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Psychometric Evaluation of the Muscle Dysmorphic Disorder Inventory (MDDI) among Cisgender Gay Men and Cisgender Lesbian Women

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Abstract

Despite increasing empirical interest in muscle dysmorphia (MD), a dearth of research has assessed this construct in sexual minority populations. In particular, the psychometric properties of one of the most widely used measures of MD symptoms—the Muscle Dysmorphic Disorder Inventory (MDDI)—have not been evaluated in sexual minority populations despite emerging evidence suggesting differential risk for MD symptoms across sexual orientation groups. In this study, we assessed the psychometric properties of the MDDI in a sample of 715 cisgender gay men and 404 cisgender lesbian women ages 18-50 years who participated in a large-scale national longitudinal cohort study of sexual and gender minority adults. The factor structure of the MDDI was examined in each sample using a two-step, split-sample exploratory and confirmatory factor analytic approach. Exploratory factor analysis supported a three-factor structure in both samples, which were confirmed by confirmatory factor analysis. Moreover, results supported the internal consistency reliability and convergent validity of the MDDI subscales in both samples. Cumulatively, these findings suggest that the MDDI is an appropriate measure of MD symptoms among cisgender gay men and cisgender lesbian women.

Keywords

Muscle dysmorphia; muscle dysmorphic disorder inventory; sexual minority; gay; lesbian

1. Introduction

Muscle dysmorphia (MD) is characterized by a pathological preoccupation with one's degree of muscularity that involves distress and fear over the idea that one's body is too small or not sufficiently muscular (H. G. Pope et al., 1997). MD is classified as a specifier for the diagnosis of body dysmorphic disorder (BDD) in the current version of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013). However, overlapping aspects of the clinical presentation of MD and eating disorders, particularly in men, has promoted ongoing debates about the current classification and diagnostic criteria (e.g., the lack of a criterion addressing muscularity-oriented disordered eating behaviors) (Murray et al., 2017). The core preoccupations in MD promote the pursuit of extreme muscularity via rigid and obsessive behaviors that can have serious health consequences and impair psychosocial functioning. Specifically, individuals with MD frequently display patterns of excessive exercise or exercise dependence, patterns of muscularity-oriented disordered eating, and the use of appearance- and performance-enhancing drugs and substances (Hildebrandt et al., 2006; Zeeck et al., 2018). Further, those with MD have been found to be at increased risk of suicidality and substance abuse problems, and they are more likely to report impairments in mood and a decreased quality of life (C. G. Pope et al., 2005). Additionally, in research using non-clinical athletic samples, MD symptoms have been found to be associated with symptoms of anxiety and depression, personality traits such as perfectionism and neuroticism, and lower self-esteem (Mitchell et al., 2017).

The male sociocultural body ideal is defined by an unrealistically muscular and lean physique that is difficult or infeasible for most men to achieve (Murray et al., 2017), which may contribute to body image concerns implicated in MD development (e.g., Grieve, 2007; Olivardia, 2001; Ricciardelli & McCabe, 2004). Unfortunately, there has been a dearth of research on MD in non-heterosexual cisgender men despite increasing evidence suggesting the presence of elevated body image concerns among cisgender gay men, including concerns related to muscularity. For example, a review by Frederick & Essayli (2016) that included five large-scale studies comprised of more than 100,000 participants found that, compared to heterosexual men, gay men were more likely to report dissatisfaction with their physical appearance and with their muscle size and tone. Gay men were also more likely to have experienced appearance-related objectification (i.e., feel more judged by their looks) and pressure to achieve a certain body shape than heterosexual men. Other research has provided evidence that gay men may be more likely than heterosexual men to place particular importance on their muscularity and to report distorted cognitions about the importance of achieving an ideal body shape (Brown & Graham, 2008; Kaminski et al., 2005; Yelland & Tiggemann, 2003).

There is a similar paucity of MD research among cisgender lesbian women despite growing recognition of the importance of toned muscularity in the athletically-oriented appearance ideal for women (Girard et al., 2018), evidenced by increasingly muscular idealized female body images depicted in traditional media (Robinson et al., 2017) and social media (Tiggemann & Zaccardo, 2018). Indeed, preliminary evidence suggests that lesbian women may be at elevated risk for symptoms of MD. For example, compared to heterosexual women, lesbian women have been found to report greater disordered eating, a common clinical symptom observed in MD (Burnette et al., 2019; McClain & Peebles, 2016). Such findings have not been consistent, however, with other research suggesting that lesbian women may actually be at lower risk of eating pathology or body dissatisfaction (Alvy, 2013; Morrison et al., 2004; Shenkman & Toussia-Cohen, 2020). Lesbian women have been found to exhibit a greater drive for muscularity compared to heterosexual women (Yean et al., 2013). Notably, research suggests that, for some women, a stronger drive for muscularity and increases in associated behaviors (e.g., weightlifting, exercise) may emerge following experiences of violence, assault, or hostile environments (Gruber & Pope, 1999). Thus, the risk for MD may be elevated among those who experience physical abuse or feel targeted in a hostile environment (Tod et al., 2016), which are stressful and traumatic experiences that have been found to be more common among lesbian women (Burgess et al., 2008; Burnette et al., 2019).

Of several questionnaires that have been developed to measure MD symptoms, one of the most commonly used is the Muscle Dysmorphic Disorder Inventory (MDDI) (Hildebrandt et al., 2004), which is comprised of 13 items with three subscales assessing Drive for Size (DFS), Appearance Intolerance (AI), and Functional Impairment (FI). Notably, the MDDI is the only MD measure with a subscale specifically assessing impairment, a key diagnostic feature. The MDDI has undergone psychometric evaluation in a variety of samples (Supplemental Table 1), and all but one (Santarnecchi & Dèttore, 2012) of the studies that used factor analytic approaches replicated the original three-factor structure (Compte et al., 2019; Devrim & Bilgic, 2018; Galiana-Linares et al., 2017; Gomes et al.,

2020; Sandgren et al., 2019; Sepúlveda et al., 2019; Subaşı et al., 2018; Zeeck et al., 2018). However, of the existing psychometric evaluation studies of the MDDI, only two included women in the samples and none focused specifically on women. Critically, none of these studies reported on sexual orientation.

1.1. Current study

As noted above, there has been a lack of research on MD among gay men and lesbian women despite the potential for elevated MD symptom risk. As such, ensuring that MD measures are reliable and valid in these populations is critical for future research. The goal of the present study was to psychometrically evaluate the MDDI in samples of cisgender gay men (i.e., gay men who were assigned male sex at birth) and cisgender lesbian women (i.e., lesbian women who were assigned female sex at birth). The MDDI factor structure was first examined in each sample using a two-step, split-sample exploratory and confirmatory factor analytic approach, and then the reliability and convergent validity of the factor-analytically derived subscales were examined. Measurement invariance across cisgender gay men and cisgender lesbian women was also evaluated. Given mostly consistent findings from multiple prior validation studies, it was hypothesized that the MDDI three-factor structure and other psychometric properties would be supported in the present samples of cisgender gay men and cisgender lesbian women. We also anticipated that adequate internal consistency would be found for the MDDI subscales in the present samples. Finally, given theoretical associations between the constructs of MD and disordered eating, we hypothesized that the MDDI subscale scores would show evidence of convergent validity based on significant associations (either positive or negative, depending on the specific subscale) with certain Eating Disorder Examination-Questionnaire (EDE-Q) scores. Specifically, it was expected that MDDI AI would be significantly, positively correlated with EDE-Q Weight Concern and Shape Concern given the overlapping conceptual nature and item content of these subscales (e.g., body image concerns). It was also expected that MDDI FI would be significantly, positively correlated with EDE-Q Global Score given the impairment-relevant item content (e.g., concentration difficulties, social avoidance) across several of the subscales that comprise the Global Score. In contrast, it was expected that MDDI DFS would negatively correlate with EDE-Q Restraint and Weight Concern given that the former is focused on concerns and behaviors related to desires to be larger, whereas the latter are focused on concerns and behaviors predominantly related to desires for a lower weight.

2. Method

2.1. Procedure

The Population Research in Identity and Disparities for Equality (PRIDE) Study is a large-scale, national, and longitudinal cohort study of sexual and gender minority (SGM) adults, including individuals who identify as lesbian, gay, bisexual, transgender, and/or queer (LGBTQ) in the U.S. Specific inclusion criteria include: identification as a sexual and/or gender minority person, living in the U.S. or its territories, age ≥18 years, and the ability to read and respond to a questionnaire written in English. Data are collected on a cloud-based, web-responsive, secure platform accessible from any smartphone, tablet, or computer. Participants in The PRIDE Study are recruited through PRIDEnet (a national network

of organizations and individuals to engage SGM communities), digital communications (blog posts and newsletters), distribution of The PRIDE Study-branded promotional items, in-person outreach at conferences and events, social media advertising, and word-of-mouth. Additional details about The PRIDE Study research platform, recruitment, and design have been previously described (Lunn, Capriotti, et al., 2019; Lunn, Lubensky, et al., 2019). All PRIDE Study participants were invited to complete the 'Eating and Body Image' questionnaire from April 2018 to August 2018.

For this analysis, we included cisgender gay men and cisgender lesbian women. Cisgender gay men were defined as participants who reported a male sex assigned at birth, exclusively indicated "man" as their gender identity, and exclusively indicated "gay" as their sexual orientation. Cisgender lesbian women were defined as participants who reported a female sex assigned at birth, exclusively indicated "woman" as their gender identity, and exclusively indicated "lesbian" and/or "gay" as their sexual orientation. Participants who reported multiple gender identities or sexual orientations (other than "lesbian" and/or "gay") were excluded. Of the 10,665 participants in The PRIDE Study at that time, 4,285 completed the questionnaire. Of these, 1,090 identified as cisgender gay men and 563 identified as cisgender lesbian women. We then limited the sample to those with age <50 given that there are age-related differences in body image concerns, with younger adults under 50 years being the most affected (Nagata, Capriotti, et al., 2020). No compensation was received for questionnaire completion. This study was approved by the [redacted] Institutional Review Boards, as well as The PRIDE Study's Research Advisory Committee and Participant Advisory Committee.

2.2. Participants

2.2.1. Cisgender gay men—A total of 28 participants had > 50% of data missing and were thus excluded from analysis. The final sample consisted of 715 participants, with a mean age of 35.4 years (*SD* = 10.1, range = 18 - 50) and a mean body mass index (BMI) of 26.9 kg/m^2 (*SD* = 6.4, range = 14.7 - 64.9); 75.2% identified as White, 4.2% as Asian, 1.8% as Black, 0.8% as Native American/American Indian, 5.7% as multiracial, 4.5% as another race, and 7.8% did not report their race/ethnicity. Additionally, a total of 7.3% of participants identified as Hispanic. A majority of participants (73.7%) reported having a college degree or higher.

2.2.2. Cisgender lesbian women—A total of 33 participants had > 50% of data missing and were thus excluded from the analysis. The final sample consisted of 404 participants, with a mean age of 31.6 years (*SD* = 8.4, range = 18 - 50) and a mean BMI of 28.82 kg/m^2 (*SD* = 8.2, range = 16.6 – 67.9); 79.7% identified as White, 1.2% as Asian, 1.2% as Black, 0.3% as Native American, 4.5% as multiracial, 6.9% as another race, and 6.2% did not report their race/ethnicity. Additionally, a total of 5.7% of the participants identified as Hispanic. A majority of participants (77.5%) reported having a college degree or higher.

2.3. Measures

2.3.1. Sociodemographics—Sociodemographic information (age, race/ethnicity, and education), weight, and height were based on self-report. Body mass index (BMI) was calculated using the standard formula weight (kilograms) divided by height (meters) squared (BMI = weight/height^2).

2.3.2. Muscle Dysmorphic Disorder Inventory (MDDI)—The MDDI is a 13-item measure that assesses symptoms of muscle dysmorphia (Hildebrandt et al., 2004). Respondents rate statements on a 1 (*never*) to 5 (*always*) scale. The MDDI includes a total score and three subscales: Drive for Size (DFS), Appearance Intolerance (AI), and Functional Impairment (FI). Prior studies have supported certain psychometric properties of the MDDI among college-aged men (Hildebrandt et al., 2004) and sexual minority men (Strübel & Petrie, 2019). In the current study, among cisgender lesbian women, item five *("I think my chest is too small")* was modified to specify "*chest (muscle)*" so as to not confuse "chest" with breast size.

2.3.3. Eating Disorder Examination-Questionnaire (EDE-Q)—The EDE-Q is a self-report questionnaire that assesses disordered eating attitudes and behaviors over the previous 28 days (Fairburn & Beglin, 2008). The measure provides a Global Score (GS) and four subscale scores: Restraint (R), Eating Concern (EC), Shape Concern (SC), and Weight Concern (WC). Responses are on a 7-point scale, in which higher scores reflect greater eating-related concerns or behaviors. Frequencies of disordered eating behaviors (e.g., binge eating, compensatory behaviors) are assessed.

2.4. Data analysis

The R software (version 3.4.4) was used to conduct analyses. Continuous variables were categorized as mean ± *SD*, and categorical variables were categorized as frequency and percentages. The mechanism of missing data was examined using the nonparametric test of homoscedasticity from the *MissMech* package (Jamshidian et al., 2014), missing data imputation was performed using the *Mice* package (van Buuren & Groothuis-Oudshoorn, 2011), and multivariate normality was assessed through the Mardia's multivariate test using the *MVN* package (Korkmaz et al., 2014).

In the sample of cisgender gay men, 0.02% of values were missing. The nonparametric test of homoscedasticity suggested that the mechanism was consistent with missing completely at random ($p = .151$). Consequently, data imputation was performed using multivariate imputation by chained equations. Following recent guidelines in scale validation (Boateng et al., 2018; Swami & Barron, 2019), participants were then randomly divided in a 1:1 ratio into a first split-half ($n = 357$) and a second split-half ($n = 358$) subsample. For the sample of cisgender lesbian women, 0.02% of missing values was observed, and the nonparametric test of homoscedasticity suggested that the mechanism was consistent with missing completely at random ($p = .713$). Thus, data imputation was performed using multivariate imputation by chained equations (van Buuren & Groothuis-Oudshoorn, 2011). Participants were then randomly divided into a first split-half ($n = 202$) and a second split-half ($n = 202$) subsample.

Exploratory factor analyses (EFA) were first conducted to determine the underlying factor structure of the MDDI in the first split-half subsamples of cisgender gay men and lesbian women. Given evidence of multivariate non-normality in the first split-half subsamples (cisgender gay men: Mardia's test of multivariate kurtosis = 25.50, $p < .001$; cisgender lesbian women: Mardia's test of multivariate kurtosis = 27.27, $p < .001$), EFA with principal-axis factoring (Fabrigar et al., 1999) was conducted. As factors were conceptually expected to correlate, the non-orthogonal Oblimin rotation was used. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were used to evaluate the adequacy of the data to undergo EFA. Values of KMO > .60 and a significant Bartlett's test were considered as evidence of data acceptability (Worthington & Whittaker, 2006). A parallel analysis (Horn, 1965) was also conducted to provide empirical guidance for the number of factors to retain, with support to retain the factors for which eigenvalues (λ) from the actual data are greater than those from the randomly generated data (Hayton et al., 2004). Eigenvalues (e.g., Kaiser's >1 criterion) and the scree plot were also used in guiding decisions on factor retention. Factor loadings of at least .40 on a primary factor and absence of cross-loadings ≥ .25 on other factors were required for retaining items (Tabachnick & Fidell, 2007). The *psych* (Revelle, 2018) and *hornpa* (Huang, 2015) packages were used to conduct these analyses.

A series of CFAs on the EFA-derived models were subsequently conducted using data from the second split-half subsamples of cisgender gay men and lesbian women. Given evidence of multivariate non-normality (cisgender gay men: Mardia's test of multivariate kurtosis = 26.45, $p < .001$; cisgender lesbian women: Mardia's test of multivariate kurtosis = 48.58, $p < .001$), the CFAs were based on a robust maximum likelihood estimation method with the Satorra-Bentler scaled correction (Satorra & Bentler, 1994). Items were set to load freely, except for one item per factor, which was set to one to ensure an identified model. Model fit was evaluated using the following robust fit indices: comparative fit index (CFI), the Tucker-Lewis index (TLI), the Standardized Root Mean Square residual (SRMR), and the Root Mean Square Error of Approximation (RMSEA) with its 90% Confidence Interval. CFI and TLI values close to .95 and SRMR values close to .08 were indicative of good fit. For the RMSEA, values close to .06 were indicative of good fit and values of about .07-.08 were indicative of adequate fit (Hu & Bentler, 1999; Swami & Barron, 2019). To identify potential misspecification and offer guidance for model improvement, modification indices (MI) were examined; MI > 5.0 were considered to have a significant effect on the model (Swami & Barron, 2019). Only residuals among items from the same factor were allowed to correlate and only in the case of conceptual consistency. The Chi-square difference test ($\Delta\chi^2$) was used to compare the original and re-specified models (Albert Satorra & Bentler, 2001). The *Lavaan* (Rosseel, 2012) and *semPlot* (Epskamp, 2015) packages were used to conduct the CFAs.

Internal consistency reliability was assessed through Cronbach's Alpha and McDonald's Omega coefficient, along with their respective 95% CI (Dunn et al., 2014); values of ≥ .80 for both were considered adequate (Nunnally, 1978). Spearman's Rank Order Correlation coefficient was used to assess associations in evaluating the convergent validity of the MDDI subscales with the theoretically-related EDE-Q subscales. Following Cohen (1988), values

of $r_s \geq .10$ - .29 were considered weak, $r_s \geq .30$ - .49 were considered moderate, and $r_s \geq .50$ were considered strong.

Mann-Whitney *U* Rank tests for group comparisons were conducted for sensitivity analyses. The coefficient *r* (*r* = *z*/square root of *N*) was used to report effect size for continuous variables with .10 - .29 being considered small, .30 - .49 being considered medium, and ≥ .50 being considered large (Cohen, 1988). Finally, a multi-group CFA/measurement invariance analysis (Chen, 2007) for the retained model was conducted using each of the second split-half subsamples to evaluate configural, metric, and scalar invariance of the MDDI across cisgender gay men and lesbian women. Briefly, configural invariance assumes that the hypothesized factor structure is the same across groups (if data does not fit at this level, invariance does not hold at any level), metric invariance implies that factor loading magnitudes are similar across groups, and scalar invariance implies that item loadings and item intercepts are similar across groups. ΔCFI < .01 was considered as an indicator of metric invariance, and scalar invariance was supported when ΔCFI < .01 and ΔRMSEA < .015 (Chen, 2007; Cheung & Rensvold, 2002). The *psych* (Revelle, 2018) and *Hmisc* (Harrell, 2008) packages were used for descriptive and bivariate statistics, and the *semTools* (Jorgensen et al., 2018) package was used to assess model invariance.

3. Results

3.1. Results for cisgender gay men

3.1.1. Descriptives—In the first split-half subsample, the mean age was 35.27 years (*SD* = 9.88) and the mean BMI was 27.18 kg/m^2 (*SD* = 6.71); in the second split-half sample, the mean age was 35.51 years (*SD* = 10.19) and the mean BMI was 26.61 kg/m^2 (*SD* = 6.11). There were no significant differences in age (Mann-Whitney U test: $z = 1.02$, $p = .847$, Cohen's $r = .04$) or BMI (Mann-Whitney U test: $z = -0.55$, $p = .291$, Cohen's $r = .02$) between the split-half subsamples.

3.1.2. EFA results—Data from the first split-half subsample ($n = 357$) were found to be adequate for EFA based on the KMO index (.81), Bartlett's test of sphericity ($\chi^2(78) = 2871.89$, $p < .001$), and a mean item communality of .60. Parallel analysis results suggested retaining three factors; the first three factors from the observed data demonstrated λs greater than the corresponding criterion λs generated by the parallel analysis ($\lambda_1 = 3.44 > 0.40$; $\lambda_2 = 2.46 > 0.25$; $\lambda_3 = 0.91 > 0.19$). The λ of the fourth factor from the actual data was lower than the corresponding criterion λ ($\lambda_4 = 0.08 < 0.19$) (Supplemental Figure 1a). As such, a three-factor solution was selected that accounted for 60.81% of the variance. Table 1 presents factor loadings, eigenvalues, and explained variance. Item primary factor loadings ranged from .63 to .94 across factors, and no cross-loadings ≥ .25 on other factors were observed. Item communalities ranged from .47 to .83.

3.1.3. CFA results—Using the factor structure derived from the EFA, a CFA was then conducted in the second split-half subsample ($n = 358$). Fit indices of the initial model indicated poor fit (CFI = .86, TLI = .83, RMSEA = .11 [95% CI = .06, .13], SRMR = .09). Inspection of the MI indicated high correlations between items 11 ("*I pass up social activities with friends because of my workout schedule*") and 13 ("*I pass up chances to*

meet new people because of my workout schedule") (MI:173.33) from the FI subscale and between items 5 ("*I think my chest is too small*") and 8 ("*I wish my arms were bigger*") from the DFS subscale (MI: 38.78). The model was re-specified, allowing error from these item pairs to correlate; the re-specified model had significantly improved fit ($\Delta\chi^2(2, n = 358) = 18.18$, $p < .001$), and fit indices of this re-specified model were acceptable (CFI = .94, TLI = .92, RMSEA = .09 [95% CI = .07, .10], SRMR = .08). Figure 1a shows standardized parameters (factor loadings, factor correlations) for the re-specified model. All factor loadings were statistically significant (ps < .001) and > .30 (standardized parameters).

3.1.4. Internal consistency reliability and convergent validity—Supplemental Table 2 presents internal consistency reliabilities for the MDDI and EDE-Q subscales for both split-half subsamples. Cronbach's alpha for the three MDDI subscales values ranged from .84 and .86, and the omega coefficient ranged from .82 and .86 across the MDDI subscales, thus supporting internal consistency reliability. Table 2 shows descriptive statistics and intercorrelations among variables for the first and second split-half subsamples of cisgender gay men. Convergent validity of the three MDDI subscales was evaluated based on theoretically expected patterns of association with EDE-Q scales, as described above. Specifically, as expected, AI was significantly (and strongly) positively correlated with both EDE-Q WC (r_s = .77 to .81, ps < .01) and EDE-Q SC (r_s = .80 to .83, ps < .01) in both subsamples. Further, as expected, FI was significantly (and moderately) positively correlated with EDE-Q GS in both subsamples (r_s = .26 to .28, ps < .01). Finally, as expected, DFS was significantly (albeit weakly) negatively correlated with EDE-Q WC in both subsamples (r_s = −.11 to −.17, ps < .05), although non-significant correlations were observed between DFS and EDE-Q R (r_s = −.09 to .04; ps > .05).

3.2. Results for cisgender lesbian women

3.2.1. Descriptives—In the first split-half sample, mean age was 31.52 years (SD = 8.29) and mean BMI was 28.53 kg/m^2 (SD = 8.07); in the second split-half sample, mean age was 31.77 years (SD = 8.63) and mean BMI was 29.12 kg/m^2 (SD = 8.35). There were no significant differences in age (Mann-Whitney U test: z = 1.16, p = .876, Cohen's r = .06) or BMI (Mann-Whitney U test: z = −0.20, p = .425, Cohen's r = .01) between the split-half subsamples.

3.2.2. EFA results—Data from the first split-half subsample (n = 202) were found to be adequate for EFA based on the KMO index (.74), Bartlett's test of sphericity ($\chi^2(78) = 1307.56$, $p < .001$), and a mean item communality of .57. Parallel analysis results suggested retaining three factors; the first three factors from the observed data demonstrated λs greater than the corresponding criterion λs generated by the parallel analysis ($\lambda_1 = 2.90 > 0.63$; $\lambda_2 = 2.24 > 0.35$; $\lambda_3 = 1.13 > 0.28$). The λ of the fourth factor from the actual data was lower than the corresponding criterion λ ($\lambda_4 = 0.19 < 0.22$) (Supplemental Figure 1b). As such, a three-factor solution was selected that accounted for 56.74% of the variance. Table 1 presents factor loadings, eigenvalues, and explained variance. Item primary factor loadings ranged from .50 to .87 across factors, were above the .40 suggested threshold, and showed no cross-loadings ≥ .25 on other factors. Item communalities ranged from .27 to .76.

3.2.3. CFA results—Using the factor structure derived from the EFA, a CFA was then conducted in the second split-half subsample ($n = 202$). Fit indices of the initial model were marginally below the suggested thresholds (CFI = .93, TLI = .91, RMSEA = .08 [95% CI = .06, .10], SRMR = .08). Consistent with the CFA results for cisgender gay men, inspection of the MI indicated high correlations between items 11 and 13 (MI: 47.81) from the FI subscale and between items 5 and 8 (MI: 13.62) from the DFS subscale. The model was re-specified, allowing error from these item pairs to correlate; the re-specified model had significantly improved fit ($\Delta\chi^2(2, n = 202) = 102.34$, $p < .001$), and fit indices of this re-specified model were acceptable (CFI = .97, TLI = .97, RMSEA = .05 [95% CI = .02, .07], SRMR = .08). Figure 1b shows standardized parameters (factor loadings and factor correlations) for the re-specified model. All factor loadings were statistically significant (ps < .001) and > .30 (standardized parameters), with the exception of item 5 (factor loading = .19, $p = .045$).

3.2.4. Internal consistency reliability and convergent validity—Supplemental Table 3 presents internal consistency reliabilities for the MDDI and EDE-Q subscales for both split-half subsamples. Cronbach's alpha for the three MDDI subscales values ranged from .76 and .84, and the omega coefficient ranged from .80 to .87 across the MDDI subscales, thus supporting internal consistency reliability. Table 3 shows descriptive statistics and intercorrelations among variables for the first and second split-half subsamples of cisgender lesbian women. Convergent validity of the three MDDI subscales was evaluated in both split-half subsamples based on theoretically expected patterns of association with EDE-Q scales, as described above. Specifically, as expected, AI was significantly (and strongly) positively correlated with both EDE-Q WC (r_s = .75 to .79, ps < .01) and EDE-Q SC (r_s = .80 to .81, ps < .01) in both subsamples. Further, as expected, FI was significantly (and moderately) positively correlated with EDE-Q GS in both subsamples (r_s = .23 to .25, ps < .01). Finally, as expected, DFS was significantly (and weakly to moderately) negatively correlated with EDE-Q WC in both subsamples (r_s = −.15 to −.26, ps < .05); DFS was significantly (albeit weakly) negatively correlated with EDE-Q R ($r_s = -.16$; $p < .05$) only in the first-split half subsample with a non-significant association observed in the second split-half subsample.

3.3. Sensitivity analysis

No significant differences were observed between the randomized first and second split-half samples of cisgender gay men on the DFS (Mann-Whitney U test: $z = -0.27$, $p = .393$, Cohen's $r = .01$), AI (Mann-Whitney U test: $z = 0.56$, $p = .713$, Cohen's $r = .02$), or FI (Mann-Whitney U test: $z = 0.59$, $p = .722$, Cohen's $r = .02$) subscales. Similarly, there were no significant differences between the randomized first and second split-half samples of cisgender lesbian women on the DFS (Mann-Whitney U test: $z = -0.07$, $p = .474$, Cohen's $r = .01$), AI (Mann-Whitney U test: $z = -1.26$, $p = .895$, Cohen's $r = .06$), or FI (Mann-Whitney U test: $z = 0.75$, $p = .772$, Cohen's $r = .04$) subscales.

3.4. Measurement Invariance

Results from the multi-group CFA that was conducted to evaluate measurement invariance of the respecified model of the MDDI supported invariance at the configural level, indicating

that the number of latent factors and the pattern of item loadings were similar across cisgender gay men and cisgender lesbian women. In addition, metric invariance was also observed (ΔCFI = .008), suggesting that the magnitude of the loadings was similar across groups. Further, scalar invariance was not observed (ΔCFI = .037, ΔRMSEA = .095), indicating that intercepts and means differed across groups (Table 4). Consistent with this, subsequent group comparison analyses revealed significant differences in the DFS subscale between cisgender gay men and cisgender lesbian women (Mann-Whitney U test: $z = -11.49$, $p < .001$, Cohen's $r = .48$). However, no significant differences were observed for the AI (Mann-Whitney U test: $z = -0.30$, $p = .381$, Cohen's $r = .01$) or FI (Mann-Whitney U test: $z = 0.22$, $p = .587$, Cohen's $r = .01$) subscales across cisgender gay men and cisgender lesbian women.

4. Discussion

This study represents the first psychometric evaluation of the MDDI in cisgender gay men and cisgender lesbian women. Sexual minority populations have been mostly neglected within the MD literature, perhaps due in part to a limited understanding of the nature of the MD construct in these populations (including any potential differences compared to cisgender, heterosexual men), as well as uncertainty regarding the applicability and utility of existing measures. This is particularly concerning given prior findings indicating that greater levels of body dissatisfaction and/or disordered eating in sexual minority groups may increase the risk for exhibiting MD symptoms (Frederick & Essayli, 2016). Establishing support for the psychometric properties of a measure in a sample that is distinct from those previously studied is a critical first step to using the measure in future research on the populations of interest. As such, the objective of this study was to evaluate the psychometrics of the MDDI in samples of cisgender gay men and cisgender lesbian women. Results from EFA and CFA approaches replicated the original three-factor structure in both groups, and both configural and metric level measurement invariance were also supported. Further, the internal consistency reliability of the three MDDI subscales was consistently supported across groups, and there was good evidence for the convergent validity of the subscales. Specifically, AI was positively correlated with both EDE-Q WC and EDE-Q SC, FI was positively correlated with EDE-Q GS in both subsamples, and DFS was negatively correlated with EDE-Q WC among both cisgender gay men and cisgender lesbian women.

Our analyses replicated the three-factor structure that was originally described (Hildebrandt et al., 2004) and that has been replicated in numerous other samples (Compte et al., 2019; Santarnecchi & Dèttore, 2012; Sepúlveda et al., 2019; Subaşi et al., 2018; Zeeck et al., 2018), indicating the robustness of the distinctive latent factors that are assessed by the three subscales of the MDDI (i.e., drive for size, appearance intolerance, and functional impairment). This robustness was further indicated by support for both configural and metric level measurement invariance, indicating equivalence of the MDDI factor structure across cisgender gay men and cisgender lesbian women. Notably, while other self-report questionnaires designed to assess MD symptoms also include similar subscales addressing muscularity-, size-, and/or appearance-related concerns, the MDDI is unique in its inclusion of multiple items comprising a subscale focused on impairment, which is a required criterion for the diagnosis of BDD with MD (i.e., in the DSM-5, American

Psychiatric Association, 2013). Indeed, given that muscularity-oriented concerns and related behaviors may be common to a certain degree among men and women (Girard et al., 2018; Murray et al., 2017), the inclusion of a scale that explicitly assesses psychosocial impairment is especially important in determining whether symptoms reflect a clinically salient level of severity. Further, consistent with the idea that impairment may arise either due to concerns about size specifically or appearance/body shape broadly, the Functional Impairment subscale was significantly positively associated with both the Drive for Size and Appearance Intolerance subscales in both cisgender gay men and cisgender lesbian women. Interestingly, however, the Drive for Size and Appearance Intolerance subscales were significantly *negatively* correlated in three of the four split-half samples. While other studies in men have shown a positive correlation between Drive for Size and Appearance Intolerance subscales (Compte et al., 2019; Gomes et al., 2020; Hildebrandt et al., 2004), a German sample of predominantly women similarly found a negative correlation (Zeeck et al., 2018). Among many women, including cisgender lesbian women, a drive for leanness or thinness may be more salient, which would contrast with a drive for larger size (Henn et al., 2019). Similarly, some cisgender gay men may ascribe to a body image ideal that more strongly emphasizes leanness or thinness, which would also contrast with a drive for larger size (Nagata, Capriotti, et al., 2020).

In addition to replicating the factor structure, the MDDI subscales had evidence of good reliability and validity in the current samples of cisgender gay men and cisgender lesbian women. Specifically, there was support for the internal consistency reliability of the three subscales in both groups, suggesting that the items on each of the respective subscales are similarly assessing the latent construct. Further, the subscales evidenced convergent validity based on significant correlations with conceptually related scales assessing facets of disordered eating pathology (e.g., weight and shape concerns, restraint). To provide further psychometric support for use of the MDDI with samples of cisgender gay men and cisgender lesbian women, it is recommended for future studies to evaluate other psychometric properties that were unable to be determined in the current study given the nature of the available measure and research design, particularly test-retest reliability, discriminant validity, and prospective validity.

Although both configural and metric level measurement invariance were supported for the MDDI across cisgender gay men and cisgender lesbian women, there were some notable group differences in the MDDI subscale scores that contributed to the lack of invariance at the lowest level. Specifically, the Drive for Size subscale was significantly higher in cisgender gay men than in cisgender lesbian women, which is consistent with the greater emphasis on muscularity size and bulk characterizing the generalized ideal male body, versus an emphasis on muscularity tone in the generalized ideal female body. This is consistent with findings from a German sample that similarly found higher Drive for Size in men versus women (sexual orientation was not reported; Zeeck et al., 2018). In contrast, scores on the Appearance Intolerance subscale did not significantly differ between cisgender gay men and cisgender lesbian women. The lack of differences in the Appearance Intolerance subscale may be due to the broader focus of the items, which assess more generalized body-related concerns that may affect cisgender gay men and cisgender lesbian women similarly (e.g., concerns about body fat, hesitation about one’s body being exposed).

This contrasts with Zeeck and colleagues (2018), who found greater Appearance Intolerance in women versus in men. Similar to the Appearance Intolerance subscale, and consistent with Zeeck and colleagues (2018), scores on the Functional Impairment subscale did not significantly differ between groups in the current study, likely suggesting a similar impact of muscularity-related concerns on social and psychological functioning in cisgender gay men and cisgender lesbian women.

Strengths of the study include the focus on populations that have been under-recognized and under-researched in the MD literature, the large sample sizes that facilitated a split-sample exploratory-then-confirmatory factor analytic approach, and examination of numerous different psychometric properties of the MDDI (*i.e.*, factor structure, internal consistency, convergent validity, and measurement invariance). However, there are limitations that also should be noted. First, we did not have data collected at multiple time points that would have allowed us to examine either test-retest reliability or prospective validity. Additionally, we did not have data from measures of constructs that were sufficiently conceptually distinct from MD to use in evaluating the discriminant validity of the MDDI subscales. Further, despite conceptual overlap between MD and disordered eating, there were limitations to using the EDE-Q for evaluating the convergent validity of the MDDI subscales, and future studies should provide further validation using other muscularity-oriented measures (e.g., the Muscularity Oriented Eating Test; Murray et al., 2019). Finally, our samples were predominantly White, highly educated, and limited to ages 18-50 years, and findings, thus, may not generalize to all cisgender gay men, cisgender lesbian women, or to other or all sexual minority samples. No bisexual participants were included, though bisexual individuals may be at elevated risk of excessive exercise and disordered eating (Nagata, Compte, et al., 2020; Von Schell et al., 2018). MD, eating disorders, and body image may be differentially experienced by individuals based on the complex intersection of multiple identities, including, but not limited to, sexual orientation, race/ethnicity, age, ability status, and socioeconomic status, a concept called intersectionality (Burke et al., 2020; Readdy et al., 2011). Finally, we were not able to develop a clinical cutoff for MD in cisgender gay men or lesbian women, and it is unclear if previously developed cutoffs in non-sexual minority populations are appropriate for our sample (Zeeck et al., 2018).

5. Conclusions

Taken together, the current findings provide preliminary support for the MDDI as an appropriate measure for use in studies of MD symptoms among cisgender gay men and lesbian women. As validation studies of the MDDI have not assessed sexual orientation or focused on sexual minority populations, despite potentially elevated risk for MD, the present investigation represents an important foundation for use of the MDDI in future research with sexual minority samples. These preliminary findings also suggest that the measure may have utility in clinical settings with regard to evaluating for MD symptoms in cisgender gay men and cisgender lesbian women patients. Future research will be needed to provide further psychometric validation of the MDDI in these populations, particularly in terms of test-retest reliability and other forms of validity. Given the relatively limited diversity of samples in the existing MD literature (see Santos Filho et al., 2016), future psychometric studies of other minority populations—including gender minorities (e.g., transgender men and

women), other sexual minorities (e.g., bisexual, asexual, pansexual, etc.) and racial/ethnic minorities—also will be needed. Additionally, the potential clinical utility of the MDDI will be bolstered by future studies that provide population-based and clinical prevalence, descriptives, and norms for the measure to aid in the interpretation of the MDDI subscale scores across diverse populations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- We validated the Muscle Dysmorphic Disorder Inventory in cisgender gay men and lesbian women.
- Exploratory factor analysis supported three factors in gay men and lesbian women.
- The internal consistency of the MDDI subscales was supported in both samples.
- There was support for convergent validity of the MDDI subscales in both samples.
- The MDDI can be used to assess muscle dysmorphia in gay and lesbian adults.

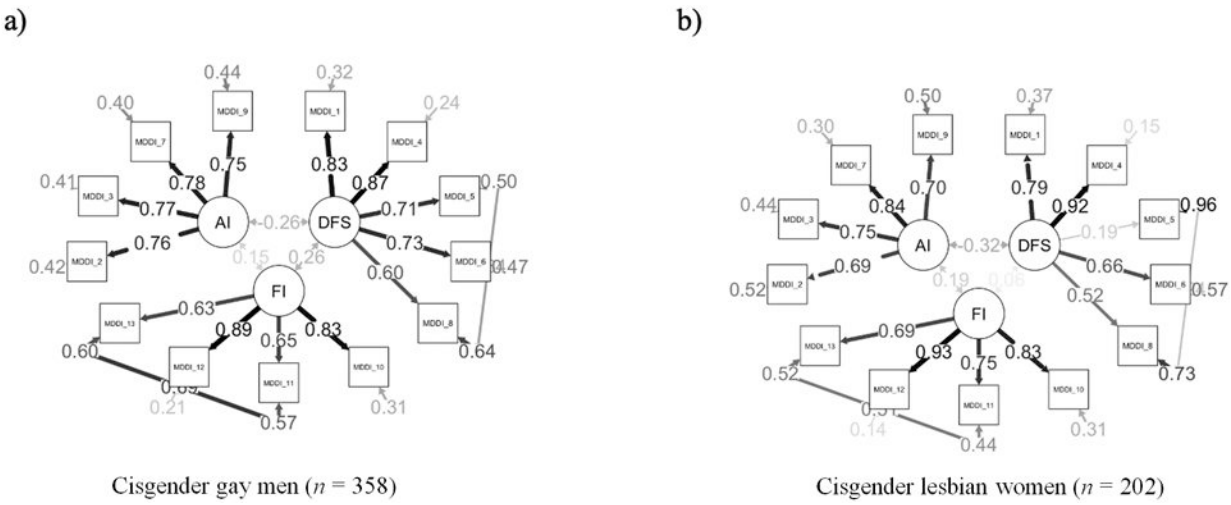

Figure 1.

Confirmatory factor analysis of the re-specified retained three-factor model for the Muscle Dysmorphia Disorder Inventory (MDDI) in second split-half subsamples of cisgender gay men (n = 358) and lesbian women (n = 202) in The PRIDE Study.

Note. DFS = Drive for Size factor, AI = Appearance Intolerance factor, FI = Functional Impairment factor.

Table 1

Factor loading for the Exploratory Factor Analysis in first split-half of cisgender gay men (n = 357) and cisgender lesbian women (n = 202) participants in The PRIDE Study.

	Cisgender gay men (*n* = 357)				**Cisgender lesbian women (*n* =202)**			
	Factor loadings			**h^2**	**Factor loadings**			**h^2**
Item/Factor	**1**	**2**	**3**		**1**	**2**	**3**	
Drive for Size (DFS)								
1. I think my body is too small.	**.72**	−.04	−.04	.55	**.80**	−.11	−.04	.62
4. I wish I could get bigger.	**.86**	−.11	.01	.80	**.86**	−.01	−.03	.76
5. I think my chest is too small.	**.77**	.09	.00	.58	**.50**	.13	.16	.27
6. I think my legs are too thin.	**.69**	−.04	.02	.49	**.72**	.09	.09	.52
8. I wish my arms were bigger.	**.64**	.23	.11	.47	**.65**	.09	−.05	.45
Appearance Intolerance (AI)								
2. I wear loose clothing so that people can' see my body.	−.10	**.71**	.05	.55	.07	−.01	**.77**	.56
3. I hate my body.	.07	**.80**	.01	.63	.11	−.11	**.73**	.49
7. I feel like I have too much body fat.	−.21	**.71**	.05	.61	−.23	.09	**.75**	.74
9. I am very shy about letting people see me with my shirt off.	.06	**.77**	−.08	.56	.04	.04	**.65**	.43
Functional Impairment (FI)								
10. I feel anxious when I miss one or more workout days.	.16	.14	**.63**	.53	−.11	**.77**	.07	.62
11. I pass up social activities with friends because of my workout schedule.	−.06	−.07	**.94**	.83	.08	**.87**	−.07	.76
12. I feel depressed when I miss one or more workout days.	.06	.09	**.74**	.61	.01	**.71**	.13	.55
13. I pass up chances to meet new people because of my workout schedule.	.01	−.03	**.85**	.71	.04	**.76**	.07	.57
Eigenvalue	4.06	1.66	3.31	-	3.48	3.17	1.96	-
Explained variance	22.13	18.43	20.25	-	20.51	19.33	16.90	-

Table 2

Descriptive statistics and intercorrelations for first and second split-half subsamples of cisgender gay men (n = 715) in The PRIDE Study.

		Split-half sample 1 (*n* = 357)	Split-half sample 2 (*n* = 358)								
		M (*SD*)	*M* (*SD*)	1	2	3	4	5	6	7	8
1	**MDDI DFS**	10.11 (4.65)	10.44 (4.89)	-	−.16**	.24**	−.09	−.03	−.11*	−.02	−.08
2	**MDDI AI**	11.74 (4.31)	11.59 (4.33)	−.20**		.11*	.40**	.63**	.77**	.80**	.78**
3	**MDDI FI**	6.27 (3.15)	6.16 (3.05)	.33**	.12*		.28**	.22**	.22**	.20**	.26**
4	**EDE-Q R**	1.48 (1.41)	1.53 (1.44)	.04	.35**	.39**		.48**	.57**	.54**	.73**
5	**EDE-Q EC**	0.73 (1.12)	0.65 (0.98)	−.04	.60**	.26**	.47**		.74**	.75**	.80**
6	**EDE-Q WC**	2.02 (1.52)	2.01 (1.48)	−.17**	.81**	.21**	.49**	.69**		.88**	.93**
7	**EDE-Q SC**	2.57 (1.67)	2.46 (1.61)	−.08	.83**	.22**	.50**	.72**	.89**		.95**
8	**EDE-Q GS**	1.86 (1.27)	1.81 (1.25)	−.09	.80**	.28**	.68**	.77**	.92**	.96**	

Note: MDDI-DFS = MDDI Drive for Size subscale; MDDI AI = MDDI Appearance Intolerance subscale; MDDI FI = MDDI Functional Impairment subscale; EDE-Q R = EDE-Q Restraint subscale; EDE-Q EC = EDE-Q Eating Concern subscale; EDE-Q WC = EDE-Q Weight Concern subscale; EDE-Q SC = EDE-Q Shape Concern Subscale; EDE-Q GS = EDE-Q Global Score

Correlations for the first split-half sample are located below the diagonal. Correlations for the second split-half sample are located above the diagonal.

* $p < .05$

** $p < .01$

Table 3

Descriptive statistics and intercorrelations for the first and second split-half subsamples of cisgender lesbian women (n = 404) in The PRIDE Study.

		Split-half sample 1 (*n* = 202)	Split-half sample 2 (*n* = 202)								
		M (*SD*)	*M* (*SD*)	1	2	3	4	5	6	7	8
1	**MDDI DFS**	6.83 (3.08)	6.42 (2.41)	-	−.04	.27**	−.06	−.01	−.15*	−.07	−.10
2	**MDDI AI**	11.97 (3.99)	11.93 (4.13)	−.19**		.15*	.42**	.65**	.79**	.81**	.79**
3	**MDDI FI**	6.12 (2.92)	6.16 (3.05)	.17*	.15*		.25**	.23**	.20**	.25**	.25**
4	**EDE-Q R**	1.38 (1.39)	1.38 (1.46)	−16*	.47**	.31**		.53**	.57**	.57**	.71**
5	**EDE-Q EC**	0.80 (1.00)	0.85 (1.08)	−.13	.61**	.17*	.46**		.76**	.76**	.82**
6	**EDE-Q WC**	2.16 (1.48)	2.05 (1.58)	−.26**	.75**	.22**	.66**	.71**		.92**	.95**
7	**EDE-Q SC**	2.25 (1.53)	2.23 (1.68)	−.20**	.80**	.16*	.58**	.71**	.91**		.95**
8	**EDE-Q GS**	1.78 (1.23)	1.75 (1.34)	−.22**	.78**	.23**	.76**	.76**	.95**	.95**	

Note: MDDI-DFS = MDDI Drive for Size subscale; MDDI AI = MDDI Appearance Intolerance subscale; MDDI FI = MDDI Functional Impairment subscale; EDE-Q R = EDE-Q Restraint subscale; EDE-Q EC = EDE-Q Eating Concern subscale; EDE-Q WC = EDE-Q Weight Concern subscale; EDE-Q SC = EDE-Q Shape Concern Subscale; EDE-Q GS = EDE-Q Global Score

Correlations for the first split-half sample are located below the diagonal. Correlations for the second split-half sample are located above the diagonal.

* $p < .05$

** $p < .01$

Table 4

Measurement invariance between second split-half subsamples of cisgender gay men (*n* =358) and lesbian women *(n* =202) in The PRIDE Study.

Fit	*df*	AIC	χ^2	Δ χ^2	Δ *df*	*p*	Robust CFI	Δ Robust CFI	ΔRobust RMSEA	ΔRobust SRMR
Configural	120	19120	348.60	-	-	-	.946	-	.076	-
Metric	130	19159	407.25	21.7	10	.017	.938	.008	.078	.002
Scalar	140	19289	557.64	244.8	10	<.001	.902	.037	.095	.017

Note: Fit Configural = base model; Fit Metric = testing for differences in factor structure; Fit Scalar = testing for differences in item means.