		Move	Rest	
1	5	4	1	Low cravings
2	10	9	3	
3	15	13	5	Below average
4	20	15	7	
5	25	17	9	
6	30	21	11	Average
7	35	23	13	
8	40	26	15	
9	45	29	17	
10	50	32	19	
11	55	34	22	
12	60	37	25	
13	65	39	28	
14	70	40	31	
15	75	43	34	
16	80	44	37	Above average
17	85	46	40	
18	90	49	42	
19	95	50	47	High cravings
20	99	50	50	

Note: Raw score of move corresponds to the sum of items 1, 2, 6, 9 and 13, whereas raw score of rest entails the sum of items 3, 4, 7, 8 and 10. Items 5, 11 and 12 are filler items, not included in the sum of neither subscales. See Table 1 for descriptive statistics.

Reliability of the CRAVE factors were calculated separately. The Move subscale yielded a Mislevy & Bock (54) reliability estimate of .94, a Cronbach's alpha of α = .93 and a Guttman's Lambda of λ = .92; whereas the Rest subscale retrieved a Mislevy & Bock (54) reliability estimate of .92, a Cronbach's alpha of α = .92 and a Guttman's Lambda of λ = .92. Those results suggest a strong reliability of both CRAVE subscales.

Exploratory Factor Analysis (EFA)

The EFA results yielded as the best solution a 2-factor structure with moderate negative significant correlation between dimensions (*r* = -.63). Table 2 depicts descriptive statistics and factor loadings of the 13-item Brazilian-adapted version of CRAVE. Regarding the correlation matrix adequacy, the Bartlett test retrieved a significant result [5808.6 (df = 78; *p* < .001)] and the Kaiser-Meyer-Olkin statistics was considered very good (KMO = .934). The bidimensional structure explained 70.36% of the cumulative variance, whereas only the two first factors showed eigenvalues above 1.0 (more precisely, 7.37 and 1.78, respectively). The goodness-of-fit index presented a good fit of the correlation matrix to the hypothesized bidimensional structure (GFI = 1.00) and the Root Mean Square of Residuals was within the expected amount of measurement error (RMSR = .028).

TABLE 2. Descriptive statistics for items in the EFA (Mean, Standard Deviation (SD), Skewness and Kurtosis) and factor loadings of the 13-item version of the Brazilian-adapted version of CRAVE.

Item	Descriptive Statistics				Factor Loading	
	Mean	SD	Skewness	Kurtosis	Rest	Move
Rest						
11. me deitar.	5.60	3.58	-.196	-1.411	**.932**	.093
12. descansar meu corpo.	5.80	3.42	-.243	-1.272	**.916**	.209
7. ficar quieto.	5.79	3.32	-.260	-1.244	**.756**	-.007
8. não levantar do sofá.	4.13	3.70	.376	-1.378	**.750**	-.132
10. ficar sem me movimentar.	3.63	3.49	.562	-1.075	**.643**	-.240
4. só ficar sentado.	3.96	3.47	.453	-1.191	**.616**	-.210
3. fazer nenhuma atividade.	3.78	3.49	.533	-1.142	**.557**	-.173
Move						
2. estar fisicamente ativo.	6.42	3.30	-.477	-1.135	.087	**.917**
5. queimar calorias.	5.89	3.64	-.339	-1.367	.046	**.772**
1. mexer meu corpo.	5.19	3.30	.006	-1.313	.009	**.735**
9. exercitar meus músculos.	5.92	3.40	-.379	-1.243	-.010	**.885**
6. gastar um pouco de energia	5.88	3.39	-.340	-1.274	-.023	**.828**
13. me movimentar.	6.07	3.19	-.377	-1.145	-.101	**.792**

Note: Highlighted in bold, factor loadings with values above .300.

Confirmatory Factor Analysis (CFA)

We tested two models in the CFA based on the 13-item scored version of CRAVE that was adapted to Brazil and the 10-item scored version suggested by Stults-Kolehmainen et al. (27) as the best solution to measure move and rest states. Table 3 depicts selected fit indexes and error statistics. Based on the lowest AIC and CAIC, the 10-item model is the best solution for the Brazilian-adapted version of CRAVE as well.

The 13-item version did not hold error below Kelley`s (56) criterion, whereas the 10-item version did, one additional evidence that suggests the last version the best structure.

The 13-item model presented significant chi-square for $\chi^2(64) = 498.56$; $p < .001$. Path coefficient between dimensions retrieved a moderate negative association for $\beta = -.61$. Relationship between items and the Move factor varied between $\beta = .65$ (item 5 – Move) and $\beta = .92$ (item 13 – Move), whereas items and Rest presented path coefficients between $\beta = .73$ (item 12 – Rest) and $\beta = .85$ (item 8 – Rest).

TABLE 3. Fit indexes, error statistics and Aikake information criteria retrieved by the CFA for both the 10- and 13-item versions of the Brazilian-adapted CRAVE.

Statistics	Model	
	10 items	13 items
Fit index		
GFI	1.00	.99
AGFI	1.00	.99
NFI	1.00	1.00
PNFI	.76	.82
CFI	1.00	1.00
Error estimates		
RMSEA	.07	.11
SRMSR	.02	.04
Information Criterion		
AIC	168.94	552.56
CAIC	281.71	697.55

The 10-item model yielded a significant chi-square: $\chi^2(64) = 126.94$; $p < .001$, even though these statistics showed lower value than the 13-item model. The relationship between factors in this model retrieved a slightly higher negative association than the other model for $\beta = -.65$. Path coefficients between items and the move factor varied between b = .79 (item 1 – Move) and b = .91 (items 9 and 13 – Move), whereas regarding rest, path coefficients varied between b = .74 (item 3 – Rest) and b = .84 (items 8 and 10 – Rest).

Evidence of validity

We calculated the product-moment correlation between the 10- and 13-item subscale scores of CRAVE (i.e., move and rest) and other variables that were supposed to relate to wants and urges to move or to rest. Those variables were:

a) self-reported number of days the participant engaged in exercise in the last week (frequency of exercise),
b) the frequency of light or mild, moderate and strenuous intensity activities (determined by metabolic equivalent of task (MET)) as measured by the Godin-Shephard Leisure-time Exercise Questionnaire, plus the composite score, called the Leisure Score Index (LSI),

c) body mass index (BMI), and
d) state anxiety as measured by the State-Trait Anxiety Inventory (STAI).

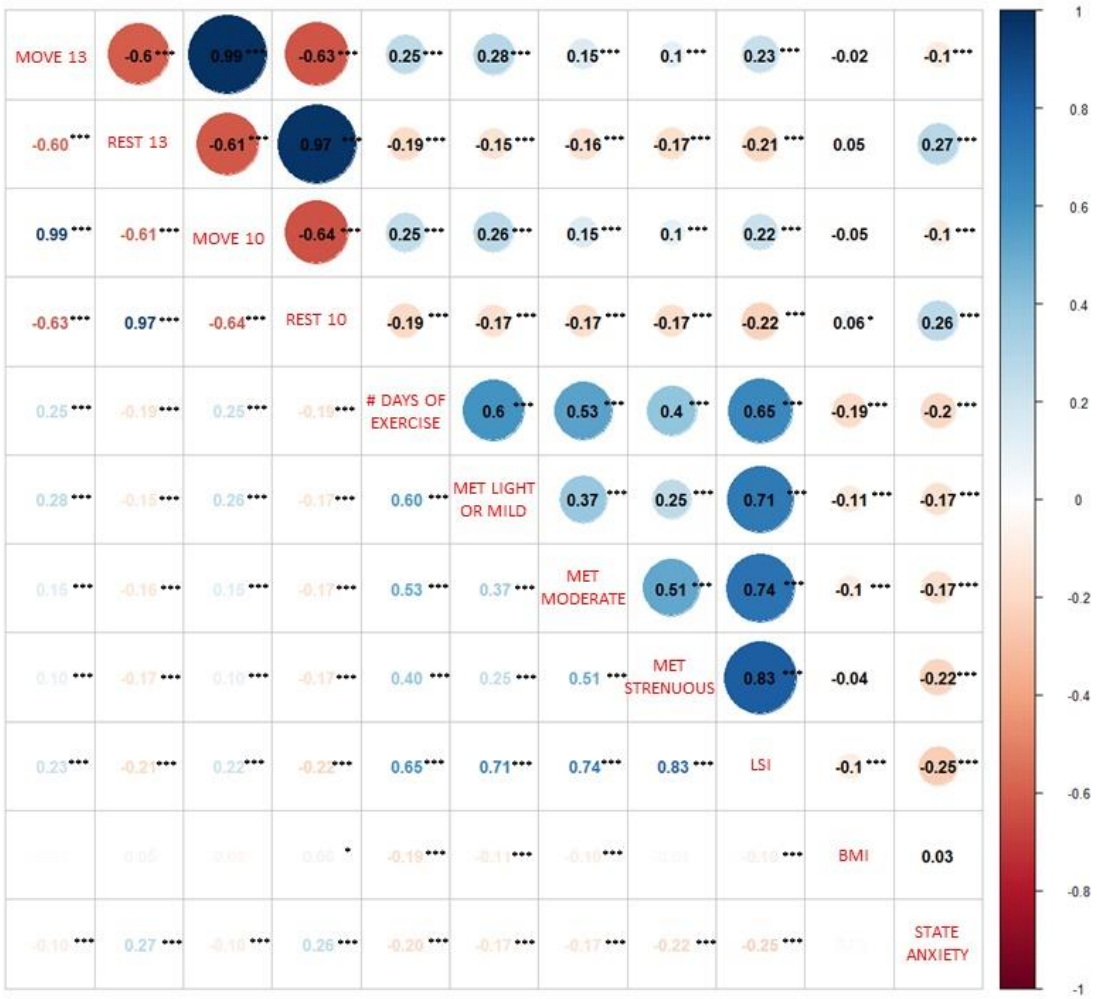


FIGURE 1. Correlation matrix (heat map) including variables to support evidence of convergent and discriminant validity* †.

* MET Light or Mild = number of times over the last 7 days completing at least 15 minutes of light or mild intensity leisure time exercise.

* MET Moderate = number of times over the last 7 days completing at least 15 minutes of moderate intensity leisure time exercise.

* MET Strenuous = number of times over the last 7 days completing at least 15 minutes of vigorous intensity leisure time exercise.

† LSI = Leisure Score Index (sum of MET scores)

BMI was the only variable not associated with wants to move or to rest. Nevertheless, the 10-item rest subscale showed small, but significant negative correlation to BMI, which would mean that the more the urge to rest, the smaller the BMI. Regarding the other variables, results were similar to what we predicted. The frequency of exercise was positively associated with urges to move, whereas it negatively correlated to wants to rest. In different degrees, light, moderate, strenuous and total exercise activity correlated positively with wants to move and negatively with urges to rest, following the same pattern of frequency of exercise. This means that the more one exercises, the more one wants to move and the less one has urges to rest. Pertaining to the state anxiety, it was negatively associated with wants to move, however this relationship was small (r = -.10). Whereas urge to rest was correlated with state anxiety in a larger extent (r = .26), which would mean that anxiety is linked to higher levels of desires to rest or lack of movement. See Figure 1.

DISCUSSION

The ARGE, the translated version of the CRAVE scale, appears to have excellent psychometric properties and is thus valid for testing in Brazilian Portuguese. The scale had excellent content validity, as rated by multiple independent raters. It also had strong reliability. Factor analyses provided a two-factor solution, as found in previous studies (27). Additionally, CFA analysis verified the original 10-item scoring scheme as opposed to a new 13-item scoring. As with previous studies, BMI was not associated with desire to move, but had a very small association with desire to rest. Though correlations were small, the 10- and 13-items versions of the ARGE had nearly identical associations between MOVE and REST sub-scales with state anxiety, and light-to-strenuous exercise behavior. Exercise-related variables did not relate strongly to motivation states. This seems to contrast results from Stults-Kolehmainen et al. (27), who found that stage-of-change for exercise has a very clear relation with the desire to move and rest, though this last construct is more closely related to habit.

This study has some notable limitations. First, the “Past week” version of the scale was not utilized as in previous studies (27). Furthermore, our assessments were conducted during the Covid-19 quarantine, a time of high societal stress (45-47). However, the CRAVE was only weakly associated with mental health factors, like state anxiety; therefore, this should not have been an undue problem. The exercise measure we used, the Godin-Shepard Leisure-Time Physical Activity Questionnaire, is highly utilized and is related to physical fitness, but has limited correspondence with objectives measures of physical activity, such as accelerometry (r = .45) (61). Therefore, future studies should compare the ARGE to objective measures of energy expenditure. Despite some limitations, there were several notable strengths, including: a) large sample from across Brazil, b) content validity with additional independent raters. Overall, psychometrics for this new version were as strong or better as those demonstrated in the original validation paper (27). The adapted scale is suitable for additional cross-cultural, longitudinal and exercise training studies involving Brazilian samples.

STUDY 2

INTRODUCTION

As part of the psychometric validation process, it is important to gather longitudinal data. For psychological states, it would be expected that data would vary to a high degree from day to day (even moment to moment), but these should correspond more closely over a shorter period (e.g., 30 minutes).

Motivation states should also change in response to a physical stimulus, or a deprivation of stimuli (10). In our previous studies (27), we found that the CRAVE scale captured motivational states rather than traits, as determined by intra-class correlations (ICCs) in a sample of >100 individuals assessed twice in a laboratory session, repeating every six months for over two years. The anticipated pattern of longitudinal responses was also demonstrated in a sample of undergraduate students who took the CRAVE 3 times during prolonged sitting (i.e., a 50-minute lecture period). In this study (27), students desire to move increased and desire to rest decreased just before class ended. Similar results were found in focus groups of 17 students from the same Midwestern state (22). With a sample from the Southwest of the United States, we found robust decreases in CRAVE-Move with a maximal treadmill stress test along with concomitant increases in CRAVE-Rest (27).

Substantial attention has been given to interval training in recent year, with bouts of aerobic activity ranging from a few seconds to a minute (62). Short Sprint Interval Training (sSIT) consists of high-intensity aerobic exercise engaged for <10 seconds. Unlike our previous investigation, which used a maximal exercise stimulus designed to rapidly drain energy systems (27), sSIT training does not exhaust anaerobic or aerobic metabolism - as demonstrated with minimal lactate production (63). Consequently, while the exercise intensity is supramaximal during the very short sprinting bouts, it does not result in excessive fatigue and pain. This is important as lactate accumulation has been associated with reduced motivation to move and continue exercise (64). This may discourage physical activity for some people. However, there is still a robust improvement in affective and cognitive responses, such as enhanced psychological attention (62, 65). Gerber and colleagues (65) found that affective and motivational responses were the same for SIT and continuous aerobic exercise, though they didn't observe changes in motivation states – instead measuring changes in more stable constructs of intrinsic and extrinsic motivation. However, a recent meta-analysis found that shorter sprints are associated to more positive affective responses (66).

The purpose of this study is to examine longitudinal responses in motivation states with the new ARGE scale. Due to their transitory nature, we hypothesize that motivation states measured before exercise sessions will have little correspondence. However, responses following sprint sessions should have greater correspondence. We do not have a hypothesis for how responses will change pre- to post-sprints because the nature of the exercise is quite different from our previous trials and less research has been completed with this type of training.

METHODS AND MATERIALS

Participants

This study is part of a larger clinical trial investing the use of Short Sprint Interval Training (sSIT) training for depression. The sample consisted of 9 women clinically diagnosed with depression, with a mean age of 37.9±11.9 and a mean BMI of 28.2±4.5 kg/m2, who were recruited through pamphlets and posters in the psychiatric care establishments and dissemination in digital media. The inclusion criteria were: having a diagnosis of moderate or severe depression as determined by the Mini International Neuropsychiatric Interview (MINI) assessment – administered by a psychiatrist (67), being sedentary and signing the Free Informed Consent Form (FICT). Exclusion criteria were: being pregnant, having diseases or conditions that interfere with cardiovascular responses (e.g., having a pacemaker, severe stenosis, heart failure, among others), taking medications that interfere with cardiovascular responses, presenting with any absolute contraindication to perform the cardiorespiratory test or high-intensity physical exercise, and performing physical exercise on a regular basis.

Procedures

The volunteers underwent 6 sessions of approximately 10 minutes of the short sprint interval training (sSIT) protocol, on a cycle ergometer, consisting of 4 -12 maximal sprints each lasting 5 seconds, with an active rest interval of ≥30 seconds at 50W. Training sessions were completed 3 times a week, all in the morning hours, with a 48-hour rest between sessions. Sessions were held at the Maria Aparecida Pedrossian University Hospital (HUMAP) of the Federal University of Mato Grosso do Sul (UFMS). There were two minutes of warm-up followed by the sprint protocol and then two minutes of cooling down at 50 rpm and 50W load. To perform the maximal sprints, an overload corresponding to 5% of body weight was added (68, 69). In the first week, the free and informed consent form was signed, and the initial assessment and familiarization took place. In the second and third weeks, the 5-second sSIT training bouts were performed in a linear periodized fashion.

Instrumentation

Motivation states for physical activity and sedentary behavior were assessed using the Brazilian version of the CRAVE scale (27), called the ARGE (Anseio por Repouso e Gastos de Energia), with construct validity and psychometric properties described in Study 1. The volunteers completed the ARGE scale 5 minutes before and 5 minutes after each SIT session.

Statistical Analysis

Two repeated measures ANOVAs were run with Time (Pre, Post) and Sprint (3/4, 4/6, 6/8, 10/12, 6/8_2) as within-subjects factors for both Move (Mover) and Rest (Descansar) subscales. To examine intra-rater reliability, intra-class correlations (ICCs) were calculated with a two-way mixed effects model (using absolute agreement) according to guidelines from Koo and Li (70). This model represents the reliability of specific raters in the experiment, and the ICC's cannot be generalized to other raters or studies. While the use of interrater reliability analysis (in this case, intra-rater) is a less common approach, it is most appropriate for the current investigation. ICCs were calculated for all data and data without session 1, which exhibited some correlations that differed substantially from the rest of the sessions.

RESULTS

Changes in Move and Rest

Composite scores of Move and Rest had varying degrees of association by pre and post measurement, with the strongest and only significant association being between Rest and Move post-sprint (r = -.84). See Figure 2. Prior to sprinting, Move scores visually seem to be higher than Rest scores. Furthermore, we can see that Move scores increased after all sprints while Rest scores decreased after all sprints. For Move, however, we could not reject the null hypothesis for Time ($F[1,7] = 1.348$, $p = 0.284$, partial eta-squared = 0.162), Sprint ($F[5,35] = 0.667$, $p = 0.651$, partial eta-squared = 0.087), or Time X Sprint ($F[2.142,14.992] = 0.209$, Greenhouse-Geisser $p = 0.284$, partial eta-squared = 0.029)*. Likewise, for Rest we could not reject the null hypothesis for Time ($F[1,7] = 2.840$, $p = 0.136$, partial eta-squared = 0.289), Sprint ($F[5,35] = 0.753$, $p = 0.590$, partial eta-squared = 0.097), or Time X Sprint ($F[2.569,17.983] = 0.362$, Greenhouse-Geisser $p = 0.751$, partial eta-squared = 0.049)*. Mauchly's test of sphericity indicates the assumption of sphericity was violated so we used the Greenhouse-Geisser correction. See Figures 3A and 3B.

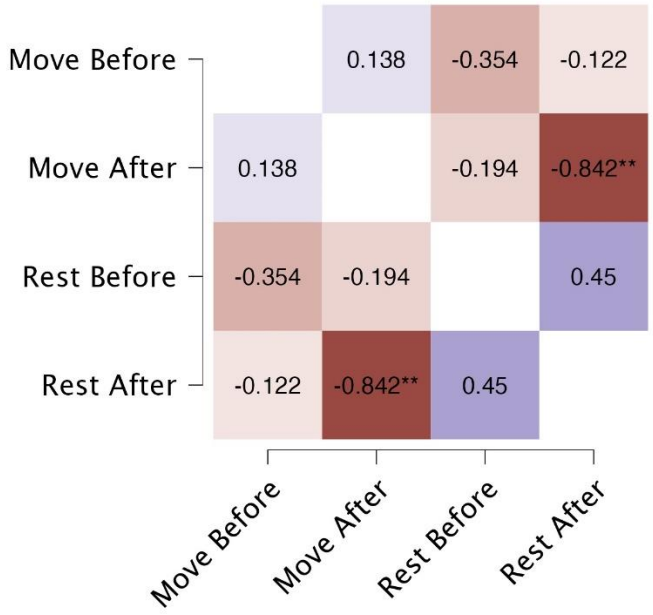
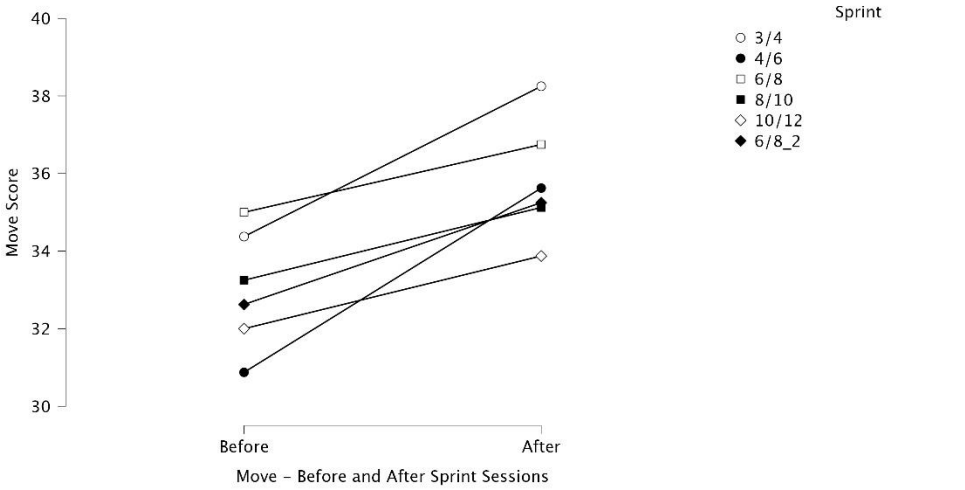
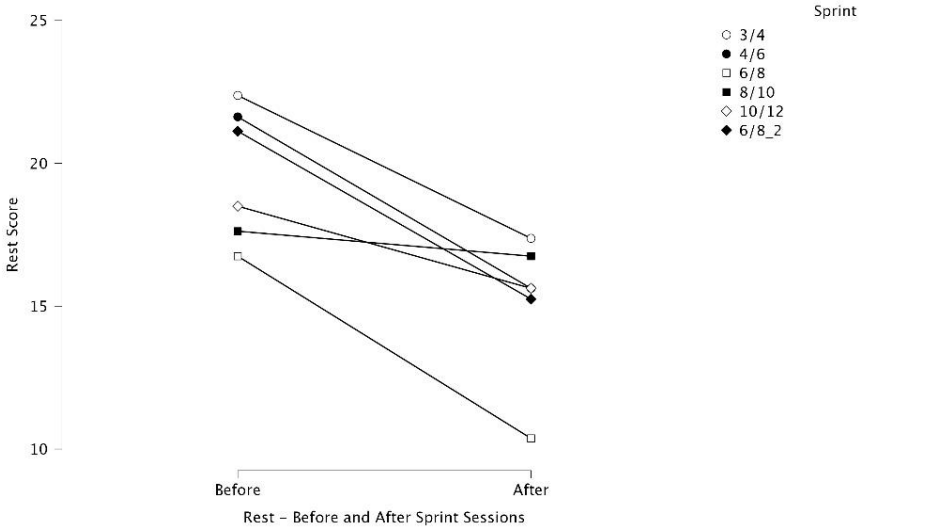


Figure 2. Pearson's *r* heatmap. Averaged across all levels of Sprint, Move and Rest post-sprint observations were negatively correlated (r = -.84, p < .01).





Figures 3A and 3B. Changes in Move and Rest Across six sessions of SIT exercise training for 9 women. Lines represent each exercise training session (session with 3 or 4 sprints; 4 or 6 sprints, etc.).

Intra-rater reliability

Intra-class correlations (ICCs) were small for Move pre-sprints (.33 and .39 for all sessions and session 2-5, respectively), but strengthened to .83 / .84 post-sprint. Likewise, ICCs for Rest strengthened from very low (.01 and .10) to moderate (.68 and .67) from pre- to post-training. ICCs for pre- to post-scores for both Move and Rest were low to moderate. See Table 4.

Table 4. Two-way mixed effects model using absolute agreement: Analysis for all sessions and with session 1 removed from analysis

Outcome		**ICC**	**95% confidence interval**	**F**	***p***	**Stability interpretation***
Move Pre	All sessions	.39	0.11 - 0.77	4.473	.001	Low
	Sessions 2-5	.33	0.04 - 0.74	3.257	.012	Low
Move Post	All sessions	.83	0.64 - 0.96	31.270	< .001	High
	Sessions 2-5	.84	0.65 - 0.96	26.084	< .001	High
Rest Pre	All sessions	.01	-0.12 - 0.39	1.057	.411	Low
	Sessions 2-5	.10	-0.112 to 0.545	1.488	.212	Low
Rest Post	All sessions	.68	0.41 - 0.91	14.296	< .001	Moderate
	Sessions 2-5	.67	0.390 to 0.906	12.116	< .001	Moderate
Move Pre to Post	All sessions	.22	-1.46 - 0.81	1.317	.353	Low
	Sessions 2-5	.50	-0.226 to 0.873	2.940	.089	Moderate
Rest Pre to Post	All sessions	.46	-0.54 - 0.86	2.183	.145	Low
	Sessions 2-5	.16	-0.462 to 0.732	1.424	.326	Low

* Based on Koo & Li (70)

DISCUSSION

In this small, pilot study of depressed women engaging in short Sprint Interval Training (sSIT), we found that the Brazilian version of the CRAVE scale (ARGE) was stable for Move and Rest measurements taken after exercise training sessions but not for measurements taken before each session's sprints. This was demonstrated with intra-class correlations (ICCs), indicators of correspondence within groups, that were stronger for both Move and Rest after individual sprint training sessions than before sprint sessions. This is in line with the theoretical basis of motivation states, that they are transient and can vary greatly from moment to moment, hour to hour, and day to day. However, there should be greater correspondence between these states after a standardized stimulus exposure in a highly controlled laboratory environment, even when repeated multiple times. This provides further evidence that the CRAVE/ ARGE reflects a state more so than a trait, as we have demonstrated in previous studies (27).

While not significant, with visual inspection of the data it is apparent that Move increased from pre- to post-sprint, and Rest decreased. This study was greatly underpowered (i.e., very small sample size), therefore, there were no significant results for the effects of time (pre vs post), session or the interaction

of these factors. However, effect sizes were medium (for across sessions) and large (for pre-post sprint session), indicating that given enough similar participants, it is likely that the null hypotheses would have been rejected (71). If these trends were to hold with a large sample size, one might interpret the data in a few different ways: a) depressed women were reinforced to move with each SIT training session, b) SIT training results in psychological responses that differ from other training methods, or c) both. Our previous work with high intensity weight training found that highly stressed, but not depressed, individuals had blunted affective responses compared to lower stressed individuals, including less pain (72). Previous studies have shown that sSIT results in improved hedonic tone, similar to other forms of exercise (65), less pain and perhaps greater "liking" or enjoyment of movement (66). Our previous data have demonstrated that short Sprint Interval Training (sSIT) typically results in improved psychological attention (62). Thus, it is also possible that participants were able to attend to internal sensations (interoception) better at the end of training sessions compared to pre-session, which is important because both endogenous and exogenous factors likely contribute to motivation states for movement and sedentarism (23).

This was a pilot study with only 9 women attending 6 sessions of training; thus, few conclusions could be drawn, and several limitations were evident. First, with the small sample size and short intervention, we were not able to examine any chronic or enduring changes from baseline of the intervention to post (e.g., in depression status). Moreover, there was no comparison group with non-depressed individuals. Future research should expand the sample and training period. There were sufficient data to determine consistency of the measures before and after sSIT sessions. Unfortunately, there were no measures during inter-sprint recovery periods or for the recovery period after sSIT training. Finally, there were few explanatory variables collected to assist with understanding the clinical implications of improved desire to move with training sessions. For instance, if people want to move more with a SIT training session, should we encourage them to do so?

STUDY 3

INTRODUCTION

The CRAVE scale, while psychometrically robust, contains 13 items that take about 90 seconds to complete. This hinders use of the scale during task (e.g., while exercising) and in ecological momentary assessment (EMA) studies. Taylor and colleagues (64) used an unvalidated single-item motivation states measure during vigorous exercise, finding that exercise intensity over lactate threshold resulted in rapid increases in the desire to stop exercising. Ponnada (73) developed and utilized an unvalidated single-item measure for EMA studies. Multiple other single-items scales exist as well, all unvalidated (discussed by Stults-Kolehmainen) (27). Lack of valid instrumentation is the prominent hindrance in the investigation of motivation states for movement, physical activity and sedentarism (29). Therefore, the objective of this study is to develop single-item versions for both the CRAVE and ARGE instruments (Move and Rest subscales).

MATERIALS AND METHODS

Participants

The sample of this study was constituted by same participants of study 1 (above) and two American samples described by Stults-Kolehmainen et al. (27) (see Data Availability section). We opted to use the *right now* databases of both the American and Brazilian CRAVE scales, using the 10-item scoring scheme.

Procedures

We asked permission of Stults-Kolehmainen et al. (27) to use the American databases of the CRAVE - available in an open repository. Holding the database from the USA and Brazil, we then proceeded to conduct statistical analyses of both Brazilian and American data. We needed to equate items to make internal comparisons using Item Response Theory (IRT). To do that, we opted for a vertical "equating" (74) merging all databases into a single spreadsheet according to the recommendations from Baker (75) and Wright (76). Analyses were conducted using the equated database. We analyzed move and rest factors separately.

Statistical Analysis

To determine the best single item to represent the move and rest subscales in the Brazilian and American versions, we opted to use the item information curve (IIC) based on the Graded Response Model (GRM), an IRT model for ordinal polytomous items developed by Samejima (77). The level information is the opposite of the level of error, which means that the item that provides more information is also the item with less measurement errors. Equating both American and Brazilian databases into the same dataset allowed comparison between IICs based on GRM (75).

Due to potential differences of IIC, we decided to further investigate whether items functioned similarly or not for the Brazilian and American datasets. Thus, we conducted a differential item functioning (DIF) analysis comparing the three datasets. To allow comparisons, we calculated the chi-square statistics, Aikake and Bayesian information criteria (AIC and BIC, respectively) for each item. This way, we might provide evidence to support whether different weights and likelihood of endorsement between countries were present.

RESULTS

We used the item information curve (IIC) to investigate which items among the set of the 10-item CRAVE's move and rest subscales were better to represent the latent trait (i.e., had higher levels of information). We employed the same method to both the Brazilian and the American databases yielding one item for both countries and subscales. Figure 4A depicts IIC for each CRAVE / ARGE Move subscale item divided by country, whereas Figure 4B presents the same graph for Rest items.

Figure 4A

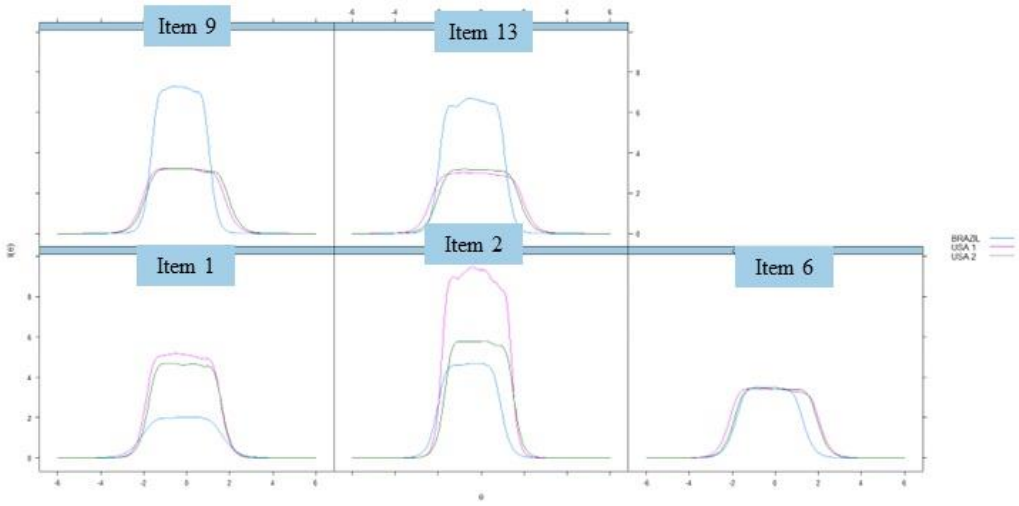
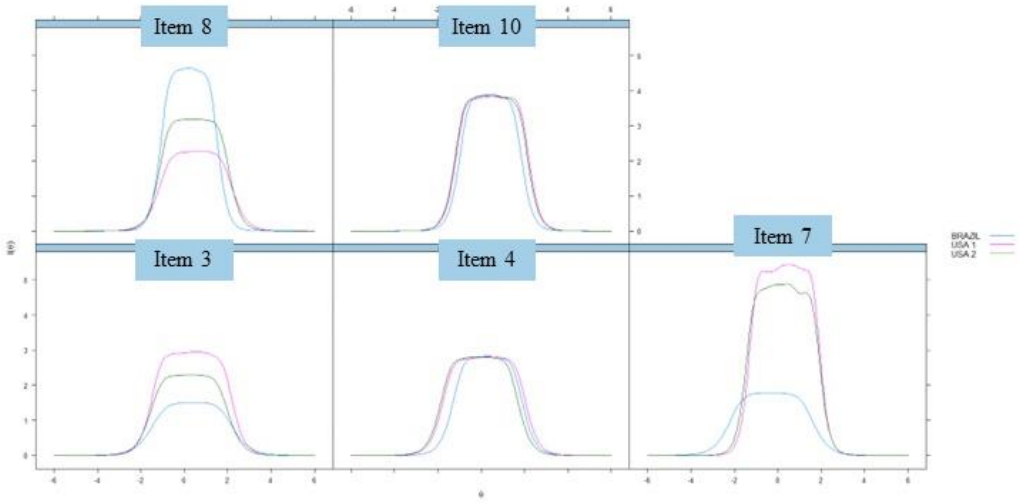


Figure 4B



FIGURES 4A and 4B. Items from the CRAVE and ARGE scales, analyzed with the Item Information Curve (IIC) and plotted by country.

Our results suggested that item 9 in the Brazilian version of the move subscale ("exercitar meus músculos / exert my muscles") and item 8 of the rest subscale from the same country ("não levantar do sofá / be a couch potato") presented the highest levels of information. Whereas move item 2 ("estar fisicamente ativo / be physically active") and rest item 7 ("ficar quieto / be still") for the American CRAVE version were the most informative items. This means that the single-item Brazilian version of CRAVE should consider items 9 and 8 to represent move and rest subscales, respectively, whereas items 2 and 7 of the American CRAVE correspond to the single-item version of the move and rest subscales, respectively. Due to the difference of item information between countries, we decided to further investigate these distinctions

777 using the differential item functioning (DIF) analysis. Table 5 summarizes the DIF results comparing
778 Brazilian and American samples.
779

TABLE 5. Brazilian and American versions of move and rest CRAVE items with chi-square statistics, Aikake and Bayesian information criteria (AIC and BIC, respectively) for the Brazilian and the two American samples (USA 1 and USA 2).

Variable	Statistics (DIF)				
	χ^2	*df*	*p*	AIC	BIC
Brazil vs USA 1st sample					
Move					
1. mexer meu corpo / move my body.	31.60	1	< .001	-29.60	-24.24
2. estar fisicamente ativo / be physically active.	14.51	1	< .001	-12.51	-7.15
6. gastar um pouco de energia / expend some energy.	3.11	1	.007	-1.11	4.25
9. exercitar meus músculos / exert my muscles.	16.86	1	< .001	-14.90	-9.50
13. me movimentar / move around.	16.90	1	< .001	-14.90	-9.54
Rest					
3. fazer nenhuma atividade / do nothing active.	13.85	1	< .001	-11.85	-6.49
4. só ficar sentado / just sit down.	.15	1	.699	1.85	7.21
7. ficar quieto / be still.	35.19	1	< .001	-33.19	-27.83
8. não levantar do sofá / be a couch potato.	11.89	1	< .001	-9.89	-4.53
10. ficar sem me movimentar / be motionless.	.61	1	.434	1.39	6.75
Brazil vs USA 2nd sample					
Move					
1. mexer meu corpo / move my body.	24.95	1	< .001	-22.95	-17.57
2. estar fisicamente ativo / be physically active.	1.90	1	.169	.10	5.49
6. gastar um pouco de energia / expend some energy.	.53	1	.528	1.47	6.85
9. exercitar meus músculos / exert my muscles.	20.23	1	< .001	-18.23	-12.84
13. me movimentar / move around.	16.89	1	< .001	-14.89	-9.51
Rest					
3. fazer nenhuma atividade / do nothing active.	5.28	1	.022	-3.28	2.11
4. só ficar sentado / just sit down.	.17	1	.676	1.83	7.21
7. ficar quieto / be still.	32.41	1	< .001	-30.41	-25.03
8. não levantar do sofá / be a couch potato.	2.94	1	.086	-.94	4.44
10. ficar sem me movimentar / be motionless.	2.56	1	.110	-.56	4.82
USA 1st vs USA 2nd sample					
Move					
1. mexer meu corpo / move my body.	.35	1	.569	1.68	6.41
2. estar fisicamente ativo / be physically active.	4.55	1	.033	-2.55	2.18
6. gastar um pouco de energia / expend some energy.	.79	1	.374	1.21	5.94
9. exercitar meus músculos / exert my muscles.	.07	1	.789	1.93	6.66
13. me movimentar / move around.	.01	1	.983	2.00	6.73
Rest					
3. fazer nenhuma atividade / do nothing active.	1.61	1	.205	.39	5.12
4. só ficar sentado / just sit down.	.45	1	.505	1.56	6.29
7. ficar quieto / be still.	.15	1	.697	1.85	6.58
8. não levantar do sofá / be a couch potato.	2.29	1	.130	-.29	4.44
10. ficar sem me movimentar / be motionless.	.44	1	.510	1.57	6.30

Note: Highlighted in bold letter the items that showed no differential functioning.

Results from DIF showed that, at least according to AIC and chi-square statistics, all items from the move subscale functioned differently between Americans in the first sample (USA 1) and Brazilians, whereas item 6 had similar item functioning when comparing Brazilians and Americans from the second sample. It was easier for Brazilians to endorse items 6, 9 and 13, whereas Americans from the samples 1 and 2 scored significantly higher on items 1 and 2. However, if we consider the positive BIC, item 6 did not function differently in Brazil in comparison to USA in neither sample, which means it is inconclusive whether item 6 shows DIF or not, however it tends to function similarly across countries.

Among items from the rest subscale, items 4 and 10 presented non-significant functioning between Brazil and USA 1, whereas the second American sample (USA 2) only yielded non-significant statistics in item 4, which suggests that item 4 is equivalent in both countries, but item 10 might not be, it is inconclusive. Nevertheless, items 3 and 7 were easier for Americans to endorse, whereas item 8 was scored higher among Brazilians. This way, we provided evidence to support different weights and likelihood of endorsement between countries.

We found a DIF between the two American samples. Item 2 “be physically active” retrieved a significant *p*-value (.033) and enough large AIC and BIC to enable different item functioning among USA 1 and 2. According to our results, sample USA 1 was less likely to endorse item 2 than sample USA 2. Regardless, with exception of item 2, other move and rest items showed equivalent item functioning between American samples, which was expected.

DISCUSSION

The current study utilized an Item Response Theory model to reduce the 10-item CRAVE and ARGE scales (5 items each for Move and Rest) into single items for each subscale. We found that the ARGE (Brazilian version of CRAVE) was best represented by ("exercitar meus músculos / exert my muscles") for Move and ("não levantar do sofá / be a couch potato") for Rest subscales. On the contrary, the best items in the North American version (original CRAVE) were ("estar fisicamente ativo / be physically active") and ("ficar quieto / be still") for Move and Rest, respectively. The concept of "being still", or a lack of motion, as representative of sedentary activities and rest seems to make sense as it is the physical condition common to sitting, laying down, watching television (typically), etc. It is also relevant in light of psychological phenomena, like freezing (e.g., in the face of threat, or in highly specific situations common to sport, like the moment before a gun fires to start a race), which are states of inactivity and behavioral inhibition but not physical or mental rest, per se (78, 79). Indeed, an entire special issue in *Philosophical Transactions* was dedicated to the topic of stillness, stopping motion and "not moving" (79-81). Noorani & Carpenter (80) concludes that, "…the maintenance of stillness is not simply a matter of doing nothing: it requires as much if not more active and accurate control as creating the movements themselves." This phenomenon was deemed "neglected" but is highly relevant for the control of motivated action of movement and sedentary behavior. Interestingly, the most representative item for Brazilian Portuguese was "não levantar do sofá ("be a couch potato"), which may reflect the general idea of being "stuck" or highly fatigued and less akin to indolence or laziness, key themes discovered in a recent qualitative study (22). Adaptations of other psychological instruments from English in Brazilian Portuguese have found similar linguistic and cultural challenges (42), and may be due to problems with the translation, back translation or other deeper factors.

Using the information curve based on the graded response model to decide the best (most informative) item to use as a single-item instrument is relatively novel and innovative (82-84). This technique is also prone to loss of other types of information and some of the nuances and details regarding individual differences in either Move or Rest or even both, which can limit the use and interpretation of CRAVE as a measurement instrument. Using differential item functioning (DIF) analysis, we found that all but two of the ten items differed between Brazilian and North American samples, signifying potential cultural differences, or perhaps differences along some other random factor. For instance, the Brazilian samples were also approximately a decade older than the American samples (30.8 and 30.3y vs. 20.9 and 20.3y). Thus, we cannot ignore the potential influence of age, but in our previous work we determined that motivation to exercise (and not move, per se) varied little across this period of life (13). Our general assessment, however, is that the single-item subscales found from this IRT analysis are valid and should be utilized in future studies, as outlined in the general discussion below.

GENERAL DISCUSSION

The present study makes several incremental advancements in the measurement of affectively-charged motivation states (ACMS) for physical activity and sedentarism (10). First, we conducted the first translation and cultural adaptation of the CRAVE scale (27), in this case into Brazilian Portuguese, creating the ARGE scale. This instrument was found to have excellent psychometric properties, similar to the original CRAVE scale or better. Importantly, these analyses verified the factor structure of the CRAVE scale in a new population from a different country and in another language. We used these data to compare 10- and 13-item versions of the CRAVE / ARGE scales, finding that the originally validated 10-item scale had the best psychometric properties. This is ideal as it substantiates two 5-item subscales (i.e., Move and

Rest) that range from 0-50 points each, which simplifies interpretation. The data were associated in the predicted manner with metrics from the Godin-Shepard Leisure Time Physical Activity Questionnaire – the first time motivation states data have been compared to exercise behavior. Prospective data from a trial involving short Sprint Interval Training (sSIT) determined that the ARGE reflects a state more than a trait. We also found some large effects in motivation states pre- to post-sprint sessions. Using Item Response Theory, we were able to reduce the scale down to two items (1 for Move and Rest) for the original CRAVE and new ARGE scales. Differences in these items revealed some potential cultural differences between the United States and Brazil for motivation for physical activity and sedentarism, one of the first reports to note such differences.

The psychometrics of the new ARGE, while remarkably similar to the psychometrics from the original CRAVE scale, had some apparent small differences. For instance, in our previous investigations (27), Move and Rest factors are correlated moderately and inversely (*r's* = −.71 and −.78, in two different studies). In the current study, we found a two-factor solution that was less strongly related (*r* = -.63). Previous investigations provided both quantitative and qualitative evidence suggestive of strong relationships between exercise behavior and motivation states to move and rest (22, 27). In this study, however, there were small associations with leisure-time physical activity indicators from the Godin-Shephard Questionnaire. It may be the case that these state measures do not correspond well with exercise measures over a period of 7+ days. We did not include the Past-Week version of the CRAVE scale in these studies, which may have corresponded better with exercise behavior. Also, the CRAVE and ARGE relate to movement and physical activity more generally, and not exercise specifically. The ARGE had negligible associations with BMI (as we previously found) (27) and state anxiety, which may be because the response can result in multifarious and contrasting movement outcomes, such as fight, flight, freeze and faint (78). Further evidence is needed from the CRAVE and ARGE scales to evaluate construct, convergent and discriminant validity.

Future research

Our previous manuscripts have extensively suggested future research possibilities (10, 21-23, 27). Primarily based on limitations that were discussed above for each study, future research could focus on the following 11 areas of need:

1. Tracking motivation states against stronger measures of exercise and lifestyle PA, including accelerometry, as well as against levels of aerobic and muscular fitness, which has never been documented.
2. Investigating more robust cross-cultural comparisons, including translation of the CRAVE into Spanish and other languages.
3. Assessing correspondence of CRAVE and/or ARGE scales with other exercise and sport motivation questionnaires.
4. Associations with other mental health states, psychological feeling states, like arousal and pleasure/displeasure and "state mindfulness for physical activity" (85, 86).
5. Associations with metabolic parameters, such as continuous measures of blood glucose.
6. Implementing studies using the single-item sub-scales during task (e.g., during vigorous exercise) (64) and recovery. Determining changes in ACMS with HIIT versus high intensity vigorous versus moderate intensity aerobic training.
7. Studies using the single-item as part of EMA studies to determine if motivation states following a particular pattern or rhythm across the day.
8. Using CRAVE / ARGE normative data to create exercise prescriptions - similar to affect-based exercise prescriptions (87).

9. Using environmental cues, including short, motivational messages, perhaps from fitness wearables, about physical activity tailored for diverse populations to promotes desires to move and be active, a process that has previously been successful in Brazil (88, 89).
10. Just in time adaptive interventions (JITAI) (90) to provide just the right amount of support for people when they are experiencing "CRAVE moments" – transient times of wanting to move.
11. Understanding the physiological, affective, and cognitive components of the "CRAVE moment" – high craving as demonstrated in Supplemental material 1 that might be close to the "mental hijacking" described by Hofmann & Van Dillen (17) in their Dynamical Model of Desire.

Conclusion

We conducted three studies to improve psychometrics for the measurement of affectively-charged motivation states (ACMS) for physical activity and sedentary behaviors. First, we adapted the CRAVE scale (27) into Brazilian Portuguese to facilitate examination of cross-cultural influences. The revised scale, named the ARGE, appears to have excellent psychometric properties. Importantly, the basic factor structure replicated with this new population and language, which is important evidence that the basic constructs measured by the CRAVE scale are valid. These data also provide evidence that the original 13-item scale should be used with 10 items scored (5 each for move and rest subscales) and 3 fillers. Motivation states had small, but significant associations with indices of exercise behavior. Move predicted more exercise and Rest predicted less. We found stability of Move and Rest after bouts of short Sprint Interval Training (sSIT) study, but not before, providing additional evidence that this facet of motivation is a state and not a trait and is influenced by numerous inputs. We also observed large effects for changes in motivation states from pre- to post-exercise. Finally, we developed single-item subscales for Move and Rest, that varied by country, which provides some additional evidence that motivation is a culturally influenced concept. Future studies should use the single-item scales to examine changes in the desire or urge to move and rest during exercise. Additional work is also needed to examine other facets of the WANT model (10), such as aversions (i.e., dread) to move and be active and how they interact with approach motivation for the same activities.

AUTHOR CONTRIBUTIONS

Study 1 was conceived and designed by AF and MSK. Translation was conducted by AF, AV, FAB, ARM and MSK. Data was collected by AF. Analyses were conducted by AF. Study 1 was equally written by AF and MSK. Study 2 was conceived and designed by DB. Data was collected by SFM. Analyses were conducted by PM. Study 2 was written by MSK, DB, SFM, and FAB, in that order. Study 3 was conceived and designed by AF and MSK. Data was collected by TAG and AF. Analyses were conducted by AF. Study 3 was equally written by AF and MSK. The manuscript was evaluated and refined by MSK, AF, DB, RS, JBB, GA, PM, AV, RK, FAB, ARM, TG and SFM, in that order. All authors provided critical feedback, reviewed, and approved the final manuscript.

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DATA AVAILABILITY

Some Brazilian data is available on the Open Science Framework (OSF) database repository (https://osf.io/ga538/; DOI 10.17605/OSF.IO/GA538). American data for IRT analyses is available on the Figshare database repository: https://figshare.com/authors/Matthew_Stults_kolehmainen/794794, https://doi.org/10.6084/m9.figshare.13322600.v1; https://doi.org/10.6084/m9.figshare.13322642.v1. Other data is available with reasonable request to the corresponding author.

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