

## Accepted Manuscript

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Geetanjali Basarkod, Baljinder Sahdra, Joseph Ciarrochi

PII: S0005-7894(17)30102-8

DOI: doi:[10.1016/j.beth.2017.09.006](https://doi.org/10.1016/j.beth.2017.09.006)

Reference: BETH 748

To appear in: *Behavior Therapy*

Received date: 6 March 2017

Accepted date: 15 September 2017



Please cite this article as: Basarkod, G., Sahdra, B. & Ciarrochi, J., Body Image-Acceptance and Action Questionnaire-5: An abbreviation using Genetic Algorithms, *Behavior Therapy* (2017), doi:[10.1016/j.beth.2017.09.006](https://doi.org/10.1016/j.beth.2017.09.006)

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**Body Image – Acceptance and Action Questionnaire – 5: An abbreviation using Genetic  
Algorithms**

Geetanjali Basarkod\*, Baljinder Sahdra, Joseph Ciarrochi

Institute for Positive Psychology and Education, Australian Catholic University, Locked Bag  
2002, Strathfield, NSW 2135, Australia

**\*Correspondence:** Geetanjali Basarkod, Institute for Positive Psychology and Education,  
Australian Catholic University, Locked Bag 2002, Strathfield, NSW 2135, Australia  
geetanjali.basarkod@myacu.edu.au

## Abstract

Body image concerns are typically linked with negative outcomes such as disordered eating and diminished wellbeing, but some people can exhibit psychological flexibility and remain committed to their valued goals despite being dissatisfied about their bodies. Such flexibility is most frequently measured by the Body Image-Acceptance and Action Questionnaire (BI-AAQ). This study used a recently validated, fully-automated method based on genetic algorithms (GAs) on data from an American community sample ( $N_1=538$ , 71.5% female, Age:  $M = 40.87$ ,  $SD = 13.5$ ) to abbreviate the 12-item BI-AAQ to a 5-item short form, BI-AAQ-5. Validation tests were conducted on data from an independent community sample ( $N_2=762$ , 44.6% female, Age:  $M = 40.65$ ,  $SD = 13.06$ ). The short form performed comparably to the long form in terms of its factor structure and correlations with theoretically relevant constructs, including body image dissatisfaction, stigma, internalisation of societal norms of appearance, self-compassion, and poor mental health. Further, preliminary analyses using structural equation modelling showed that body image flexibility, as measured by either the long or short form, was associated with almost all the criterion variables, even while controlling for a highly related construct of body image dissatisfaction. These results demonstrate the potential discriminant validity of both the long and short form of the BI-AAQ, and show that the BI-AAQ-5 is a suitable alternative to its long form. We discuss how psychological flexibility with respect to body image dissatisfaction can be conducive to positive functioning.

**Keywords:** body image, genetic algorithm, questionnaire abbreviation, psychometrics, psychological flexibility

**Abbreviations:** GA, Genetic Algorithm; BI-AAQ, Body Image – Acceptance and Action Questionnaire

Body image dissatisfaction refers to the negative subjective evaluation of one's body (Stice & Shaw, 2002). The lifetime prevalence rate for body image dissatisfaction is estimated at 13.4%-31.8% for women and 9.0%-28.4% for men in the U.S. (Fallon, Harris, & Johnson, 2014). Owing to these high estimates, the term 'normative discontent' was coined to describe that a substantial proportion of the population feels insecure about their body weight and is dissatisfied with how their body looks (Rodin, Silberstein, & Striegel-Moore, 1984, p. 267). This is a significant issue as research shows body image dissatisfaction to be detrimental to the mental and physical health of both women and men, as it has been linked with higher levels of depression (Pimenta, Sánchez-Villegas, Bes-Rastrollo, López, & Martínez-González, 2009), anxiety (Szymanski & Henning, 2007), feelings of worthlessness (Olivardia, Pope Jr, Borowiecki III, & Cohane, 2004), and disordered eating (Neumark-Sztainer, Paxton, Hannan, Haines, & Story, 2006), as well as lower levels of self-esteem (Grossbard, Lee, Neighbors, & Larimer, 2009; Sarwer, Thompson, & Cash, 2005; Tiggemann, 2005) and mental health (Ganem, de Heer, & Morera, 2009).

Several possible explanations exist for the pervasiveness of body image dissatisfaction. One possibility is the self-discrepancy theory (Higgins, 1987) which states that the difference between an individual's perceived actual and ideal body, or the failure to achieve their ideal body, can lead to emotional distress. This ideal is promoted through widely-held cultural norms of appearance such as the idea that women need to look young, tall and thin, and have a low waist to hip ratio (Hargreaves & Tiggemann, 2004; Streeter & McBurney, 2003), and that men need to be muscular and athletic, with a low waist to chest ratio (Coy, Green, & Price, 2014; Strahan, Wilson, Cressman, & Buote, 2006). The narrow cultural norms deny the naturally occurring diversity of body types, making the ideal for attractiveness unrealistic and unattainable. This discrepancy between real and ideal then manifests as body image dissatisfaction (eg., Kim & Damhorst, 2010). Another explanation

comes from objectification theory (Fredrickson & Roberts, 1997) which posits that society's rampant objectification of women's bodies leads to acculturation and internalisation of this objectification. Chronic self-objectification, i.e. constantly viewing their own bodies as objects and experiencing the accompanying body-related shame and anxiety, can lead women of all ages to be dissatisfied with their bodies (Grippo & Hill, 2008). Although this theory was originally applied to understanding body image dissatisfaction in women, recent research has also applied it to understanding the phenomenon in men (Daniel & Bridges, 2010; Strelan & Hargreaves, 2005). In fact, some of these findings suggest that objectification theory may explain disordered eating, depression, body shame, and self-esteem in both women and men (Calogero, 2009; Hebl, King, & Lin, 2004; Tiggemann & Kuring, 2004).

Despite the abundance of evidence for the harmful effects of body image dissatisfaction, research suggests that psychological flexibility might dampen the negative impact of body image dissatisfaction. Psychologically flexible individuals have the ability to mindfully experience their body image dissatisfaction for what it is – fleeting thoughts and feelings that come and go, that do not have to interfere with meaningful, valued action (Hayes, Luoma, Bond, Masuda, & Lillis, 2006; Sandoz, Wilson, Merwin, & Kellum, 2013). In a recent study with college-bound females, Webb (2015) showed that body image flexibility partially mediated the link between body dissatisfaction and body appreciation. Webb (2015) operationalised body dissatisfaction (the predictor) using different measures of body size real-ideal discrepancy, and conceptualised body appreciation (the outcome variable) as value-consistent action. Body image flexibility (the mediator) partially explained the link between dissatisfaction and value-consistent action, regardless of the measure used, even after controlling for body mass index. Thus, these findings suggest that bolstering peoples' body image flexibility may increase their value-consistent action, even when they believe their body to be less than ideal. Further, body image flexibility has also been shown

to weaken the link between body image dissatisfaction and disordered eating attitudes (Ferreira, Pinto-Gouveia, & Duarte, 2011; Sandoz et al., 2013).

On the flip side, psychologically inflexible individuals, that is, those who tend to experience their negative thoughts about their body image as literal truths that interfere with their ability to engage in valued activities, often engage in ineffective efforts to escape these difficult internal experiences (Hayes, Wilson, Gifford, Follette, & Strosahl, 1996). These attempts to escape may alleviate distress in the short-term but impair health and well-being in the long run. Avoidant and inflexible behaviours have been linked with higher levels of self-objectification, body shame, depressive symptoms, and disordered eating, as well as with lower levels of subjective well-being and quality of life (Cash, Santos, & Williams, 2005; Choma, Shove, Busseri, Sadava, & Hosker, 2009; Corstorphine, Mountford, Tomlinson, Waller, & Meyer, 2007; Gámez et al., 2014).

Research focused on the potential benefits of body image flexibility has been gaining attention in the last few years (Duarte & Pinto-Gouveia, 2016; Mancuso, 2016; Webb, 2015). Body image flexibility has primarily been measured by the Body Image – Acceptance and Action Questionnaire (BI-AAQ), which consists of 12 items assessing the extent to which people are flexible with respect to negative thoughts and emotions about their bodies, and are able to engage in valued activity despite the difficult internal experiences about their body image (Sandoz et al., 2013). There is growing evidence for the construct validity of this measure and studies show that body image flexibility is negatively related to body image dissatisfaction, disordered eating, stigma, depression, and anxiety, and positively related to mindfulness and self-compassion (Duarte & Pinto-Gouveia, 2016; Kelly, Vimalakanthan, & Miller, 2014; Moore, Masuda, Hill, & Goodnight, 2014).

### **Abbreviating the BI-AAQ**

We hope to facilitate the growth of literature on body image flexibility by abbreviating the BI-AAQ. A short form of the measure could benefit researchers by expanding the breadth of constructs covered (by creating more room for other measures), minimising participant burden (by reducing the length of the overall battery), potentially reducing drop-out rates, and improving data quality (Diehr, Chen, Patrick, Feng, & Yasui, 2005; Snyder, Watson, Jackson, Cella, & Halyard, 2007). Reducing the length of the survey can also lower the cost of representative samples that can be purchased from professional survey companies (e.g., Sahdra et al., 2017). Finally, a short measure could also help clinicians and practitioners reduce the time their clients spend answering questionnaires in the session, thus making more time available for treatment. In cases where clients are asked to complete the questionnaires outside the therapy sessions, a brief measure may help increase compliance by minimising burden on the clients.

However, creating a new abbreviated version of a previously validated questionnaire can be challenging and time-consuming as it often involves a combination of statistical techniques, subjective judgments, and the consideration of varied psychometric criteria (Marsh, Ellis, Parada, Richards, & Heubeck, 2005; Sahdra, Ciarrochi, Parker, & Scrucca, 2016; Sandy, Gosling, & Koelkebeck, 2014). Fortunately, recent advances in psychometrics utilising genetic algorithms (GAs) make the process of scale abbreviation fully automated and computationally efficient, hence fast and less prone to the biases of researchers' subjective judgments (Sahdra et al., 2016; Schroeders, Wilhelm, & Olaru, 2016; Yarkoni, 2010). Therefore, we employed the GA-based method to shorten the BI-AAQ.

The GA-based approach to scale abbreviation is a robust machine-learning method that implements the principles of biological evolution (e.g., mutation, crossover, and selection based on fitness) in a computational framework to efficiently derive a suitable short version of a long form that is reliable, valid, and preserves most of the variance in the data of the

original questionnaire (Eisenbarth, Lilienfeld, & Yarkoni, 2015; Sahdra et al., 2016; Yarkoni, 2010). A detailed explanation, with diagrams, of the GA-based method can be found in Schroeders et al. (2016). The computational details of the GA (Holland, 1975; Scrucca, 2013), and its specific application to questionnaire abbreviation are discussed elsewhere (Sahdra et al., 2016; Yarkoni, 2010). The GA-based method has been successfully employed to abbreviate long forms of several psychological constructs, such as, personality traits (Yarkoni, 2010), psychopathy (Eisenbarth et al., 2015), and experiential avoidance (Sahdra et al., 2016).

### **Is body image inflexibility more than body image dissatisfaction?**

Despite the popularity of the BI-AAQ, there is a lack of adequate research showing the discriminant validity of the BI-AAQ over and above measures of body image dissatisfaction. Previous research has shown a high correlation (around -.75) between measures of body image flexibility and body image dissatisfaction (Duarte & Pinto-Gouveia, 2016; Sandoz et al., 2013), casting a doubt on whether the two kinds of measures can be distinguished. However, such a high correlation is theoretically expected because it is unlikely that people would report having body image inflexibility unless they also felt dissatisfied about their bodies. That is, dissatisfaction, or the presence of negative thoughts about one's body, may often be a precondition for responding either effectively or ineffectively to those thoughts (body image flexibility or inflexibility). The question is, can people distinguish between having negative thoughts about their body (body image dissatisfaction) and having flexibility with regard to those thoughts (body image flexibility)? Studies have previously used hierarchical multiple regressions to show that body image flexibility has incremental validity over body image dissatisfaction (Ferreira et al., 2011; Sandoz et al., 2013). Whilst this result is encouraging, this methodology has been noted to have drawbacks, such as reliance on manifest variables and the consequent assumption that

there is no measurement error. Failure to account for measurement error can lead to biased estimates of standard errors (Fornell, 1985; Maas & Hox, 2004). In short, the discriminant validity of the BI-AAQ with respect to a measure of body image dissatisfaction remains to be tested whilst minimising measurement error.

### Current Study

This paper has two main aims: the first, methodological, aim was to apply the genetic algorithms-based method of questionnaire abbreviation to the 12-item Body Image-Acceptance and Action Questionnaire (BI-AAQ; Sandoz et al., 2013) to create a reliable and valid short form that performs similarly to the original long form in terms of internal consistency, factor structure, and correlations with constructs that are theoretically relevant to body image concerns: body image dissatisfaction, stigma, internalisation of societal norms of appearance, self-compassion, and poor mental health. The second, substantial aim, was to use structural equation models to differentiate between the BI-AAQ and a measure of body image dissatisfaction, the Body Shape Questionnaire - 8C (BSQ-8C), to test whether body image flexibility matters above and beyond simply the presence of negative thoughts about one's body. Data from a sample from the U.S. general population was used to abbreviate the BI-AAQ using the GA. Data from a second independent U.S. sample was then used for all validation tests on the new BI-AAQ short form and to test the discriminant validity of the BI-AAQ with respect to the BSQ-8C.

To test for construct validity, we examined the links between both the long and short forms of the BI-AAQ and the above mentioned theoretically relevant constructs. Previous research has shown that individuals who are less psychologically flexible tend to have high levels of body image dissatisfaction (Sandoz et al., 2013; Webb, 2015), presumably because they find it hard to avoid their negative concerns about their body. Psychologically inflexible individuals may also be more inclined to report instances of stigma as previous research

shows a negative link between psychological flexibility and stigma (Lillis, Luoma, Levin, & Hayes, 2010). Inflexible individuals may have a higher tendency to internalise societal norms of appearance and feel that they will be more socially accepted if they fit the cultural ideals of physical appearance (Hohlstein, Smith, & Atlas, 1998). However, the inherent impossibility of achieving these ideals only increases the salience of such cultural norms. In line with this reasoning, studies have shown negative links between psychological flexibility and internalisation of societal norms of appearance (Timko, Juarascio, Martin, Faherty, & Kalodner, 2014). Further, interventions aimed at increasing psychological flexibility have been shown to reduce the internalisation of stigma and cultural norms of appearance (Lillis, Hayes, Bunting, & Masuda, 2009; Mikorski, 2013), and may increase kindness towards oneself. Past research shows that measures of body image flexibility and self-compassion are positively correlated with each other (Ferreira et al., 2011; Kelly et al., 2014) as both constructs reflect the ability to take a flexible perspective on one's perceived flaws. Further, psychologically flexible individuals may be more able to engage in meaningful behaviours which have been linked with improved wellbeing outcomes (Aked, Marks, Cordon, & Thompson, 2008; Ferreira et al., 2011). Based on these past findings, we expected that body image flexibility, as measured by both the long and short form of BI-AAQ in our study, will be negatively correlated with body image dissatisfaction, stigma, internalisation of societal norms of appearance, poor mental health, and positively correlated with self-compassion.

We used data from our second sample to conduct structural equation models to assess whether the BI-AAQ was uniquely associated with the criterion variables of stigma, internalisation of societal norms of appearance, self-compassion, and poor mental health, even while controlling for body image dissatisfaction. We also ran the same models with the new short form BI-AAQ to test whether this short form performed as well as the full form BI-AAQ.

The methodological and substantive goals of this study are intertwined. Our hypotheses about the links between body image flexibility and the health-related constructs, and the discriminant validity of body image flexibility with respect to body image dissatisfaction, apply both to the long and short form of the BI-AAQ. That is, we expect the GA-derived short form of the BI-AAQ to perform just as well as the long form in terms of their unique associations with the constructs controlling for body image dissatisfaction. If the short form performs as well as the long form in these models, that would show that the short form is a suitable alternative to the long form, with all the benefits, as we discussed above, of having a short form.

### **Method**

#### **Participants and design**

Data from two samples from the general population in the US were purchased from a professional survey company after obtaining ethical approval from the university's ethics committee. Sample 1 consisted of 538 participants with an age range of 18 to 65 years ( $M = 40.87$ ,  $SD = 13.5$ ), and 71.5% of them were female. Of the participants, there were 66.5% Caucasians, 12.1% Hispanics, 10% African Americans, and 11.3% other ethnicities. With respect to annual household income, 18% of the participants reported earning less than \$20,000, 28.4% between \$20,001-\$40,000, 20.8% between \$40,001-\$60,000, 13.6% between \$60,001-\$80,000, 10.2% between \$80,001-\$100,000, 8.7% more than \$100,000, and 0.2% other. Regarding education, 24.9% of the participants had an education up to high school, 57.1% up to a college diploma level, and 18% up to a graduate degree. Sample 2 consisted of 762 participants with an age range of 18 to 65 years ( $M = 40.65$ ,  $SD = 13.06$ ), and 44.6% of them were female. There were 68.6% Caucasian, 10.5% Hispanic, 9.6% African American, and 11.3% other ethnicities. With regard to annual household income, 16.4% of the participants reported having a household income of less than \$20,000, 24.9% between

\$20,001-\$40,000, 19.7% between \$40,001-\$60,000, 14.8% between \$60,001-\$80,000, 10.8% between \$80,001-\$100,000, 13.1% more than \$100,000, and 0.3% other. Finally, 23.5% of the participants in this sample had an education up to high school, 58.4% up to a college diploma level, and 18.1% up to a graduate degree. For completing the survey, the respondents from both samples could choose between a \$0.50 donation to the charity of their choice or enter a sweepstake to win \$100. All participants were told that the survey would take approximately 30 minutes to complete and that they should do so in a quiet place free of distractions and in a single sitting. The first page of the survey was the consent form; if respondents agreed to participate, they proceeded to the next page. Consistent with the cross-validation recommendations for machine learning applications (James, Witten, & Hastie, 2014), the first sample was used as the training sample on which the GA-based method was applied, and the second sample was used as the validation sample on which all further analyses were conducted.

### **Genetic algorithm procedure**

The genetic algorithm procedure for scale abbreviation was conducted in R, an open source statistical computing environment (R Core Team, 2015), using the GAabbreviate package (Scrucca & Sahdra, 2015). The details of the genetic algorithms procedure for questionnaire abbreviation are described in Yarkoni (2010). Briefly, from the initial pool of items, the GA-based method first takes different combinations of items. Each item is treated as a gene, each item-set as a chromosome, and the group of item-sets as a population. The maximum number of items in each item-set is specified by the researcher. Within the initial selection of item-sets (initial population), the GA tests each item-set with respect to a fitness function or the psychometric goal for the short-form, in our case explaining the maximum possible variance in the original data of the long form. The item-sets that do not meet the fitness criterion are removed from the population, while the remaining item-sets go through

crossovers and mutations to introduce new combinations into the population. In crossover, a subset of items within an item-set are exchanged with the same number of items from another item-set. In mutation, items within an item-set are randomly replaced with items from the initial pool of items. The new combinations of item-sets are again evaluated against the fitness function, and these iterations are repeated until an item-set meets the fitness criterion.

The details of the GAabbreviate package can be found in Sahdra et al. (2016). The GAabbreviate aims to select a set of items that minimise the overall cost of the items in the abbreviated scale based on the formula below, as described by Sahdra et al. (2016):

$$Cost = Ik + \sum_{i=1}^s w_i (1 - R_i^2)$$

Here,  $I$  is the item cost,  $k$  is the number of items to be retained,  $s$  is the number of subscales in the measure (if applicable),  $w_i$  are the weights associated with the each subscale (if applicable), and  $R^2$  is the variance that a linear combination of individual item scores can explain in the  $i$ th subscale (or the original full scale if there are no subscales). Consistent with prior research (e.g., Yarkoni, 2010; Sahdra et al., 2016), preliminary analyses were conducted by varying the levels of the GA parameters (e.g. item cost). This was done to find the optimal levels of the parameters that would result in a short form explaining a high amount of variance in the original data. These analyses were conducted using only the data from the training sample, and never using the data from the validation sample. The final GAabbreviate specifications used in the current study were the same as the ones used by Sahdra et al. (2016) except for the following: (a) the item cost was constrained to .01 to allow for a sufficient number of items in the short form that explained a high degree of variance in the data of the long form; (b) the maximum number of items to be selected was unconstrained; (c) the weighting of subscales were irrelevant in the current study because the BI-AAQ is a unidimensional measure; and (d) the ‘crossVal’ argument (which is set to TRUE by default in

the GAabbreviate) was turned off because we conducted all validation tests using data from the second independent sample. These settings were used to allow the GAabbreviate to employ all available data in the sample (instead of splitting the sample for cross-validation) to yield a short form that was sufficiently long to account for a high degree of variance (at least 95%) in the data of the long form.

## Measures

**Body image flexibility.** We employed the Body Image – Acceptance and Action Questionnaire (BI-AAQ; Sandoz et al., 2013), a 12-item questionnaire that assesses the acceptance of one's thoughts, feelings, and emotions towards the body in the service of engaging in behaviours that are important to the individual. The 12 items were rated on a scale ranging from 1 (*never true*) to 7 (*always true*). All items were reverse-coded so that higher scores reflected higher levels of body image flexibility. Example items include: “worrying too much about my weight makes it difficult for me to live a life that I value” and “to control my life, I need to control my weight.” The measure has been shown to have good construct validity and test-retest reliability in past research (Ferreira et al., 2011; Sandoz et al., 2013), showed high internal consistency in previous studies ( $\alpha = .92\text{-.93}$ ; Sandoz, et al., 2013) as well as in our sample ( $\alpha = .96$ ), and has previously been used and validated in samples consisting of both males and females (Sandoz et al., 2013). This measure was used in both Samples 1 and 2. Sample 2 also included the following measures:

**Body Mass Index (BMI).** We calculated BMI by dividing each participant's self-reported weight in kilograms by the square of their reported height in metres (eg., Johnson & Wardle, 2005).

**Body image dissatisfaction.** The extent of pathological concern about one's body shape was measured by the Body Shape Questionnaire – 8C (Evans & Dolan, 1993). The items were rated on a 6-point scale ranging from 1 (*never*) to 6 (*always*), where higher values

indicated higher levels of body dissatisfaction. Example items include: “has seeing your reflection (e.g. in a mirror or shop window) made you feel bad about your shape” and “have you been particularly self-conscious about your shape when in company of other people.” As the wording of the BSQ-8C items is gender neutral, the questionnaire has previously been used in male samples and has yielded satisfactory reliability (Welch, Lagerström, & Ghaderi, 2012). The measure showed high internal consistency in our sample ( $\alpha = .94$ ) echoing reliability values seen previously ( $\alpha = .91\text{-.92}$ ; Evans & Dolan, 1993).

**Stigma.** Participants’ experiences with instances of weight-based stigma were measured by the 10-item Brief Situations of Stigma Inventory (Vartanian, 2015). The items were rated on a 10-point scale ranging from 0 (*never*) to 9 (*daily*) where higher scores indicated more frequent experiences with weight stigma. Example items include: “Being glared at or harassed by bus passengers for taking up ‘too much’ room.” and “children loudly making comments about your weight to others”. The 10-item short form has been shown to be reliable in previous studies ( $\alpha = .84\text{-.90}$ ; Vartanian, 2015) as well as in the current sample ( $\alpha = .97$ ).

**Internalisation.** The extent to which individuals internalise societal norms of appearance was measured by the thin and muscle appearance internalisation subscales of the Social Attitudes Towards Appearance Questionnaire – 4 (SATAQ-4; Schaefer et al., 2014). Each subscale included 5 items and each item was rated on a scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Example items include: “it is important for me to look athletic” (muscular appearance;  $\alpha = .91$ ) and “I want my body to look very thin” (thin appearance;  $\alpha = .85$ ). Previous research has shown both scales to have similar internal consistency (muscular appearance  $\alpha = .87\text{-.91}$ ; thin appearance  $\alpha = .75\text{-.82}$ ; Schaefer et al., 2014) to what was seen in our sample.

**Self-compassion.** We used the 12-item Self-Compassion Scale – Short Form (SCS-SF; Raes, Pommier, Neff, & Van Gucht, 2011) to measure self-compassion. Each item was rated on a scale from 1 (*almost never*) to 5 (*almost always*) with higher scores reflective of higher levels of self-compassion. Example items include: “I try to see my failings as part of the human condition” and “when something upsets me I try to keep my emotions in balance.” This questionnaire has been shown to have a near perfect correlation ( $r \geq .97$ ) with the original long form Self-Compassion Questionnaire (Neff, 2003), and had sufficient internal consistency in the initial development study ( $\alpha = .86\text{-.87}$ ; Raes et al., 2011) as well as in our current sample ( $\alpha = .78$ ).

**Poor mental health.** To measure poor mental health, we used the General Health Questionnaire-12 (GHQ-12; Goldberg, 1992). Each of the 12 items were rated on a 4-point scale with varying labels (such as *not at all* to *much more than usual*) for different items. Each item began with a sentence stem, “Have you recently...”. Example items include: “been feeling unhappy or depressed” and “felt constantly under strain.” The GHQ-12, when using the Likert method of scoring, has been shown to have sufficient internal consistency ( $\alpha = .73\text{-.90}$ ; Hankins, 2008) which was replicated in the current sample ( $\alpha = .91$ ). Higher scores indicate greater psychological distress.

We originally also measured self-reported exercise, but information about this variable and basic analyses using this variable, have now only been included in Online Supplementary Material S1. This variable was removed from the main paper because of the complicated associations between exercise and body image related constructs. For instance, people with low levels of body image flexibility, as is the case with individuals with eating disorders, might engage in excessive exercise, while individuals with high body image flexibility might also engage in regular exercise. We did not have such nuanced data

regarding exercise. More rigorous measurement of exercise is needed to better examine the links between exercise and body image.

## Results

### GA-derived short measure

The GA-based method applied on data from Sample 1 (the training sample) yielded a 5-item solution (see Appendix for the items of the short form) with a Cronbach's alpha of .91. The short measure (BI-AAQ-5 henceforth) explained 96% of the variance in the data of the original questionnaire. The corrected item-total correlations for the original BI-AAQ ranged from .62 to .87, and those for the BI-AAQ-5 ranged from .71 to .87. Cronbach's alpha for the BI-AAQ-5 in Sample 2 was .93. All validation tests reported below were conducted on data from Sample 2 (an independent testing sample).

### Factor structure and reliability

As the BI-AAQ is a single-factor measure (Sandoz et al., 2013), a confirmatory factor analysis (CFA) was conducted with all 12 items loading onto a single factor, with robust maximum likelihood estimation, in which the standard errors and chi-square test statistics are robust to non-normality and non-independence of observations (Huber, 1967; Muthén & Muthén, 1998-2010; White, 1980). The model fit the data well:  $\chi^2(54) = 261.79, p < .001$ , CFI = .96, TLI = .95, RMSEA = .07, 90% CI [.07 .08], as per the commonly accepted fit criteria of  $CFI/TLI \geq .90$  and  $RMSEA \leq .06$  (Bentler, 1990; Hu & Bentler, 1999; Kenny, Kaniskan, & McCoach, 2014). A second CFA was conducted by loading only the five items from the GA solution onto one factor. This CFA model also showed excellent fit:  $\chi^2(5) = 31.06, p < .001$ , CFI = .98, TLI = .96, RMSEA = .08, 90% CI [.06 .10]. The omega estimate of internal consistency of the long form was .96, 95% CI [.96 .97] and that of the GA-derived short form was .93, 95% CI [.92 .94]. These results show that the factor structure and reliability of the BI-AAQ-5 were comparable to those of the original 12-item measure.

A separate set of CFAs were conducted to test whether treating the manifest variables as ordinal instead of continuous, would affect the factor structure of the BI-AAQ and BI-AAQ-5. The fit indices of both sets of models showed that all models fit the data well, and the BI-AAQ-5 performed comparably to the BI-AAQ in all models (See Online Supplementary Material S2, Table S2), lending further support to the factor structure of the BI-AAQ-5. All results reported in the main paper are from models that treat the manifest variables as continuous, to be consistent with past research using the BI-AAQ (Sandoz et al., 2013).

### **Construct validity**

As shown in Table 1, the BI-AAQ-5 and the BI-AAQ were almost identical in terms of their correlations with a number of theoretically relevant variables. Using the standards of correlation coefficients where .10, .30, and .50 indicate small, medium, and large effect sizes respectively (Cohen, 1992), both versions of the BI-AAQ had large negative correlations with body image dissatisfaction, stigma, internalisation of societal norms of thin appearance, medium negative correlations with societal norms of muscular appearance and poor mental health, and medium positive correlations with self-compassion. Further, body image flexibility explained 76% of the variance in body image dissatisfaction, 42% of the variance in stigma, 31% of the variance in internalisation of societal norms of thin appearance, 11% of the variance in internalisation of societal norms of muscular appearance, 18% of the variance in poor mental health, and 16% of the variance in self-compassion. In the complete Sample 2, the absolute mean difference between the correlations of the long and short form of the BI-AAQ with other measures was .012, that is, the difference in the correlation patterns was negligible. In addition, BI-AAQ and the BI-AAQ-5 were correlated at .98 with each other. We hasten to add that this correlation is artifactualy inflated due to the high overlap of the items of the two measures, thus requiring further validation tests, as reported below. Also

note that consistent with prior research (Sandoz et al., 2013), the correlation of the BI-AAQ (both the long or short form) with the BSQ-8C, a measure of body image dissatisfaction, was very high (around -.86), which called for tests of the discriminant validity of the long and short form of BI-AAQ with respect to the BSQ-8C measure.

### **Covariates**

We ran individual t-tests to examine whether gender was linked to the criterion variables. These tests revealed significant gender differences for all the criterion variables; women scored higher than men on dissatisfaction, internalisation of norms of thinness, and poor mental health, and lower than men on experiences of stigma, internalisation of norms of muscularity, and self-compassion. The results of these t-tests are reported in the Online Supplementary Material S3 (Table S3). To test whether age or BMI could have any confounding effects, we looked at the correlations of age and BMI with each of the criterion variables. Age and BMI were significantly correlated with almost all the criterion variables (See Table 1). Based on these results, we decided to control for these three variables in all our structural equation models. However, the results for models using BI-AAQ and BI-AAQ-5 were comparable even when these variables were not controlled for (these results can be found on our Open Science Framework page: <https://osf.io/6uwnt/>).

### **Discriminant validity**

We conducted structural equation models (SEMs) to examine whether each version of the BI-AAQ was uniquely associated with the theoretically-relevant criterion variables of stigma, internalisation, self-compassion, and poor mental health, over and above the BSQ-8C and while controlling for gender, age, and BMI. SEMs are second generation multivariate approaches that are more powerful than the first generation approaches such as multiple regression using scale scores (Fornell, 1985). The key benefits of using SEMs – especially in combination with robust estimation methods – over linear regressions are that (a) SEMs use

latent instead of manifest variables, hence they account for measurement error, and (b) all the variables are analysed simultaneously (Alavifar, Karimmalayer, & Anuar, 2012; Fornell, 1985). We used the R package, lavaan (Rosseel, 2012) to conduct these analyses.

The fit indices of the SEMs are presented in Table 2, which shows that all models had good fit, and the standardised regression coefficients and variance explained ( $R^2$ ) are presented in Table 3 (to enhance readability of the tables, only estimates for dissatisfaction and flexibility are presented here. For the estimates of age, gender, and BMI in the reported models, please see Step 5 in each model in Online Supplementary Material S4, Tables S4 and S5). Both BI-AAQ measures were significantly uniquely associated with stigma, internalisation of both thin and muscular standards of appearance, and self-compassion, over and above body image dissatisfaction, gender, age, and BMI. For the models with poor mental health, the full-scale BI-AAQ was not significantly associated while the short form BI-AAQ-5 was. The unique associations of body image flexibility with the criterion variables were comparable to the unique associations of body image dissatisfaction with the same criterion variables. The absolute average differences in fit indices from the models with BI-AAQ and models with BI-AAQ 5 were negligible (TLI = .008, CFI = .007, RMSEA = .006). Further, the absolute mean difference in variance explained was .006 and the absolute average difference in path estimates was .05, which suggests that both versions of the BI-AAQ performed comparably in these models.

In order to compare the results from the SEM approach to the widely-used multiple regressions, we conducted both SEMs and multiple regressions step-wise, and the results for both, including the variance explained by each model, can be found in Online Supplementary Material S4 (Tables S4 and S5) and Online Supplementary Material S5 (Tables S6), respectively. The results were comparable. It should be noted, however, that slight improvements in the regression coefficients and in the variance explained are common when

using SEM, i.e., latent variable analysis, rather than multiple regression with manifest variables, because the SEM includes an estimation of measurement error whereas a traditional regression model does not. Therefore, latent variable approaches are generally considered superior to analyses relying solely on manifest variables.

As the correlation between body image dissatisfaction and psychological flexibility was large, we also checked for multicollinearity by examining the variance inflation factor (VIF) and tolerance (TOL) of our independent variables in the linear regression models, and by conducting ridge regressions. The VIF and TOL for all variables in our models were within acceptable limits of  $VIF < 5$  (Rogerson, 2001) and  $TOL > .1$  (Dormann et al., 2012). The estimates obtained from the ridge regressions remained stable as lambda increased, indicating that multicollinearity had minimal influence on our estimates and conclusions. These results are included in the Online Supplementary Materials S6, Table S7.

### Subsamples

To increase the generalisability of the results, we conducted several sensitivity analyses to evaluate the validity and utility of the long and short forms of the BI-AAQ in different subsets of Sample 2. Specifically, we examined the two measures' reliability, factor structure, and correlations with the criterion variables using only the data from potentially at-risk participants in our sample – those who scored 19 or above on the measure of body image dissatisfaction, BSQ-8C, thus indicating at least mild dissatisfaction. We considered these participants at-risk based on previous research linking body image disturbances to disordered eating (eg., Neumark-Sztainer et al., 2006). We also ran similar analyses on data from subsamples of females, males, and four different age groups separately, to compare the performance of the long and short form in these subgroups. These results are reported in Online Supplementary Material 7, Tables S8 and S9, and consistently show that the BI-AAQ-

5 performs similarly to the original 12-item BI-AAQ in terms of the alpha reliabilities, factor structure, and correlations with the criterion variables in all subsamples.

We also conducted structural equation models to test the unique associations of psychological flexibility with our criterion variables in the data from our subsample of participants with body image dissatisfaction scores of 19 and above. These supplementary analyses, reported in Online Supplementary Material S8, Tables S10 and S11, provide evidence for the incremental value of psychological flexibility, as measured by either the BI-AAQ or BI-AAQ-5, in predicting the criterion variables over and above body image dissatisfaction in the potentially at-risk group.

### **Discussion**

The key goals of this study were to shorten the Body Image – Acceptance and Action Questionnaire (BI-AAQ) by employing the questionnaire abbreviation method based on genetic algorithms (GAs), compare the short form with the original BI-AAQ in terms of their correlations with theoretically relevant criterion variables, and test the discriminant validity of the two versions of the BI-AAQ above and beyond a measure of body image dissatisfaction. In a sample of Americans from the general population, the GA-based approach produced a 5-item short form, the BI-AAQ-5, which explained 96% of the variance in the data of the original 12-item measure, and had a near perfect correlation with the original BI-AAQ. Validation tests on the BI-AAQ-5 were conducted on data from an independent sample of community adult Americans. The short and long forms were similarly correlated with and explained comparable amounts of variance in a variety of theoretically relevant criterion variables: body image-related constructs, resilience, and poor mental health. Equally as important, both versions of the BI-AAQ predicted the criterion variables similarly, over and above body image dissatisfaction. The results demonstrate that the 5-item short form performs comparably to its 12-item counterpart, proving it as a suitable alternative to the long

form, and that both versions of the BI-AAQ are distinguishable from body image dissatisfaction.

These results contribute to the growing body of evidence for the GA-based approach as an efficient and effective method for abbreviating questionnaires (Eisenbarth et al., 2015; Sahdra et al., 2016; Schroeders et al., 2016; Yarkoni, 2010). Specifically, the GA-based method limits the time taken by a researcher to find a reliable short alternative to a lengthy questionnaire and reduces computational demand on account of being a fully automated process. Further, the GA-based method is relatively easy to use (the R script for the current study is publicly available and the sample code for how to run a GA for questionnaire abbreviation in R is also presented in Sahdra et al. (2016)). The GA-based method is efficient and fast regardless of the size of the original scale, much faster than other machine learning methods (e.g., the Ant Colony Optimization method; Schroeders et al., 2016), and the time-saving benefits are especially salient when shortening lengthier questionnaires (Sandy et al., 2014).

Our results also provide a substantive contribution. We first investigated the links between body image flexibility and theoretically relevant criterion variables of body image dissatisfaction, stigma, internalisation of societal norms, self-compassion and poor mental health, and the results were as expected. We confirmed the large negative correlation found in previous studies between body image flexibility and body image dissatisfaction (Sandoz et al., 2013; Webb, 2015) with both versions of the BI-AAQ. A large correlation between these two variables was expected as both the constructs relate to body image distress – the BSQ-8C measures this distress and the BI-AAQ measures the response to the distress. The large negative correlation suggests that people who are inflexible about their negative body image concerns and find it hard to engage in value-consistent behaviour tend to also be dissatisfied about the way their body looks. This is anticipated, because in order for individuals to be

inflexible about their negative body image related thoughts, they often first need to have experienced the negative thoughts.

We found large negative correlations with stigma and the internalisation of thin norms of appearance, and a medium negative correlation with internalisation of muscular norms of appearance. These results were consistent with previous research, as individuals who are dissatisfied with their body and show psychologically inflexible behaviours, report having experienced more frequent weight-related stigma (Bauer, Yang, & Austin, 2004; Friedman et al., 2005; Diane Neumark-Sztainer, Falkner, Story, Perry, & Hannan, 2002). The negative effects of stigma are especially damaging when individuals internalise popular attitudes about appearance (Friedman et al., 2005). Fortunately, intervention studies have shown that increasing psychological flexibility can reduce both perceived stigma and internalisation (Lillis et al., 2009; Mikorski, 2013).

Body image flexibility was moderately positively correlated with self-compassion, as has been found in previous research (Ferreira et al., 2011; Kelly et al., 2014), suggesting perhaps, that people who are resilient in one regard may also be resilient in other ways. This could be because of shared characteristics between the resilience constructs, such as the ability to accept one's flaws and treat one's body (body image flexibility) and one's self (self-compassion) in a kind and nurturing way. We also found that higher body image flexibility was linked to greater mental health, a finding that is consistent with previous studies that show that being flexible in general (as measured by the AAQ) is associated with better mental health and fewer mental health issues (Callaghan, Sandoz, Darrow, & Feeney, 2015; Kashdan & Rottenberg, 2010; Wendell, 2011).

Our SEM results showed that after controlling for body image dissatisfaction, body image flexibility was uniquely associated with the criterion variables of stigma, internalisation of societal norms, self-compassion, and poor mental health. That is, body

image flexibility accounted for variance in the criterion variables even when controlling for body image dissatisfaction. These results indicate that despite being highly correlated, body image flexibility and dissatisfaction are not psychometrically redundant and that people may be able to distinguish between body image related distress and their response to such distress. In simpler terms, having negative thoughts about one's body (dissatisfaction) is linked to variables such as felt stigma and self-compassion, but so may be the way one relates to such negative thoughts about one's body (flexibility). Body image flexibility seems to be as vital as body image dissatisfaction in understanding how salient we find stigmatising situations, how much importance we place on the societal norms of appearance, how compassionate we are to ourselves, and how much body image issues affect our mental health. Not surprisingly, similar results were obtained when we conducted hierarchical linear regressions on manifest variables (instead of SEMs using latent variables), replicating the findings of previous studies using the same method, to investigate the unique associations of body image flexibility with criterion variables while controlling for body image dissatisfaction (Ferreira et al., 2011; Sandoz et al., 2013). Our findings extend past findings and make a novel contribution to the literature because they demonstrate that the brief measure performs comparably to the long form even when using the SEM approach, which is arguably more reliable and powerful than the methods used in past research. Further, past research has mostly looked at how body image flexibility and dissatisfaction explain variance in eating disorders (Ferreira et al., 2011; Hill, Masuda, & Latzman, 2013; Sandoz et al., 2013; Timko et al., 2014), while our study included less-studied constructs of felt stigma, internalisation of societal norms of thin and muscular appearances, self-compassion, and poor mental health.

Our results also showed that the BI-AAQ-5 is valid and reliable when used with subsamples of females, males, different age groups, and participants with at least mild body image dissatisfaction (an at-risk sample). Further, SEMs conducted on data from the

subsample of participants with body image concerns showed that body image flexibility still had unique associations with criterion variables above and beyond body image dissatisfaction. More importantly, the BI-AAQ-5 still performed similarly to the BI-AAQ-5 in this at-risk sample. These supplementary analyses suggest that the BI-AAQ-5 is a suitable alternative to its lengthier 12-item counterpart, regardless of the level of body image dissatisfaction of participants, their gender, or their age.

One of the limitations of our study is that we did not assess disordered eating as is commonly done in studies that include the BI-AAQ (Ferreira et al., 2011; Masuda, Hill, Tully, & Garcia, 2015; Sandoz et al., 2013). Further research could look at how the BI-AAQ-5 compares with the BI-AAQ in relation to a measure of disordered eating, although we would expect both versions of the BI-AAQ to perform equally given they are very highly correlated and demonstrated similar unique associations with a wide variety of criterion variables. Future research could also look at creating a body image flexibility measure that does not limit its assessment to people who feel fat. Feeling too thin also has negative effects on wellbeing, with body image dissatisfaction being prevalent in such populations, especially among underweight men (Bearman, Presnell, Martinez, & Stice, 2006; Kostanski, Fisher, & Gullone, 2004). Our study is also limited in its use of cross-sectional data, a limitation that can be addressed in future studies with longitudinal data that could tease apart, for example, the causal ordering of body image flexibility and perceived stigma. Further, we only focused on American samples. It remains to be seen whether our results would generalize to individuals in other countries. Although our inferences remain limited to the characteristics of our samples, our findings suggest that the short form performs similarly to the long form, even amongst the potentially at-risk participants in our sample. We hope that our results will encourage further research with younger adolescents and clinical samples of individuals suffering with illnesses such as anorexia nervosa or bulimia nervosa, as body image

dissatisfaction plays a large role in the development and maintenance of these psychiatric disorders (Stice & Shaw, 2002; Thompson, Heinberg, Altabe, & Tantleff-Dunn, 1999). It is important and useful to also test the discriminant validity of psychological flexibility in such populations, where the prevalence of body image dissatisfaction is high.

Our findings are also limited by the use of self-report measures, and the wording of the items of the BI-AAQ assumes that individuals will be aware, to some extent, of the nature of their thoughts and that they are not physically limited by their weight. Specifically, although body image refers to one's perception (i.e., thoughts or feelings) about one's own body, for some individuals (e.g., someone with an eating disorder), these perceptions may feel like literal truths while not necessarily matching reality, a situation indicating that these individuals are "fused" with their thoughts (Moran, 2010). For other individuals, however, such perceptions may be relatively accurate and match their physical situation (e.g. when they are physically limited and, therefore, cannot engage in valued action). Future research is needed to directly assess the possibility of valued action in this group of individuals. Future research could also include behavioural measures of engagement with valued actions, in addition to body image flexibility and dissatisfaction, to directly test the extent to which an individual's negative internal experiences about their body image are seen as fleeting thoughts (flexible perspective) or as literal truths (fused perspective), and how this influences their ability to act in accordance with their values. Qualitative assessments of participants' experiences could be especially helpful in shedding light on how participants relate to negative body image related thoughts. A randomized controlled trial with a cognitive-defusion intervention designed to boost psychological flexibility can also help disentangle the extent to which psychological flexibility may decouple the negative impact of body image dissatisfaction on valued activities related to eating and physical fitness, for instance. We hope that the BI-AAQ-5 will facilitate such future research. Despite its limitations, our study

supports the substitution of the BI-AAQ with the shorter BI-AAQ-5 and the notion that it may not merely be the presence of body image issues but also our reaction to such issues that affect our experiences and mental health.

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## Appendix

### *BI-AAQ-5*

Never	Very	Seldom	Sometimes	Frequently	Almost	Always
True	Seldom	True	True	True	Always	True
					True	
1	2	3	4	5	6	7

1. Worrying about my weight makes it difficult for me to live a life that I value.
2. I shut down when I feel bad about my body shape or weight.
3. My thoughts and feelings about my body weight and shape must change before I can take important steps in my life.
4. I will have better control over my life if I can control my negative thoughts about my body.
5. Feeling fat causes problems in my life.

Table 1

*Zero-order correlations between the original BI-AAQ, BI-AAQ-5, and theoretically-relevant variables in Sample 2*

	1	2	3	4	5	6	7	8	9	
1 BI-AAQ	—									
2 BI-AAQ-5	.98***	—								
3 Age		.15***	.15***	—						
4 BMI		-.28***	-.29***	.16***	—					
5 BSQ-8C		-.87***	-.86***	-.16***	.33***	—				
6 BSSI		-.65***	-.64***	-.18***	.13***	.59***	—			
7 Thin		-.56***	-.53***	-.17***	-.01	.54***	.38***	—		
8 Muscle		-.33***	-.31***	-.19***	-.16***	.26***	.37***	.58***	—	
9 SCS-SF		.39***	.40***	.24***	-.04	-.40***	-.21***	-.29***	-.12***	—
10 GHQ-12		-.41***	-.42***	-.12**	.08*	.44***	.32***	.26***	.07*	-.53***

*Note.* None of the correlations are statistically different between the two versions of the BI-AAQ. BI-AAQ = Body Image – Acceptance and Action Questionnaire; BI-AAQ-5 = Body Image – Acceptance and Action Questionnaire – 5; BMI = Body Mass Index; BSQ-8C = Body Shape Questionnaire – 8C; BSSI = Brief Situations of Stigma Inventory; Thin = Sociocultural Attitudes Towards Appearance Questionnaire – 4 thin-internalisation subscale; Muscle = Sociocultural Attitudes Towards Appearance Questionnaire – 4 muscle-internalisation subscale; SCS-SF = Self-Compassion Scale – Short Form; GHQ-12 = General Health Questionnaire-12

\* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .

Table 2

*Summary of goodness of fit for models from structural equation models using Sample 2 showing the unique variance explained by the original long form (BI-AAQ) and the new short form (BI-AAQ-5) of body image flexibility, when controlling for body image dissatisfaction, gender, age, and BMI.*

	Chi square	df	CFI	TLI	RMSEA [90% CI]
<b>Stigma</b>					
BI-AAQ	1567.93	483	.93	.92	.05 [.05 .06]
BI-AAQ 5	996.53	287	.94	.93	.06 [.05 .06]
<b>Internalisation</b>					
BI-AAQ	1765.08	477	.92	.91	.06 [.06 .06]
BI-AAQ 5	1203.40	281	.92	.91	.07 [.06 .07]
<b>Self-Compassion</b>					
BI-AAQ	2616.33	548	.87	.86	.07 [.07 .07]
BI-AAQ 5	2067.82	338	.85	.83	.08 [.08 .09]
<b>Low Mental Health</b>					
BI-AAQ	1859.97	548	.92	.91	.06 [.05 .06]
BI-AAQ 5	1274.60	338	.92	.91	.06 [.06 .06]

*Note.* CFI = comparative fit index; TLI = Tucker Lewis index; RMSEA = root mean square error of approximation; CI = confidence interval; BI-AAQ = Body Image – Acceptance and Action Questionnaire; BI-AAQ-5 = Body Image – Acceptance and Action Questionnaire – 5

Table 3

*Standardised path coefficients and variance explained ( $R^2$ ) from structural equation models using Sample 2 showing the unique variance explained by the short and long measure of body image flexibility, when controlling for body image dissatisfaction, gender, age, and BMI.*

	Body Image Flexibility long form (BI-AAQ)				Body Image Flexibility short form (BI-AAQ-5)			
	Estimate	SE	p value	$R^2$	Estimate	SE	p value	$R^2$
Stigma				.49				.50
Dissatisfaction	.05	.16	.614		-.01	.17	.907	
Flexibility	-.66	.13	.000		-.73	.14	.000	
Thin				.46				.45
Internalisation								
Dissatisfaction	.31	.07	.002		.35	.08	.002	
Flexibility	-.40	.06	.000		-.36	.07	.002	
Muscle				.30				.29
Internalisation								
Dissatisfaction	.00	.07	.997		.02	.08	.890	
Flexibility	-.46	.06	.000		-.44	.07	.000	
Self-Compassion				.46				.46
Dissatisfaction	-.28	.08	.006		-.24	.08	.025	
Flexibility	.41	.06	.000		.45	.06	.000	
Low Mental				.25				.26
Health								
Dissatisfaction	.40	.03	.001		.30	.04	.016	
Flexibility	-.13	.02	.218		-.23	.03	.041	

## Highlights

This document contains highlights for the manuscript:

### **Body Image – Acceptance and Action Questionnaire – 5: An abbreviation using Genetic**

### **Algorithms**

[Authors' details blinded for review]

1. The Body Image-Acceptance and Action Questionnaire (BI-AAQ) was reduced to 5 items
2. This short form (BI-AAQ-5) was constructed using a genetic algorithm-based method
3. The BI-AAQ-5 performed comparably to the BI-AAQ
4. Body image flexibility is distinct from closely-related body image dissatisfaction
5. Both constructs were uniquely associated with criterion variables