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SYSTEMATIC REVIEW

Muscle Dysmorphia Symptomatology and Associated Psychological Features in Bodybuilders and Non-Bodybuilder Resistance Trainers: A Systematic Review and Meta-Analysis

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Abstract
Background Muscle dysmorphia (MD) is associated with a self-perceived lack of size and muscularity, and is characterized by a preoccupation with and pursuit of a hypermesomorphic body. MD symptoms may hypothetically be more prevalent in bodybuilders (BBs) than in non-bodybuilder resistance trainers (NBBRTs).
Objective Our objective was to compare MD symptomatology in BBs versus NBBRTs and identify psychological and other characteristics associated with MD in these groups.
Methods We searched relevant databases from earliest record to February 2015 for studies examining MD symptoms in BBs and/or NBBRTs. Included studies needed to assess MD using a psychometrically validated assessment tool. Study quality was evaluated using an adapted version of the validated Downs and Black tool. We calculated between-group standardized mean difference (effect sizes [ESs]) and 95 % confidence intervals (CIs) for each MD subscale, and performed meta-analysis when five or more studies used the same MD tool. We also extracted data describing psychological or other characteristics associated with MD.
Results Of the 2135 studies initially identified, 31 analyzing data on 5880 participants (BBs: $n = 1895$, NBBRTs: $n = 3523$, controls: $n = 462$) were eligible for inclusion, though study quality was generally poor–moderate (range 7–19/22). Most participants were male (90 %). Eight different MD assessment tools were used. Meta-analysis for five studies all using the Muscle Dysmorphia Inventory (MDI) revealed there was a medium to large pooled ES for greater MD symptomatology in BBs than in NBBRTs on all MDI subscales (ES 0.53–1.12; $p \leq 0.01$). Competitive BBs scored higher than non-competitive BBs (ES 1.21, 95 % CI 0.82–1.60; $p < 0.001$). MD symptoms were associated with anxiety (r 0.32–0.42; $p \leq 0.01$), social physique anxiety (r 0.26–0.75; $p < 0.01$), depression (r 0.23–0.53; $p \leq 0.01$), neuroticism (r 0.38; $p < 0.001$), and perfectionism (r 0.35; $p < 0.05$) and were inversely associated with self-concept (r –0.32 to –0.36; $p < 0.01$) and self-esteem (r –0.42 to –0.47; $p < 0.01$).
Conclusions MD symptomatology was greater in BBs than in NBBRTs. Anxiety and social physique anxiety, depression, neuroticism, and perfectionism were positively associated with MD, while self-concept and self-esteem were negatively associated. It remains unclear whether these characteristics are exacerbated by bodybuilding, or whether individuals with these characteristics are attracted to the bodybuilding context.

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Key Points

Greater muscle dysmorphia symptomatology is present in bodybuilders than in non-bodybuilder resistance trainers.

Muscle dysmorphia is associated with anxiety, depression, perfectionism, and low self-esteem.

Further evidence is required to elucidate whether bodybuilding is a cause of muscle dysmorphia or whether bodybuilding attracts those predisposed to muscle dysmorphia.

1 Introduction

Societal expectations of the ideal physique for men and women have evolved over time [1, 2]. A large body of research has identified the ideal male physique as mesomorphic, strong, athletic, and lean [3–5]. For females, there is an increasing acceptability of a lean and muscular physique, progressing from the previously idealized thin and toned body [5, 6]. The rewards for attaining this ideal physique, and the pressure associated with achieving it, drive attempts to alter body size and shape and, particularly for males, increase muscle size and strength [5, 6]. This is achieved through dietary modifications as well as exercise, especially resistance training. The popularity of muscularity-enhancing pursuits has steadily increased. Evidence suggests that resistance training is one of the most common worldwide fitness trends [7], the use of muscle-building dietary supplements such as protein and creatine is common [8, 9], and the prevalence of anabolic–androgenic steroid (AAS) use in adolescents and adults is predicted to be high [10, 11].

Muscle dysmorphia (MD) is characterized by a pathological preoccupation with, and pursuit of, a lean hypermuscular body, coupled with the belief that one is insufficiently muscular [12]. Individuals engage in obsessive behaviors regarding nutrition, exercise, and often AAS use to achieve this mesomorphic body [13, 14]. While muscle dissatisfaction is increasingly common among males [15, 16], the distinguishing characteristics differentiating MD from a non-pathological desire to increase muscle mass are the overvaluation of the ideal body shape and a disproportionate influence of one's body in determining self-worth [17]. In conjunction with this is a disturbed body-image perception, whereby individuals have a core belief that they are insufficiently muscular, when in fact they are large and strong [18]. Compensatory efforts to allay the anxiety associated with this belief include engagement in rigid pathological eating and exercise practices [18–20] and often also excessive use of dietary supplements and AAS [13, 14]. Mild deviation from these regimens results in marked distress [18]. The body dissatisfaction is associated with other behavioral symptoms, including declining social, occupational, or recreational activities to maintain workout and diet schedules and avoiding situations where the body is exposed, such as the locker room or beach [18].

A similarly fastidious pursuit of hyper-muscularity is often seen amongst bodybuilders (BBs), who commit to a rigorous diet and training regimen with the aim of achieving a highly muscular, lean, symmetrical, and well-proportioned physique [21]. In competitive bodybuilding, participants pose before a panel of judges, who score each entrant on the basis of muscular size, definition, development, and symmetry [21]. Individuals may rely heavily on the use of supplements to attain the most muscular and sculpted physique, and a subgroup of BBs use appearance- and performance-enhancing drugs designed to aid in the accumulation of muscle mass, including AAS [22–24]. Thus, it is logical to suggest that bodybuilding as a context and process may appeal to those with MD symptoms, either seeking body image satisfaction or removal of existing symptoms; likewise, the performance and social context itself could also increase the manifestation of MD symptomatology and associated behaviors.

In delineating between the pathological pursuit of muscularity, and a sport that covets the cultivation of muscle mass, the history of MD has been intertwined with bodybuilding since its recognition in the early 1990s. The first reported cases of MD were in a group of BBs who described beliefs of appearing small and weak despite the reality of them being physically large and muscular [25]. The authors identified these BBs as experiencing a "reverse anorexia" because of the similar but reversed body-related concerns and behaviors as those experienced with anorexia nervosa. Subsequent research led to the renaming of the condition as MD based on the thesis that compulsive exercise was more central in MD than pathological eating [18], with tentative diagnostic criteria formalizing the nosological integrity of this cluster of symptoms. Since then, the disorder has been often measured in BBs, power lifters [19], recreational weight trainers [26], college footballers [27], and non-trained individuals [28].

Given the increasing popularity of resistance training to improve muscularity, both within the general community and in athletes, and the well-documented benefits of increased muscle mass and reduced fat mass for chronic disease prevention [29], a critical endeavor lies in accurately delineating between healthful muscularity-enhancing pursuits versus pathological endeavors. Whereas several reviews of MD have been published spanning both its nosological status [20, 30] and etiological underpinnings [17, 31], few have explicitly addressed the distinction between a pathological versus non-pathological pursuit of hyper-muscularity, and many have conflated the terms bodybuilding and MD. An inadequate distinction between such pursuits is of great clinical and empirical significance, as the pathologizing of normative muscularity-enhancing pursuits likely augments the existing stigma related to muscularity-related body image concerns [32], as well as confounding treatment studies. Therefore, the primary aim of this study was to conduct a systematic review with meta-analysis to compare MD symptomatology between BBs and non-bodybuilder resistance trainers (NBBRTs). Such a comparison will determine whether engagement in bodybuilding results in more severe MD symptomatology. A secondary aim was to identify psychological features and other characteristics associated with MD in BBs and NBBRTs.

2 Methods

2.1 Design

One researcher (LM) conducted a systematic literature search to identify studies examining MD in BBs and resistance-trained individuals. Databases searched from earliest record until February 2015 were MEDLINE (Ovid), PsycINFO (Ovid), CINAHL (EBSCO), Proquest 5000 (via Proquest central), Scopus, PubMed, SPORTDiscus (EBSCO), and Web of Science.

The search strategy combined the following keywords: (muscle dysmorphia, bigorexia, reverse anorexia, Adonis complex, manorexia, male eating disorder) and (bodybuilding, body building, bodybuilder, body builder, strength training, weight training, resistance training, progressive training, progressive resistance, weight lifting, athlete). Reference lists of all retrieved papers were manually searched for potentially additional eligible papers. Following the search, we completed a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) [33] informed systematic review process.

2.2 Inclusion and Exclusion Criteria

Included studies were required to describe MD in participants defined by study authors as BBs or NBBRTs. Studies could be descriptive, cross-sectional, case study, or longitudinal in design. Baseline measurement of MD from randomized controlled trials or intervention studies was also eligible for inclusion. Studies were included if they measured MD using a psychometrically validated scale of MD symptomatology and were considered eligible if participants were in any phase of training, competition preparation, or competition recovery. As the number of magazine and newspaper articles and television and radio transcripts was large, the search was limited to full-text peer-reviewed journal manuscripts. Theses were excluded. Manuscripts from all languages were included.

After eliminating duplicates, one reviewer (LM) screened the search results against the eligibility criteria. Those references that could not be eliminated by title and abstract were retrieved and independently reviewed for inclusion.

2.3 Data Extraction and Conversions

Data relating to the manuscript, namely author(s), date of publication, and country in which the study was conducted, were recorded. The institution country of the first author was used as the country if the study country was not described in the text. Data extracted from each paper included participant characteristics (age, sex, hours of training per week, years of training, competition caliber, weight, height, body composition, and ethnicity), MD assessment tools used and scores, data on assessed psychological features (perfectionism, anxiety, self-esteem, neuroticism, self-concept, depression, extraversion), including the psychological assessment tool utilized and correlation (Pearson's r) with MD score. Likewise, any information related to AAS and other performance-enhancing substance use and comorbid diagnoses were extracted. All data were independently extracted from each paper by two of four researchers (LM, DH, SC, LC), with disagreements resolved by discussion with a third researcher (HO). Where journal articles contained insufficient information, we attempted to contact authors to obtain missing details. In some studies, data for MD scores were presented in graphical format rather than numerical form. In this instance, graphs were enlarged and data obtained using a ruler, in duplicate. Anthropometrical parameters reported in imperial units (e.g., pounds, inches) were converted to kg and cm (1 kg = 2.2 pounds; 1 cm = 0.3937 inches). Body mass index (BMI) was calculated (weight/height^2) from the mean height (m) and body mass (kg). Extracted data were presented as mean and standard deviation (SD) when SD was reported. Weighted means were calculated for age, anthropometric variables, and training history.

2.4 Assessment of Methodological Quality

The methodological quality of the 31 papers that met inclusion criteria were assessed by two of three researchers (LM, JG, LC) using a modified version of an assessment scale devised by Downs and Black [34]. One researcher (LM) assessed all papers. Two others (JG, LC) shared the parallel assessment of the 31 papers. In using the scale, 16 of the 27 items of the original checklist were retained. Items 4, 8, 9, 13, 14, 15, 17, 19, 23, 24, and 26 were excluded because they related to interventions (items 4, 8, 13, 14, 17, 19, 23, 24), follow-up assessments (9, 26), and blinding of subjects and measurers (14, 15) and therefore were not relevant to the included studies. The following additional seven items were included from a secondary checklist [36] because they were relevant to the assessment of the literature included in this study:

- "If cohort or cross-sectional study, were groups comparable on important confounding factors and/or were pre-existing differences accounted for by using appropriate adjustments in statistical analysis?"
- "Were psychological measures appropriate to the question and outcome of concern?" (Modified from "nutrition measures")
- "Were the observations and measurements based on standard, valid, and reliable data collection instruments/procedures?"
- "Was clinical significance as well as statistical significance reported?"
- "Was there a discussion of findings?"
- "Were study biases and study limitations identified and discussed?"
- "Were the sources of funding and investigators' affiliations described?"

Each reviewer checked for internal (intra-rater) validity across items for each paper. Differences in scores between researchers were discussed, with disagreements resolved via discussion with a third researcher (HO) for consensus.

2.5 Analyses

To descriptively compare MD symptomatology between BBs and NBBRTs, and to identify characteristics associated with MD, we calculated the between-group standardized mean difference, or effect size (ES), and 95 % confidence interval (CI) for each subscale of MD tools used in studies that provided sufficient data. We transferred the extracted data (mean, SD, and sample size) to Comprehensive Meta-Analysis (CMA) version 2 software (Biostat, 2005, Englewood, IL, USA) to calculate the ES and 95 % CIs.

We did not conduct a data analysis for studies that did not provide sufficient data (i.e., mean, SD, or sample size). Instead, we extracted and tabulated the raw data. We used extracted correlation data between MD score and psychological features to identify associations between MD symptomatology and psychological features. These correlations were not analysed; we extracted and tabulated raw data (Pearson's *r*) instead.

2.6 Meta-Analyses

To quantitatively compare MD symptomatology between BBs and NBBRTs, we performed meta-analyses of mean differences of Muscle Dysmorphia Inventory (MDI) subscales between BBs and NBBRTs. We did not perform meta-analyses of mean differences of other scales because the number of studies using each of these scales to compare BBs with NBBRTs were insufficient to warrant meta-analysis. We used CMA for all pairwise comparisons in the quantitative analysis. Standardized mean differences (ES), standard error, variance, and 95 % CI were calculated. We applied an invariance random-effects model, assuming that studies drew on divergent populations and contexts and potentially included different research designs. We generated forest plots to display the ES and 95 % CI results of each study and the pooled estimate, which was described based on Cohen's suggestions [35], whereby a small ES was >0.2, a medium ES was >0.5, and a large ES was >0.8. A positive ES indicated an effect favoring BBs, whereas a negative ES indicated an effect favoring NBBRTs. The Q statistic (with degrees of freedom [*df*] and p value) provided a test of the null hypothesis that all studies shared a common ES. If all studies shared a similar ES, the Q value would be approximately equal to the *df*. The I^2 statistic identified the proportion of the observed variance, reflecting differences in true ESs as opposed to sampling error. Moderate to high values (i.e., $\geq$0.50) were considered as demarcating the likelihood of heterogeneity.

To maintain independence, only one BB group and one NBBRT group were included in the meta-analysis from each paper. Where more than one group was present in a study, (1) competitive BBs were selected; (2) non-AAS users were selected; (3) NBBRTs for a sport were not selected.

3 Results

3.1 Identification and Selection of Studies

The original search netted 2135 potential articles, and an additional article was included after hand searching the reference list of all retrieved papers. We removed 624 duplicates, then screened the titles and abstracts to exclude a further 1431 and, finally, retrieved the full text of the remaining 81 articles. Of these, we excluded 50 as they did not meet the eligibility criteria, resulting in 31 eligible manuscripts. Figure 1 presents a summary of the systematic PRISMA process.

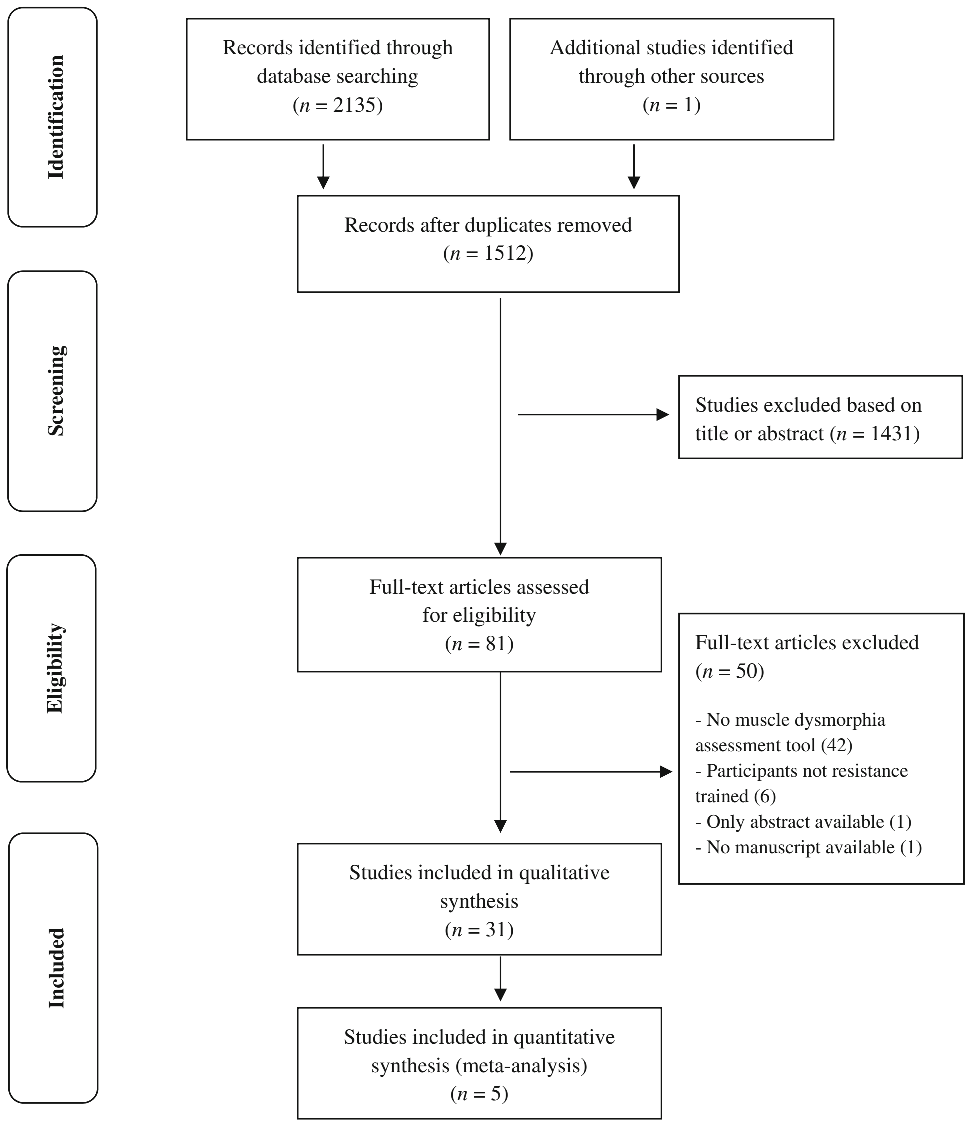

Fig. 1 Flowchart showing the process for inclusion of studies

3.2 Evaluation of Methodological Quality

We evaluated the methodological quality of 29 of the 31 studies. Two studies [48, 54] could not be rated because an adequate English translation of all text was not available. The mean quality rating score was 12.2 (SD $\pm$ 2.5) from a possible 22 (Table S1 in the Electronic Supplementary Material [ESM]). All studies described the main outcomes to be measured, described the main findings in the results, and discussed the findings. All but one study [13] specified their hypotheses, and all but one study [57] used appropriate statistical tests. The lowest scores were for items "Were the subjects asked to participate in the study representative of the entire population?" (mean score 0.03 $\pm$ 0.19), "Were those subjects who were prepared to participate representative of the entire population from which they were recruited?" (mean score 0.07 $\pm$ 0.26), and "Was there adequate adjustment for confounding in the analyses from which the main findings were drawn?" (mean score 0.07 $\pm$ 0.26).

3.3 Demographic Characteristics, Competition Phase/Caliber, and Drug Use

Participant demographic characteristics are outlined in Tables 1 and 2 for studies including BBs and NBBRTs, respectively. The 31 studies described a total of 5880 participants (BBs, $n = 1895$; NBBRTs, $n = 3523$, non-training controls, $n = 462$). The weighted mean age of all participants was 28 $\pm$ 7.6 years. The male and female BBs were aged 30.9 $\pm$ 8.6 and 34.2 $\pm$ 8.7 years, respectively. The male and female NBBRTs were aged 27.3 $\pm$ 7.4 and 22.2 $\pm$ 5.5 years,

Table 1 Participant characteristics of bodybuilders

Study, country	Group (*n*)	Sex (age, y)	Weight, kg	Height, cm	BMI, kg/m^2	% Fat	Training, y	Caliber	Drug use
Babusa and Tury [37], Hungary	BB (60)	M (27.7 ± 7.53)	88.5 ± 14.73	180.6 ± 7.23	27.13			NC	18.3 % yes
	Control (60)	M (27.8 ± 7.45)	80 ± 12.47	180.5 ± 8.62	24.55			NS	
Boyda and Shevlin [47], UK	BB (51)	M (31.33 ± 8.06 [18–55])						NS	
Castro-Lopez et al. [48], Spain	BB (154)	M, F (24.97 ± 6.9 [16–49])						NS	
Gonzalez-Marti et al. 2014 [49], Spain	BB and weightlifters (734)	M, F (30.92 ± 9.41)	73.73 ± 12.07	171 ± 8.47	25.2			NS	
Lopez-Barajas et al. [50], Spain	BB (154)	M, F (24.97 ± 6.9 [16–49])						NS	
Wolke and Sapouna [51], UK	BB (200)	M (29.8 ± 9.1 [16–62])	92.9 ± 15.13	177.83 ± 7.55	29.28 ± 4.49			NS	
Baghurst and Lirgg [27], USA	Non-natural BB (47)	M	96.13 ± 13.44	167.41 ± 35.36	34.33	10.28 ± 2.36	16.02 ± 10.26	P	Yes
	Natural BB (65)	M (32.22 ± 11.12)	87.56 ± 11.33	173.86 ± 20.75	28.97	9.43 ± 3.11	12.97.76	80.3 % P	No
	Weight train for physique (115)	M (29.78 ± 10.22)	88.7 ± 15.58	177.62 ± 12.93	28.12	12.83 ± 7.04	8.51 ± 8.16	NS	
	Footballers (66)	M (20.5 ± 4.41)	103.15 ± 18.57	185.55 ± 8.31	29.96	10.31 ± 4.38	5.68 ± 2.44	NCAA collegiate	
Cella et al. [44], Italy	BB (119)	M (30.63 ± 7.85)						NS	
	Non-BB (98)	M (30.86 ± 8.669)						NS	
Davies and Smith [38], UK	Former AAS-users (30)	M (30 [18–48])						NC	No
	AAS users (30)	M (30 [18–70])						NC	Yes
Hale et al. [26], USA	E BB (26)	F (18–48)					7.95 ± 5.65	E	
	NV BB (29)	F (18–48)					7.48 ± 5.23	NV	
	Fitness lifters (19)	F (18–48)					3.96 ± 3.16	NS	
Lantz et al. [19], USA	BB (100)	M, F (30.99 ± 7.22)					12.75 ± 4.49	N	
	Powerlifters (68)	M, F (31.68 ± 6.62)					15.53 ± 7.74	N	
Santarnecchi and Dettore [28], Italy	C BB (60)	M (33 ± 7 [23–41])			27.93			C	
	NC BB (60)	M (32 ± 10 [23–36])			24.6			NC	
	Control (non-training) (60)	M (33 ± 8 [24–37])			25.02			NS	
Skemp et al. [42], USA	AE (51)	M, F (35.3)	77	159.77	30.16			C, NC	
	PE (82)	M, F (27.4)	86.05	172.72	28.84			C, NC	
Soler et al. [43], Brazil	BB (25)	M (30.8 ± 5.45)	81.8 ± 17.24	174 ± 7.0	27.76 ± 5.03		11.12 ± 6.87	N	
	Gymgoers (151)	M (27.66 ± 6.54)	82.87 ± 13.11	177 ± 7.0	26.72 ± 4.24		6.25 ± 5.62	NS	

Data are presented as mean ± standard deviation [range]

AAS anabolic–androgenic steroids, *AE* appearance enhancement, *BB* bodybuilder, *BMI* body mass index, *C* competitive, *E* expert, *F* female, *M* male, *N* national, *NC* non-competitive, *NCAA* National Collegiate Athletic Association, *NS* not stated, *NV* novice, *P* professional, *PE* performance enhancement

Table 2 Participant characteristics of non-bodybuilder resistance trainers

Study, country	Group (*n*)	Sex (age, y)	Weight, kg	Height, cm	BMI, kg/m^2	% Fat	Training, y	Drug use
Babusa et al. [39], Hungary	Weightlifters (289)	M (28 ± 7.43)	87.8 ± 14.76	179.6 ± 6.06	27.2 ± 4.13		6.1 ± 6.08	10 % yes
	Controls (240)	M (20.3 ± 2.78)	75.6 ± 14.7	181.6 ± 7.48	22.9 ± 3.98			
Cafri et al. [63], USA	Weightlifters with MD (23)	M						
	Weightlifters without MD (28)	M						
Hildebrandt et al. [52], USA	Weightlifters (237)	M (32.64 ± 12.37)			26.7 ± 4.35	12.52 ± 5.6	8.92 ± 7.94	
Kanayama et al. [40], USA	AAS users (48)	M (29.3 ± 6.5)						Yes
	Non-users (41)	M (30.1 ± 10.5)						No
Kim [54], Korea	Resistance trained (429)	M						
Kuennen and Waldrom [53], USA	Resistance trained (49)	M (28.27 ± 8.35)	93.71 ± 14.07	179 ± 0.7	29.25	18.36 ± 6.14		
Maida and Armstrong [55], USA	Resistance trained (106)	M (18–45)						
Segura-Garcia et al. [46], Italy	Male gain (52)	M (27.2 ± 6.8)			23.6 ± 2.8			
	Male lose (34)	M (28.4 ± 7)			26.5 ± 2.2			
	Female lose (48)	F (28.6 ± 5.8)			21.6 ± 2.9			
	Eating disorder (20)	F (22.1 ± 5.6)			18.7 ± 2.9			
Thomas et al. [41], UK	Resistance trained (146)	M (22.8 ± 5.0)	82 ± 11.1	180 ± 7.0	25.1 ± 3.0		2.9 ± 1.9	
De Lima et al. [61], Brazil	Resistance trained (23)	M (24 ± 3.8)	75.9 ± 9.4					
Giardino and Procidano [57], Mexico	Male Mexican (35)	M (23.34 ± 4.26)						
Mexico	Female Mexican (11)	F (22.18 ± 2.4)						
USA	Male USA (43)	M (20.47 ± 2.26)						
	Female USA (24)	F (20.17 ± 1.37)						
Nieuwoudt et al. [59], Australia	Resistance trained (648)	M (29.5 ± 10.1)						
Olivardia et al. [13], USA	Weightlifters with MD (24)	M (25.4 ± 3.7)	89.63 ± 16.36	175.51 ± 6.86	28.94	13.1 ± 5.4		46 % yes
	Weightlifters without MD (30)	M (25.4 ± 3.2)	84.54 ± 16.27	177.29 ± 6.1	26.98	14.1 ± 6		7 % yes
Robert et al. [58], USA	Male (55)	M (24.06 ± 7.96)	83.45 ± 14.72	181.23 ± 6.81	25.32 ± 3.73		3.85 ± 1.22	
	Female (59)	F (21.88 ± 5.34)	61.93 ± 7.54	168.22 ± 7.1	22.02 ± 2.67		3.49 ± 1.28	
Skemp et al. [42], USA	Male (79)	M (31.7)	93.0	175.6	30.16			
	Female (54)	F (29.3)	67.23	158.28	26.84			
Thomas et al. [56], UK	Resistance trained (30)	M (20.93 ± 2.6)	86.87 ± 10.59	176.0 ± 1.0	28.04		3.57 ± 2.53	13 % yes
Tod and Edwards [60], UK	Resistance trained (294)	M (20.5 ± 3.1)					2.47 ± 2.4	
Valdes et al. [62], Chile	Male (112)	M [18–25]						
	Female (88)	F [18–25]						

Data are presented as mean ± standard deviation [range]

AAS anabolic-androgenic steroids, *BMI* body mass index, *F* female, *M* male, *MD* muscle dysmorphia respectively. The male and female non-training controls were aged 23.7 ± 4.4 and 27.3 ± 6.2 years, respectively. Of the 31 studies, 21 described men, one described women, and the remaining nine studies described both men and women. A large number of studies were conducted in Europe ($n = 14$) and the USA ($n = 12$), whereas two were from Brazil, and one each were from Australia, Chile, and Korea. The BBs had trained for a mean of 10.8 years (range 4–16) and the NBBRTs for 5 years (range 2.5–9). Use of anabolic agents was reported in seven of the 31 studies [13, 27, 37–41], with two of these studies also reporting or implying no steroid use because participants were competing in drug-tested competition, leaving the drug-taking status of the remaining 24 studies unknown.

Eight of 31 studies reported participant caliber [19, 26–28, 37, 38, 42, 43]. Participants were identified as national [19, 43], professional [27], expert [26], novice [26], competitive or non-competitive [28, 37, 38, 42] (see Tables 1, 2). One study reported the competition phase of participants [19], and the remaining 30 studies did not identify the phase of training or competition cycle.

3.4 Anthropometric and Body Composition Characteristics

The weighted mean height of male and female BBs was 175.4 cm (range 154.9–180.6) and 156.2 cm (range 150–168.3), respectively; of male and female NBBRTs was 178.6 cm (range 172.7–185.6) and 165.6 cm (range 153–168.2), respectively; and of male non-training controls was 181.4 cm (range 180.5–181.6). None of the studies reported height for female non-training controls. The weighted mean body mass, BMI, and percent fat of male BBs was 90.9 kg (range 81.8–96.1), 29.7 kg/m^2 (range 24.6–37.5), and 9.8 % (range 9.4–10.3), respectively. In male NBBRTs, these parameters were 86.9 kg (range 75.9–103.2), 27.2 kg/m^2 (range 25.1–30.0), and 12.9 % (range 10.3–18.4), respectively. In male non-training controls, weighted mean body mass and BMI were 76.5 kg (range 75.6–80) and 23.5 kg/m^2 (range 22.9–25), respectively. The weighted mean body mass and BMI for female BBs were 65.5 kg (range 63.6–69) and 27 kg/m^2 (range 24.4–28.3), respectively. For female NBBRTs, these parameters were 64.2 kg (range 61.9–70.9) and 23.6 kg/m^2 (range 22–28.4), respectively. For female non-training controls, weighted mean BMI was 22.7 kg/m^2 (range18.7–26.5). No studies reported body fat for females or non-training controls nor body mass for female non-training controls.

3.5 Muscle Dysmorphia (MD) Assessment Tools

In the 31 studies, eight different tools were used to assess MD. The most commonly used tools were the MDI ($n = 11$) and the Muscle Appearance Satisfaction Scale (MASS) ($n = 11$). Other tools used were the Muscle Dysmorphic Disorder Inventory (MDDI) ($n = 6$), the Adonis Complex Questionnaire ($n = 3$), the Bodybuilder Image Grid (BIG) ($n = 2$), the Muscle Dysmorphia Questionnaire ($n = 2$), the Muscle Dysmorphia Symptom Questionnaire (MDSQ) ($n = 2$), and the Muscle Appearance Satisfaction Scale-6 ($n = 1$).

3.6 MD

The results of MD symptom severity assessment are presented in Tables 3, 4 and 5. Computations of standardized mean difference, ESs, and 95 % CIs are presented in Tables 6, 7, 8, 9, 10, 11, 12 and 13.

3.6.1 Do Bodybuilders (BBs) Display More MD Symptoms than Non-BBs?

Eight of 31 studies compared the prevalence of MD symptoms in BBs and non-BBs, each of which provided sufficient data to enable the calculation of ES [19, 26–28, 37, 42–44]. The BB groups comprised competitive, non-competitive, steroid using, non-steroid using, expert, novice, male, and female BBs. Non-BBs ranged from non-training controls and recreational fitness lifters to competitive powerlifters and collegiate footballers. The eight studies used four tools to measure MD symptoms: MDI ($n = 4$), MDDI ($n = 1$), MASS ($n = 1$), MDDI and BIG ($n = 1$), and MDI and MASS ($n = 1$).

The MD subscale scores of the BB are summarized in Table 2. Five studies assessed MD using the MDI in BBs and NBBRTs [19, 26, 27, 42, 44]. In the case of the dietary behavior subscale, all five studies showed a significant ES of BBs on subscale score (ES range 0.66–1.96, $p < 0.001$) [19, 26, 27, 42, 44]. Similarly, for the supplement use subscale, all five studies showed a positive ES for BBs (ES range 0.1–2.35), four of which were significant ($p \leq 0.002$) [26, 27, 42, 44]. Four of five studies showed a positive ES for BBs for the pharmacological use subscale (ES range –0.1 to 0.99), three of which were significant ($p < 0.001$) [19, 42, 44]. On the exercise dependence subscale, three of the four studies showed a significant positive ES for BBs (ES range 0.03–2.15, $p \leq 0.006$) [26, 42, 44]. For the size/symmetry subscale, all five studies showed a positive ES for BBs (ES range 0.09–1.67), of which four were significant ($p \leq 0.04$) [19, 26, 42, 44]. The final subscale, physique protection, also had an ES favoring BBs in all five studies (ES range 0.07–1.13), with a significant difference in four studies ($p \leq 0.021$) [19, 26, 42, 44].

Two studies assessed MD using the MDDI in BBs [28, 43]. One study used NBBRTs as a comparison group

Table 3 Muscle dysmorphia assessment results of bodybuilders

Study	Group	*n*	Tool	Subscale	Results	Main findings
Baghurst and Lirgg [27]	Non-natural BB	47	MDI	Dietary behavior	23.04 ± 3.37	Non-natural BB significantly higher ($p < 0.05$) than natural BB on pharmacological subscale, significantly higher ($p < 0.05$) than weight training for physique on all subscales except physique protection and size/symmetry, significantly higher ($p < 0.05$) than football on all subscales except physique protection
				Supplement use	17.85 ± 3.83	
				Pharmacological use	6.29 ± 2.57	
				Size/symmetry	21.15 ± 4.92	
				Physique protection	14.38 ± 5.53	
	Natural BB	65	MDI	Dietary behavior	23.35 ± 4.73	Natural BB significantly higher ($p < 0.05$) than weight training for physique on dietary behavior, supplement use. Significantly higher ($p < 0.05$) than football for all subscales except physique protection and pharmacological use
				Supplement use	16.63 ± 3.99	
				Pharmacological use	3.65 ± 1.38	
				Size/symmetry	20.02 ± 5.14	
				Physique protection	13.46 ± 4.82	
	Weight training for physique (NBBRT)	115	MDI	Dietary behavior	20.17 ± 4.89	Significantly higher ($p < 0.05$) than football for dietary behavior, size/symmetry
				Supplement use	13.82 ± 4.96	
				Pharmacological use	3.79 ± 1.47	
				Size/symmetry	19.52 ± 5.67	
				Physique protection	13.08 ± 5.79	
	Football	66	MDI	Dietary behavior	16.56 ± 4.85	Significantly higher ($p < 0.05$) than natural BB for dietary behavior, size/symmetry
				Supplement use	12.3 ± 4.6	
				Pharmacological use	5.62 ± 4.03	
				Size/symmetry	16.83 ± 4.8	
				Physique protection	17.38 ± 5.62	
Cella et al. [44]	BB	119	MDI, MASS	Dietary behavior	22.45 ± 5.52	$n = 4$ (3.4 %) met MD diagnostic criteria. BB significantly higher ($p \leq 0.003$) scores on all MDI subscales, significantly higher ($p < 0.001$) scores on all MASS subscales except muscle satisfaction
				Supplement use	16.49 ± 5.97	
				Pharmacological use	4.71 ± 3.25	
				Exercise dependence	18.61 ± 4.27	
				Size/symmetry	17.59 ± 6.41	
				Physique protection	14.88 ± 8.47	
				MASS total	55.72 ± 16.93	
				Bodybuilding dependence	14.41 ± 5.64	
				Muscle checking	10.21 ± 5.08	
				Substance use	9.73 ± 4.55	
				Injury	9.09 ± 3.64	
				Muscle satisfaction	11.25 ± 3.26	
	NBBRT	98	MDI, MASS	Dietary behavior	10.98 ± 8.86	
				Supplement use	6.6 ± 3.51	
				Pharmacological use	3.12 ± 0.52	
				Exercise dependence	9.96 ± 5.17	
				Size/symmetry	8.86 ± 3.65	
				Physique protection	7.5 ± 2.63	
				MASS total	33.02 ± 9.4	
				Bodybuilding dependence	8.02 ± 3.54	
				Muscle checking	5.31 ± 2.3	
				Substance use	5.07 ± 2.16	
				Injury	5.11 ± 3.13	
				Muscle satisfaction	9.55 ± 3.13	

Table 3 continued

Study	Group	n	Tool	Subscale	Results	Main findings
	BB, AAS users		MDI, MASS	Dietary behavior	24.26	AAS users significantly higher ($p < 0.05$) on all MDI subscales except exercise dependence, significantly higher ($p \leq 0.003$) on all MASS subscales except muscle satisfaction
				Supplement use	19.0	
				Exercise dependence	19.21	
				Size/symmetry	21.44	
				Physique protection	19.74	
				Bodybuilding dependence	17.47	
				Muscle checking	12.3	
				Substance use	12.79	
				Injury	10.88	
				Muscle satisfaction	11.02	
	BB, AAS non-users		MDI, MASS	Dietary behavior	21.43	
				Supplement use	15.07	
				Exercise dependence	18.28	
				Size/symmetry	15.41	
				Physique protection	12.13	
				Bodybuilding dependence	12.68	
				Muscle checking	9.03	
				Substance use	8.0	
				Injury	8.08	
				Muscle satisfaction	11.38	
Hale et al. [26]	Expert BB	26	MDI	Dietary behavior	23.92 ± 3.78	Expert and novice BB significantly higher ($p < 0.05$) than fitness lifters on all subscales except pharmacological use and physique protection. No difference between expert and novice BB
				Supplement use	18.42 ± 4.82	
				Pharmacological use	4.27 ± 1.71	
				Exercise dependence	19.54 ± 3.64	
				Size/symmetry	17.62 ± 4.34	
				Physique protection	13.04 ± 3.84	
	Novice BB	29	MDI	Dietary behavior	21.44 ± 5.32	
				Supplement use	14.1 ± 6.21	
				Pharmacological use	4.34 ± 2.58	
				Exercise dependence	16.93 ± 3.66	
				Size/symmetry	16.17 ± 6.69	
				Physique protection	13.97 ± 7.24	
	Fitness lifters (NBBRT)	19	MDI	Dietary behavior	13.89 ± 6.39	
				Supplement use	7.86 ± 3.77	
				Pharmacological use	3.63 ± 1.64	
				Exercise dependence	11.31 ± 3.93	
				Size/symmetry	10.26 ± 4.29	
				Physique protection	10.53 ± 2.98	
Lantz et al. [19]	BB	100	MDI	Dietary behavior	32.9 ± 8.15	BB significantly higher ($p < 0.001$) than powerlifters on all subscales except supplement use and exercise dependence
				Supplement use	15.59 ± 5.15	
				Pharmacological use	12.76 ± 4.56	
				Exercise dependence	20.9 ± 3.44	
				Size/symmetry	18.9 ± 5.17	
				Physique protection	7.88 ± 2.95	
	Powerlifters (NBBRT)	68	MDI	Dietary behavior	26.16 ± 7.89	
				Supplement use	15.15 ± 6.62	
				Pharmacological use	9.89 ± 3.34	
				Exercise dependence	20.78 ± 4.17	
				Size/symmetry	16.24 ± 5.44	
				Physique protection	6.46 ± 2.63	

Table 3 continued

Study	Group	*n*	Tool	Subscale	Results	Main findings
Skemp et al. [42]	Appearance enhancement athletes (BB)	51	MDI	Dietary behavior	20 ± 6	Appearance enhancement significantly higher ($p < 0.01$) than performance enhancement on all MDI subscales
				Supplement use	13 ± 6	
				Pharmacological use	4 ± 1	
				Exercise dependence	17 ± 4	
				Size/symmetry	15 ± 6	
				Pharmacology use	10 ± 4	
	Performance enhancement athletes (NBBRT)	82	MDI	Dietary behavior	15 ± 6	
				Supplement use	10 ± 5	
				Pharmacological use	3 ± 1	
				Exercise dependence	15 ± 4	
				Size/symmetry	13 ± 5	
				Physique protection	8 ± 3	
	Male weight trainers (NBBRT)	79	MDI	Dietary behavior	17 ± 6	Males significantly higher ($p < 0.05$) than females on supplement use, physique protection, size/symmetry
				Supplement use	12 ± 5	
				Pharmacological use	3 ± 1	
				Exercise dependence	16 ± 4	
				Size/symmetry	16 ± 6	
				Physique protection	10 ± 4	
	Female weight trainers (NBBRT)	54	MDI	Dietary behavior	17 ± 7	
				Supplement use	10 ± 6	
				Pharmacological use	4 ± 1	
				Exercise dependence	16 ± 4	
				Size/symmetry	11 ± 4	
				Physique protection	9 ± 3	
Santarnecchi and Dettore [28]	Competitive BB	60	MDDI, BIG	MDDI total	38.5 ± 7.97	Competitive BB significantly higher ($p < 0.01$) than non-competitive and non-training controls on MDDI total and all subscales, current muscle mass, ideal muscle mass, most attractive muscle mass indices of BIG. Significantly lower ($p < 0.001$) than non-competitive BB and non-training individuals on all fat indices of BIG
				Drive for size	15.45 ± 4.78	
				Appearance intolerance	10.32 ± 3.9	
				Functional impairment	11.87 ± 3.58	
				Current body type—fat	27.33 ± 17.84	
				Current body type—muscle mass	64.33 ± 12.12	
				Ideal body type—fat	14.33 ± 9.63	
				Ideal body type—muscle mass	75.17 ± 16.0	
				Most attractive body type—fat	15.33 ± 9.47	
				Most attractive body type—muscle mass	69.0 ± 16.12	
				Most attractive to women—fat	19.0 ± 11.75	
				Most attractive to women—muscle mass	51.67 ± 13.92	
	Non-competitive BB	60	MDDI, BIG	MDDI total	29.6 ± 6.56	Non-competitive BB significantly higher ($p < 0.01$) than non-training individuals on MDDI total and all subscales, and current, ideal and most attractive muscle mass BIG indices. Significantly lower ($p < 0.05$) than non-training individuals on current and ideal fat indices
				Drive for size	10.0 ± 4.0	
				Appearance intolerance	14.63 ± 3.95	
				Functional impairment	6.32 ± 4.17	
				Current body type—fat	41.67 ± 18.33	
				Current body type—muscle mass	46.83 ± 18.55	
				Ideal body type—fat	30.5 ± 17.02	
				Ideal body type—muscle mass	53.17 ± 9.83	
				Most attractive body type—fat	32.5 ± 17.31	
				Most attractive body type—muscle mass	53.17 ± 9.11	
				Most attractive to women—fat	31.5 ± 17.45	
				Most attractive to women—muscle mass	47.33 ± 14.36	

Table 3 continued

Study	Group	n	Tool	Subscale	Results	Main findings
	Non-training individuals	60	MDDI, BIG	MDDI total	16.1 ± 3.45	
				Drive for size	5.83 ± 2.66	
				Appearance intolerance	6.23 ± 2.79	
				Functional impairment	3.57 ± 1.68	
				Current body type—fat	50.67 ± 18.4	
				Current body type—muscle mass	29.33 ± 15.17	
				Ideal body type—fat	37.33 ± 16.04	
				Ideal body type—muscle mass	42.0 ± 16.95	
				Most attractive body type—fat	38.0 ± 18.48	
				Most attractive body type—muscle mass	45.33 ± 15.35	
				Most attractive to women—fat	32.67 ± 18.58	
				Most attractive to women—muscle mass	50.67 ± 14.25	
Soler et al. [43]	BB	25	MDDI	MDDI total	45.5 ± 12.53	No difference between BB and NBBRT for MDDI total and all MDDI subscales
				Drive for size	19.1 ± 6.1	
				Appearance intolerance	12.74 ± 4.43	
				Functional impairment	13.52 ± 4.53	
	NBBRT	151	MDDI	MDDI total	45.92 ± 12.43	
				Drive for size	18.76 ± 7.22	
				Appearance intolerance	12.44 ± 3.12	
				Functional impairment	14.72 ± 4.7	
Babusa and Tury [37]	BB	60	MASS	MASS total	47.9 ± 13.21	BB significantly higher ($p < 0.001$) than undergraduate students on MASS total and all subscales except muscle satisfaction
				Bodybuilding dependence	12.8 ± 4.18	
				Muscle checking	7.8 ± 3.95	
				Substance use	8.9 ± 4.18	
				Injury risk	9.2 ± 3.42	
				Muscle satisfaction	9.1 ± 3.24	
	Non-BB undergraduate students	60	MASS	MASS total	33.2 ± 7.88	
				Bodybuilding dependence	7.2 ± 3.01	
				Muscle checking	5.2 ± 2.32	
				Substance use	4.9 ± 1.43	
				Injury risk	6.5 ± 2.47	
				Muscle satisfaction	9.2 ± 2.67	
Davies and Smith [38]	BB, former AAS users	30	MDI	Dietary behavior	21.9	No significant differences between former AAS users and current AAS users
				Supplement use	17.1	
				Pharmacological use	6.2	
				Exercise dependence	19.2	
				Size/symmetry	21.7	
				Physique protection	14.2	
	BB, current AAS users	30	MDI	Dietary behavior	21.2	
				Supplement use	16.5	
				Pharmacological use	7.6	
				Exercise dependence	17.8	
				Size/symmetry	20.5	
				Physique protection	13.9	

Data are presented as mean ± standard deviation

AAS anabolic–androgenic steroid, *BB* bodybuilder, *BIG* Bodybuilder Image Grid, *MASS* Muscle Appearance Satisfaction Scale, *MD* muscle dysmorphia, *MDDI* Muscle Dysmorphic Disorder Inventory, *MDI* Muscle Dysmorphia Inventory, *NBBRT* non-bodybuilder resistance trainer

Table 4 Muscle dysmorphia assessment results of non-bodybuilder resistance trainers

Study	Group	*n*	Tool	Subscale	Results	Main findings
de Lima et al. [61]	NBBRT	23	MASS			$n = 4$ (17 %) demonstrated positive risk for MD
Cafri et al. [63]	NBBRT, MD	23	MASS, MDDI	Bodybuilding dependence	26.07 ± 3.63	MD group significantly higher ($p < 0.01$) on bodybuilding dependence, muscle checking, muscle satisfaction and functional impairment subscales than non-MD
				Muscle checking	20.13 ± 5.18	
				Substance use	16.53 ± 7.31	
				Injury risk	13.87 ± 5.14	
				Muscle satisfaction	15.8 ± 3.55	
				Functional impairment	21.67 ± 3.48	
	NBBRT, no MD	28	MASS, MDDI	Bodybuilding dependence	19.53 ± 5.56	
				Muscle checking	13.67 ± 5.61	
				Substance use	12.25 ± 4.02	
				Injury risk	11.33 ± 3.55	
				Muscle satisfaction	12.3 ± 4.1	
				Functional impairment	13.44 ± 3.38	
Giardino and Procidano [57]	NBBRT, Mexican men	35	MASS	MASS total	25.77 ± 12.48	Mexican men significantly higher ($p = 0.043$) MASS total than Mexican women
	NBBRT, Mexican women	11	MASS	MASS total	17.26 ± 9.06	
	NBBRT, US men	43	MASS	MASS total	29.42 ± 13.1	US men significantly higher ($p = 0.002$) MASS total than US women
	NBBRT, US women	24	MASS	MASS total	19.44 ± 11.1	
Nieuwoudt et al. [59]	NBBRT	648	MASS	MASS total	66.5 ± 19.05	$n = 110$ (17 %) at risk for MD
				Bodybuilding dependence	18.46 ± 6.21	
				Muscle checking	12.43 ± 5.55	
				Substance use	11.63 ± 4.4	
				Injury risk	12.61 ± 4.24	
				Muscle satisfaction	12.61 ± 4.24	
Robert et al. [58]	NBBRT M	55	MASS	MASS total	42.56 ± 12.35	Males significantly higher ($p < 0.05$) than females on MASS total
	NBBRT F	59	MASS	MASS total	38.76 ± 9.31	
Thomas et al. [41]	NBBRT, training day	30	MDDI	Drive for size	15.87 ± 3.67	All subscale scores significantly higher ($p < 0.05$) on rest day than training day
				Appearance intolerance	8.97 ± 2.79	
				Functional impairment	9.47 ± 3.8	
	NBBRT, rest day	30	MDDI	Drive for size	18.0 ± 4.4	
				Appearance intolerance	10.1 ± 3.47	
				Functional impairment	10.2 ± 4.36	
Tod and Edwards [60]	NBBRT	294	MASS	Bodybuilding dependence	12.15 ± 5.5	
				Muscle satisfaction	8.49 ± 2.64	
Valdes et al. [62]	NBBRT M	112	ACQ		56.3 % mild concern	
					43.7 % moderate concern	
	NBBRT F	88	ACQ		53.4 % mild concern	
					46.6 % moderate concern	

Table 4 continued

Study	Group	n	Tool	Subscale	Results	Main findings
Kanayama et al. [40]	NBBRT, AAS users	48	MDQ	Preoccupied with body size	$n = 43$ (90 %)	More AAS users answered yes to first two questions than non-users
				Always covers body with clothes	$n = 19$ (40 %)	
				Gives up pleasurable activities	$n = 11$ (23 %)	
	NBBRT, AAS non-users	41	MDQ	Preoccupied with body size	$n = 26$ (63 %)	
				Always covers body with clothes	$n = 5$ (12 %)	
				Gives up pleasurable activities	$n = 3$ (7 %)	
Olivardia et al. [13]	NBBRT, MD	24	MDSQ	Weigh-ins per week	5.0 ± 3.9	MD group showed significantly more symptoms ($p < 0.001$) of muscle dysmorphia than non-MD group
				Mirror checks per day	9.2 ± 7.5	
				Minutes per day preoccupied with thoughts of being too small	325.0 ± 337	
	NBBRT, no MD	30	MDSQ	Weigh-ins per week	2.0 ± 2.0	
				Mirror checks per day	3.4 ± 3.3	
				Minutes per day preoccupied with thoughts of being too small	41.2 ± 173	
Segura-Garcia et al. [46]	Men gaining weight	52	MDI	Dietary behavior	13.5 ± 7	No significant difference between men gaining weight and men losing weight on all subscales
				Supplement use	10 ± 6.5	
				Pharmacological use	3.3 ± 2.5	
				Exercise dependence	16.5 ± 5.5	Men gaining weight significantly higher ($p < 0.001$) than female groups on all MDI subscales except pharmacological use and physique protection
				Size/symmetry	14 ± 7.5	
				Physique protection	10 ± 5.5	
	Men losing weight	34	MDI	Dietary behavior	12.5 ± 6.25	
				Supplement use	7.5 ± 5.5	
				Pharmacological use	3.5 ± 2	Men losing weight significantly higher ($p < 0.001$) than ED group on exercise dependence
				Exercise dependence	13.7 ± 5.75	
				Size/symmetry	12 ± 5.75	
				Physique protection	11.2 ± 5.5	
	Women losing weight	48	MDI	Dietary behavior	9.75 ± 4.75	
				Supplement use	5 ± 2.75	
				Pharmacological use	3.8 ± 2	
				Exercise dependence	11.6 ± 4.5	
				Size/symmetry	8.6 ± 4	
				Physique protection	9.45 ± 4.5	
	Women ED	20	MDI	Dietary behavior	9 ± 3.5	
				Supplement use	4.7 ± 2.1	
				Pharmacological use	3.5 ± 1	
				Exercise dependence	8.6 ± 4.75	
				Size/symmetry	9 ± 4	
				Physique protection	9.4 ± 3.5	

Data are presented as mean ± standard deviation (except where otherwise indicated)

AAS anabolic–androgenic steroid, *ACQ* Adonis Complex Questionnaire, *ED* eating disorder, *F* female, *M* male, *MASS* Muscle Appearance Satisfaction Scale, *MD* muscle dysmorphia, *MDDI* Muscle Dysmorphic Disorder Inventory, *MDI* Muscle Dysmorphia Inventory, *MDQ* Muscle Dysmorphia Questionnaire, *MDSQ* Muscle Dysmorphia Symptom Questionnaire, *NBBRT* non-bodybuilder resistance trainer

[43], whereas the second study used non-training controls as a comparison group [28]. Results for these studies varied. BBs showed a positive ES on MDDI total in both studies (ES range 0.03–3.62), but only one of these was significant ($p < 0.001$) [28]. In the case of the drive for size subscale, one study showed a significant positive ES for BBs (ES range –0.05 to 2.47, $p < 0.001$) [28]. The ES for the appearance intolerance subscale significantly favored BBs in one study (ES – 0.07 to 1.2, $p < 0.001$) [28]. Both studies showed an ES favoring BBs on the functional impairment subscale (ES range 0.26–2.95), one of which was significant ($p < 0.001$) [28].

Table 5 Muscle dysmorphia and psychological traits in bodybuilders and non-bodybuilder resistance trainers

Study	Group	*N*	Tool	Subscale	Results	Main findings
Babusa et al. [39]	BB	60	MASS	MASS total	47.9 ± 13.21	No perfectionism-MD correlation. BB higher perfectionism than undergraduate students
			EDI	Perfectionism	6.3 ± 3.85	
	Non-BB undergraduate students	60		MASS total	33.2 ± 7.88	
				Perfectionism	4.1 ± 2.89	
Boyda and Shevlin [47]	BB	51	MASS	MASS total	59.09 ± 14.82	Anxiety correlated with MD ($r = 0.42$, $p < 0.01$)
			DASS	Depression		
				Anxiety		
Castro-Lopez et al. [48]	BB	154	ACQ	ACQ total		Neuroticism correlated with MD ($r = 0.38$, $p < 0.001$)
			NEO 5-FPI	Neuroticism	28.21 ± 7.3	
				Extraversion	39.59 ± 5.36	
Gonzalez-Marti et al. [49]	BB, NBBRT	734	MASS	MASS total		General self-concept (*r* range: –0.2 to –0.5, $p < 0.01$) and general physical self-concept (r range: –0.16 to –0.53, $p < 0.01$) negatively correlated with MASS total and all subscales
			PSCS	Bodybuilding dependence		
				Muscle checking		
				Substance use		
				Injury risk		
				Muscle satisfaction		
				General self-concept		
				General physical self-concept		
Lopez-Barajes et al. [50]	BB	154	ACQ	ACQ total	18.67 ± 3.63	MD correlated with state anxiety ($r = 0.247$, $p < 0.01$), emotional self-concept ($r = –0.23$, $p < 0.01$) and academic-occupational self-concept ($r = 0.14$, $p < 0.05$)
			STAI	State anxiety		
			SCQ-5	Trait anxiety		
				Emotional self-concept		
				Academic–occupational self-concept		
Wolke and Sapouna [51]	BB	100	MDI	MDI total	25.28 ± 12.83	MD correlated with depression ($r = 0.38$, $p < 0.01$), anxiety ($r = 0.32$, $p < 0.01$). Negative correlation with self-esteem ($r = –0.46$, $p < 0.01$)
			RSES	Self esteem	32.88 ± 5.24	
			SC90	Depression	10.88 ± 10.06	
				Anxiety	7.87 ± 7.15	
Babusa and Tury [37]	Weightlifters	289	MASS	Muscle satisfaction		Self-esteem negatively correlated with all MASS subscales except injury risk (*r* range –0.12 to –0.31, $p < 0.05$)
			RSES	Substance use		
				Injury risk		
				Muscle checking		
				Bodybuilding dependence		
				Self-esteem		
Hildebrandt et al. [52]	Dysmorphic	40	MDDI	Drive for size	14.87 ± 4.12	Dysmorphic group higher than all other groups on each MDDI subscale
			BIG-O	Appearance intolerance	13.67 ± 5.17	
			SPAS	Functional impairment	15.49 ± 4.37	Significantly higher ($p < 0.001$) than all groups except fat concern group on social physique anxiety
				Desired muscle	0.72 ± 0.72	
				Desired fat	1.3 ± 0.97	
				Social physique anxiety	34.72 ± 7.34	
	Muscular concern	63		Drive for size	11.31 ± 4.8	
				Appearance intolerance	7.06 ± 3.73	
				Functional impairment	9.51 ± 4.83	
				Desired muscle	1.12 ± 0.4	
				Desired fat	0.69 ± 0.98	
				Social physique anxiety	28.13 ± 5.23	

Table 5 continued

Study	Group	*N*	Tool	Subscale	Results	Main findings
	Fat concern	66		Drive for size	5.5 ± 4.82	
				Appearance intolerance	12.3 ± 5.12	
				Functional impairment	12.28 ± 5.11	
				Desired muscle	–0.29 ± 0.71	
				Desired fat	1.36 ± 0.93	
				Social physique anxiety	32.98 ± 6.29	
	Normal-behavioral	38		Drive for size	5.47 ± 3.8	
				Appearance intolerance	2.97 ± 2.69	
				Functional impairment	6.63 ± 4.6	
				Desired muscle	–0.13 ± 0.41	
				Desired fat	0.6 ± 0.94	
				Social physique anxiety	22.16 ± 3.46	
	Normal	30		Drive for size	4.8 ± 3.25	
				Appearance intolerance	2.17 ± 2.59	
				Functional impairment	5.2 ± 2.72	
				Desired muscle	0.5 ± 0.73	
				Desired fat	0.37 ± 1.05	
				Social physique anxiety	23.46 ± 3.06	
Kuennen and Waldrom [53]	Resistance trained	49	MDI, RSES, NPI, MPS	Dietary behavior	3.38 ± 1.13	Negative association between self-esteem and size/symmetry ($r = –0.42$, $p < 0.01$), physique protection ($r = –0.39$, $p < 0.01$). Perfectionism associated with exercise dependence ($r = 0.35$, $p < 0.05$)
				Supplement use	3.18 ± 1.41	
				Pharmacological use	1.13 ± 0.3	
				Exercise dependence	4.42 ± 0.87	
				Size/symmetry	3.59 ± 1.1	
				Physique protection	2.04 ± 0.68	
				Self-esteem	0.95 ± 0.66	
				Narcissism	19.82 ± 6.64	
				Perfectionism	2.98 ± 0.49	
Kim [54]	Resistance trained	429	MDI, BDI			Depression associated with MD ($r = 0.529$, $p < 0.001$)
Maida and Armstrong [55]	Resistance trained	106	MDSQ, EDI, BSI		$n = 26$ (25 %) heightened MD symptoms	Perfectionism ($r = 0.41$, $p < 0.01$), depression ($r = 0.36$, $p < 0.01$), anxiety ($r = 0.39$, $p < 0.01$) each associated with MD
				Perfectionism	5.2 ± 0.16	
				Depression	0.21 ± 0.33	
				Anxiety	0.26 ± 0.31	
Thomas et al. [56]	Resistance trained	146	MDI, MASS-6, SPAS	Dietary behavior	2.91 ± 1.14	Social physique anxiety associated with supplement use ($r = 0.26$, $p < 0.05$), size/symmetry ($r = 0.36$, $p < 0.05$), physique protection ($r = 0.75$, $p < 0.05$), and overall MD ($r = 0.29$, $p < 0.05$)
				Supplement use	3.02 ± 1.38	
				Exercise dependence	3.7 ± 1.1	
				Size/symmetry	3.3 ± 1.17	
				Physique protection	2.1 ± 0.82	
				MASS-6	2.88 ± 0.91	
				Social physique anxiety	2.43 ± 0.8	

Data are presented as mean ± standard deviation unless otherwise indicated

ACQ Adonis Complex Questionnaire, *BB* bodybuilder, *BDI* Beck Depression Inventory, *BIG-O* Bodybuilder Image Grid Original, BSI Brief Symptom Inventory, *DASS* Depression Anxiety Stress Scale, *EDI* Eating Disorder Inventory, *MASS* Muscle Appearance Satisfaction Scale, *MASS-6* Muscle Appearance Satisfaction Scale 6 items, *MD* muscle dysmorphia, *MDDI* Muscle Dysmorphic Disorder Inventory, *MDI* Muscle Dysmorphia Inventory, *MDSQ* Muscle Dysmorphia Symptom Questionnaire, *MPS* Multidimensional Perfectionism Scale, *NBBRT* non-bodybuilder resistance trainer, *NEO 5-FPI* NEO 5 Factor Personality Inventory, *NPI* Narcissistic Personality Inventory, *PSCS* Physical Self-Concept Scale, *RSES* Rosenberg Global Self-Esteem Scale, *SC90* Symptom Checklist 90, *SCQ-5* Self-Concept Questionnaire 5, *SPAS* Social Physique Anxiety Scale, *STAI* State Trait Anxiety Inventory

Two studies used the MASS to assess MD in BBs [37, 44]. One study used NBBRTs as a comparison group [44], whereas the second study compared BBs with non-training controls [37]. The MASS total score showed a significant ES for BBs in both studies (ES range 1.34–1.61, $p < 0.001$) [37, 44]. The ES for bodybuilding dependence significantly favored BBs in both studies (ES range 1.33–1.53, $p < 0.001$) [37, 44]. Both also showed a

Table 6 Effect size of differences in Muscle Dysmorphia Inventory subscale scores between bodybuilders and non-bodybuilder resistance-trained individuals

Study	Comparison	Scale	Subscale	Hedges' *g*	*p* value
Baghurst and Lirgg [27]	Natural BB vs. NBBRT (WTP)	MDI	Dietary behavior	0.66 ± 0.16 (0.35–0.97)	<0.001
			Supplement use	0.6 ± 0.16 (0.28–0.91)	<0.001
			Pharmacological use	–0.1 ± 0.16 (–0.4–0.21)	0.531
			Size/symmetry	0.09 ± .016 (–0.21–0.39)	0.557
			Physique protection	0.07 ± 0.16 (–0.23–0.37)	0.654
Cella et al. [44]	BB vs. NBBRT (non-BB)	MDI	Dietary behavior	1.58 ± 0.16 (1.28–1.89)	<0.001
			Supplement use	1.97 ± 0.17 (1.64–2.29)	<0.001
			Pharmacological use	0.65 ± 0.14 (0.38–0.93)	<0.001
			Exercise dependence	1.83 ± 0.16 (1.52–2.15)	<0.001
			Size/symmetry	1.63 ± 0.16 (1.32–1.94)	<0.001
			Physique protection	1.13 ± 0.15 (0.84–1.42)	<0.001
Hale et al. [26]	BB (expert) vs. NBBRT (FL)	MDI	Dietary behavior	1.96 ± 0.36 (1.25–2.66)	<0.001
			Supplement use	2.35 ± 0.39 (1.59–3.11)	<0.001
			Pharmacological use	0.37 ± 0.3 (–0.21–0.96)	0.211
			Exercise dependence	2.15 ± 0.37 (1.42–2.88)	<0.001
			Size/symmetry	1.67 ± 0.35 (1.0–2.35)	<0.001
			Physique protection	0.7 ± 0.31 (0.1–1.3)	0.021
Lantz et al. [19]	BB vs. NBBRT (PL)	MDI	Dietary behavior	0.83 ± 0.16 (0.52–1.15)	<0.001
			Supplement use	0.1 ± 0.16 (–0.21–0.41)	0.517
			Pharmacological use	0.7 ± 0.16 (0.38–1.0)	<0.001
			Exercise dependence	0.03 ± 0.16 (–0.28–0.34)	0.839
			Size/symmetry	0.5 ± 0.16 (0.19–0.81)	0.002
			Physique protection	0.5 ± 0.16 (0.19–0.81)	0.002
Skemp et al. [42]	BB (AE) vs. NBBRT (PE)	MDI	Dietary behavior	0.83 ± 0.18 (0.47–1.19)	<0.001
			Supplement use	0.55 ± 0.18 (0.2–0.91)	0.002
			Pharmacological use	0.99 ± 0.19 (0.63–1.36)	<0.001
			Exercise dependence	0.5 ± 0.18 (0.15–0.85)	0.006
			Size/symmetry	0.37 ± 0.18 (0.02–0.72)	0.04
			Physique protection	0.58 ± 0.18 (0.23–0.94)	0.001

Data are presented as standardized mean difference (effect size) ± standard error (95 % confidence interval)

AE appearance enhancement, *BB* bodybuilder, *FL* fitness lifters, *MDI* Muscle Dysmorphia Inventory, *NBBRT* non-bodybuilder resistance trainer, *PE* performance enhancement, *PL* powerlifters, *WTP* weight trainers for physique

Table 7 Effect size of differences in Muscle Dysmorphic Disorder Inventory subscale scores between bodybuilders and non-bodybuilders

Study	Comparison	Scale	Subscales	Hedges' *g*	*p* value
Santarnecchi and Dettore [28]	BB (competing) vs. controls (non-training)	MDDI	Total	3.62 ± 0.3 (3.04–4.21)	<0.001
			Drive for size	2.47 ± 0.24 (2.0–2.95)	<0.001
			Appearance intolerance	1.2 ± 0.2 (0.81–1.59)	<0.001
			Functional impairment	2.95 ± 0.26 (2.43–3.47)	<0.001
Soler et al. [43]	BB vs. NBBRT (gym goers)	MDDI	Total	0.03 ± 0.22 (–0.39–0.46)	0.877
			Drive for size	–0.05 ± 0.22 (–0.48–0.37)	0.802
			Appearance intolerance	–0.07 ± 0.22 (–0.49–0.35)	0.745
			Functional impairment	0.26 ± 0.22 (–0.16–0.69)	0.223

Data are presented as standardized mean difference (effect size) ± standard error (95 % confidence interval)

BB bodybuilder, *MDDI* Muscle Dysmorphia Disorder Inventory, *NBBRT* non-bodybuilder resistance trainer

Table 8 Effect size of differences in Muscle Appearance Satisfaction Scale subscale scores between bodybuilders and non-bodybuilders

Study	Comparison	Scale	Subscales	Hedges' *g*	*p* value
Babusa and Tury [37]	BB (non-competitive) vs. controls (students, non-BB)	MASS	Total	1.34 ± 0.2 (0.95–1.74)	<0.001
			Bodybuilding dependence	1.53 ± 0.21 (1.12–1.93)	<0.001
			Muscle checking	0.8 ± 0.19 (0.43–1.17)	<0.001
			Substance use	1.27 ± 0.2 (0.88–1.66)	<0.001
			Injury	0.9 ± 0.19 (0.53–1.27)	<0.001
			Muscle satisfaction	–0.03 ± 0.18 (–0.39–0.32)	0.854
Cella et al. [44]	BB vs. NBBRT (non-BB)	MASS	Total	1.61 ± 0.16 (1.3–1.92)	<0.001
			Bodybuilding dependence	1.33 ± 0.15 (1.03–1.62)	<0.001
			Muscle checking	1.2 ± 0.15 (0.91–1.49)	<0.001
			Substance use	1.27 ± 0.15 (0.97–1.56)	<0.001
			Injury	1.25 ± 0.15 (0.96–1.56)	<0.001
			Muscle satisfaction	0.53 ± 0.14(0.26–0.8)	<0.001

Data are presented as standardized mean difference (effect size) ± standard error (95 % confidence interval)

BB bodybuilder, *MASS* Muscle Appearance Satisfaction Scale, *NBBRT* non-bodybuilder resistance trainer

Table 9 Effect size of differences in Muscle Dysmorphic Disorder Inventory subscale scores between competitive and non-competitive bodybuilders

Study	Comparison	Scale	Subscales	Hedges' *g*	*p* value
Santarnecchi and Dettore [28]	BB (competing) vs. BB (non-competing)	MDDI	Total	1.21 ± 0.2 (0.82–1.6)	<0.001
			Drive for size	1.23 ± 0.2 (0.84–1.62)	<0.001
			Appearance intolerance	–1.09 ± 0.2 (–1.47 to –0.71)	<0.001
			Functional impairment	1.42 ± 0.2 (1.02–1.82)	<0.001

Data are presented as standardized mean difference (effect size) ± standard error (95 % confidence interval)

BB bodybuilder, *MDDI* Muscle Dysmorphic Disorder Inventory

Table 10 Effect size of difference in Muscle Dysmorphia Inventory subscale scores between expert and novice bodybuilders

Study	Comparison	Scale	Subscale	Hedges' *g*	*p* value
Hale et al. [26]	BB (expert) vs. BB (novice)	MDI	Dietary behavior	0.53 ± 0.27 (–0.01–1.06)	0.053
			Supplement use	0.76 ± 0.28 (0.22–1.3)	0.006
			Pharmacological use	–0.03 ± 0.27 (–0.55–0.49)	0.907
			Exercise dependence	0.71 ± 0.28 (0.17–1.24)	0.01
			Size/symmetry	0.25 ± 0.27 (–0.27–0.78)	0.348
			Physique protection	–0.16 ± 0.27 (–0.68–0.37)	0.559

Data are presented as standardized mean difference (effect size) ± standard error (95 % confidence interval)

BB bodybuilder, *MDI* Muscle Dysmorphia Inventory

significant positive ES for BBs on muscle checking (ES range 0.8–1.2, $p < 0.001$) [37, 44]. The substance use ES significantly favored BBs (ES 1.27, $p < 0.001$) [37, 44]. For injury risk, both studies showed a significantly positive ES of BBs (ES range 0.9–1.25, $p < 0.001$) [37, 44]. The ES for muscle satisfaction significantly favored BBs in one of the studies (ES range –0.03 to 0.53, $p < 0.001$).

One study used the BIG to assess MD symptoms in BBs and non-training controls [28]. The ES showed BBs scored higher on all muscle indices (ES range 0.07–2.53), all of which were significant ($p < 0.001$) except the subscale assessing 'most attractive to women'. There was a significant negative ES for BBs on all indices related to fat mass (ES range –0.87 to –1.93, $p < 0.001$).

3.6.1.1 Meta-Analysis We conducted meta-analyses on studies comparing BBs and NBBRTs using the MDI ($n = 5$) [19, 26, 27, 42, 44]. However, meta-analysis of

Table 11 Effect size of difference in Muscle Appearance Satisfaction Scale and Muscle Dysmorphia Inventory subscale scores between male and female non-bodybuilder resistance trainers

Study	Comparison	Scale	Subscale	Hedges' *g*	*p* value
Giardino and Procidano [57]	US M vs. US F	MASS	Total	0.79 ± 0.26 (0.28–1.31)	0.002
Giardino and Procidano [57]	Mexican M vs. Mexican F	MASS	Total	0.71 ± 0.35 (0.03–1.39)	0.041
Robert et al. [58]	M vs. F	MASS	Total	0.35 ± 0.19 (–0.02–0.72)	0.064
Skemp et al. [42]	F vs. F	MDI	Dietary behavior	0 ± 0.28 (–0.54–0.54)	1.0
			Supplement use	0.36 ± 0.28 (–0.19–0.9)	0.201
			Pharmacological use	–0.99 ± 0.29 (–1.56 to –0.41)	0.001
			Exercise dependence	0 ± 0.28 (–0.54–0.54)	0.314
			Size/symmetry	0.97 ± 0.29 (0.4–1.54)	0.001
			Physique protection	0.28 ± 0.28 (–0.26–0.82)	0.314

Data are presented as standardized mean difference (effect size) ± standard error (95 % confidence interval)

F female, *M* male, *MASS* Muscle Appearance Satisfaction Scale, *MDI* Muscle Dysmorphia Inventory, *NBBRT* non-bodybuilder resistance trainer

Table 12 Effect size of difference in Muscle Dysmorphic Disorder Inventory subscale scores between training day and rest day in non-bodybuilder resistance trainers

Study	Comparison	Scale	Subscale	Hedges' *g*	*p* value
Thomas et al. [41]	Training day vs. rest day (NBBRT)	MDDI	Drive for size	0.52 ± 0.26 (0.01–1.03)	0.045
			Appearance intolerance	0.35 ± 0.26 (–0.15–0.86)	0.168
			Functional impairment	0.18 ± 0.26 (–0.32–0.68)	0.49

Data are presented as standardized mean difference (effect size) ± standard error (95 % confidence interval)

MDDI Muscle Dysmorphic Disorder Inventory, *NBBRT* non-bodybuilder resistance trainer

Table 13 Effect size of differences in Bodybuilder Image Grid subscale scores between bodybuilders and controls

Study	Comparison	Scale	Subscale	Hedges' *g*	*p* value
Santarnecchi and Dettore [28]	BB (competing) vs. BB (non-competing)	BIG	Current body type—fat	–0.79 ± 0.19 (–1.16–0.42)	<0.001
			Current body type—muscle mass	1.11 ± 0.2 (0.73–1.49)	<0.001
			Ideal body type—fat	–1.16 ± 0.2 (–1.55 to –0.78)	<0.001
			Ideal body type—muscle mass	1.65 ± 0.21 (1.23–2.06)	<0.001
			Most attractive body type—fat	–1.22 ± 0.2 (–1.61 to –0.84)	<0.001
			Most attractive body type—muscle mass	1.2 ± 0.2 (0.82–1.59)	<0.001
			Most attractive to women—fat	–0.84 ± 0.19 (–1.21 to –0.46)	<0.001
			Most attractive to women—muscle mass	0.31 ± 0.18 (–0.05–0.66)	0.095
Santarnecchi and Dettore [28]	BB (competing) vs. non-training controls	BIG	Current body type—fat	–1.28 ± 0.2 (–1.67 to –0.89)	<0.001
			Current body type—muscle mass	2.53 ± 0.24 (2.05–3.01)	<0.001
			Ideal body type—fat	–1.93 ± 0.21 (–2.15 to –1.31)	<0.001
			Ideal body type—muscle mass	2.0 ± 0.22 (1.56–2.44)	<0.001
			Most attractive body type—fat	–1.53 ± 0.21 (–2.01 to –1.19)	<0.001
			Most attractive body type—muscle mass	1.49 ± 0.21 (1.09–1.9)	<0.001
			Most attractive to women—fat	–0.87 ± 0.19 (–1.25 to –0.5)	<0.001
			Most attractive to women—muscle mass	0.07 ± 0.18 (–0.29–0.43)	0.697

Data are presented as standardized mean difference (effect size) ± standard error (95 % confidence interval)

BB bodybuilder, *BIG* Bodybuilder Image Grid studies using other MD instruments was considered implausible, as too few used other instruments and they contained subscales that were too heterogeneous to pool. Therefore, including these studies in the analyses would have introduced bias [45]. The pooled overall estimates for each subscale consistently indicated medium to large mean differences, with higher MD symptoms in BB relative to NBBRT samples (see Figs. 2, 3, 4, 5, 6, 7). A large pooled ES was evident for dietary behavior (ES 1.12, 95 % CI 0.69–1.55; $p < 0.001$). Assessment of heterogeneity yielded a significant finding ($Q = 27.41$; $df = 4$; $p < 0.001$), with $I^2 = 85.41$ %. A large pooled ES was evident for supplement use (ES 1.08, 95 % CI 0.31–1.84; $p = 0.006$), and there was evidence of significant heterogeneity ($Q = 88.61$; $df = 4$; $p < 0.001$; $I^2 = 95.49$ %). A large pooled ES was also evident for exercise dependence (ES 1.1, 95 % CI 0.12–2.08; $p = 0.03$), with evidence of significant heterogeneity ($Q = 80.17$; $df = 3$; $p < 0.001$; $I^2 = 96.23$ %). A medium pooled ES was evident for pharmacological use (ES 0.53, 95 % CI 0.14–0.91; $p = 0.007$), with heterogeneity significant ($Q = 24.62$; $df = 4$; $p < 0.001$; $I^2 = 83.75$ %). A medium pooled ES was evident for size/symmetry (ES 0.83, 95 % CI 0.2–1.46; p = 0.01), with evidence of significant heterogeneity ($Q = 63.48$; $df = 4$; $p < 0.001$; $I^2 = 93.7$ %). A medium pooled ES was also evident for physique protection (ES 0.59, 95 % CI 0.2–0.98; $p = 0.003$), with significant heterogeneity ($Q = 25.32$; $df = 4$; $p < 0.001$; $I^2 = 84.2$ %). We did not conduct further investigations into the heterogeneity because of the small number of studies.

3.6.2 Do Non-BB Resistance Trainers Display More MD Symptoms than Non-Resistance Trained Individuals?

One study compared symptoms of MD in resistance trained and non-resistance trained individuals. Using the MDI, Segura-Garcia et al. [46] found no significant differences in MD symptoms between males training to gain weight and males training to lose weight. However, males training to gain weight scored significantly higher on all MDI subscales except physique protection and pharmacological use than females training to lose weight and females with a diagnosed eating disorder (anorexia nervosa and bulimia nervosa; see Table 3).

3.6.3 Does Bodybuilding Caliber Affect MD Symptoms?

One study used the MDDI and BIG to compare symptoms of MD between competitive and non-competitive BBs [28]. The ES significantly favored competitive BBs on MDDI total score, drive for size, and functional impairment subscales (ES range 1.21–1.42, $p < 0.001$), but significantly favored non-competitive BBs on the appearance intolerance subscale (ES –1.09, $p < 0.001$). The competitive BBs showed a positive ES for each of the BIG indices related to muscle (ES range 0.31–1.65), of which three—current muscle, ideal muscle, and most attractive muscle—were significant ($p < 0.001$). The competitive BBs also showed a significant negative ES on all four indices related to fat—current, ideal, most attractive, and most attractive to women (ES range –0.79 to –1.22, $p < 0.001$)—suggesting lower current, ideal, most attractive, and most attractive to women body fat percentage than non-competitive BBs. One study [26] compared symptoms of MD between expert (defined as having competed in ten or more bodybuilding competitions) and novice (defined as having competed in three or fewer competitions) BBs, using the MDI, noting a greater ES in the dietary behavior, supplement use, exercise dependence, and size/symmetry subscales among expert BBs (ES range –0.16 to 0.76); however, only supplement use and exercise dependence were significant ($p \leq 0.01$).

Reference	n	ES (95% CI)	p value
Baghurst et al. (2009) [27]	65	0.655 (0.35 to 0.97)	<0.001
Cella et al. (2012) [44]	119	0.158 (1.28 to 1.89)	<0.001
Hale et al. (2013) [26]	26	1.96 (1.25 to 2.66)	<0.001
Lantz et al. (2002) [19]	100	0.83 (0.52 to 1.15)	<0.001
Skemp et al. (2013) [42]	51	0.83 (0.47 to 1.12)	<0.001
Pooled estimate		1.12 (0.69 to 1.55)	<0.001

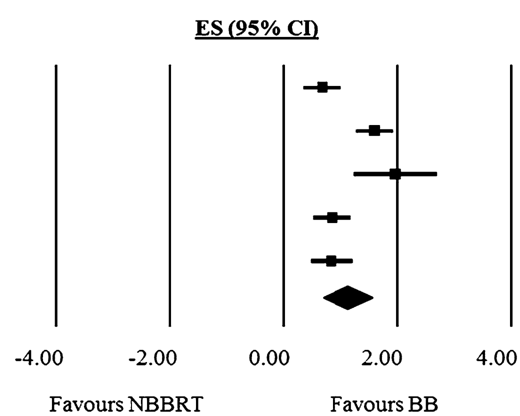

Fig. 2 Meta-analysis of the pooled effect of BB vs. NBBRT on the dietary behavior subscale of the Muscle Dysmorphia Inventory. *BB* bodybuilder, *CI* confidence interval, *ES* effect size, *NBBRT* non-bodybuilding resistance trainer

Reference	n	ES (95% CI)	p value
Baghurst et al. (2009) [27]	65	0.6 (0.3 to 0.91)	<0.001
Cella et al. (2012) [44]	119	1.97 (1.64 to 2.29)	<0.001
Hale et al. (2013) [26]	26	2.35 (1.59 to 3.11)	<0.001
Lantz et al. (2002) [19]	100	0.1 (-0.21 to 0.41)	0.517
Skemp et al. (2013) [42]	51	0.55 (0.2 to 0.91)	0.002
Pooled estimate		1.08 (0.31 to 1.84)	0.006

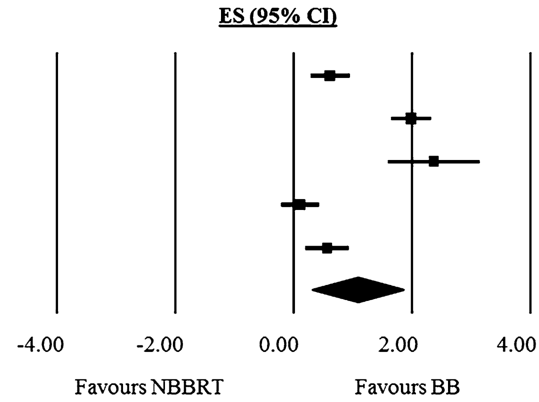

Fig. 3 Meta-analysis of the pooled effect of BB vs. NBBRT on the supplement use subscale of the Muscle Dysmorphia Inventory. *BB* bodybuilder, *CI* confidence interval, *ES* effect size, *NBBRT* non-bodybuilding resistance trainer

Reference	n	ES (95% CI)	p value
Baghurst et al. (2009) [27]	65	-0.1 (-0.4 to 0.21)	0.531
Cella et al. (2012) [44]	119	0.65 (0.38 to 0.93)	<0.001
Hale et al. (2013) [26]	26	0.37 (-0.21 to 0.96)	0.211
Lantz et al. (2002) [19]	100	0.7 (0.38 to 1.01)	<0.001
Skemp et al. (2013) [42]	51	0.99 (0.63 to 1.36)	<0.001
Pooled estimate		0.53 (0.14 to 0.91)	0.007

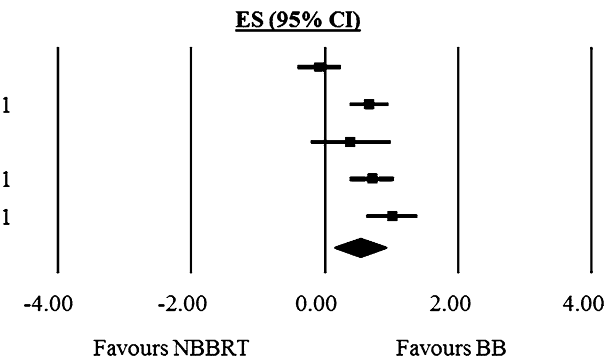

Fig. 4 Meta-analysis of the pooled effect of BB vs. NBBRT on the pharmacological use subscale of the Muscle Dysmorphia Inventory. *BB* bodybuilder, *CI* confidence interval, *ES* effect size, *NBBRT* non-bodybuilding resistance trainer

Reference	n	ES (95% CI)	p-Value
Cella et al. (2009) [44]	119	1.83 (1.52 to 2.15)	<0.001
Hale et al. (2013) [26]	26	2.18 (1.42 to 2.88)	<0.001
Lantz et al. (2002) [19]	100	0.03 (-0.28 to 0.34)	0.839
Skemp et al. (2013) [42]	51	0.5 (0.15 to 0.85)	0.006
Pooled estimate		1.1 (0.12 to 2.08)	0.027

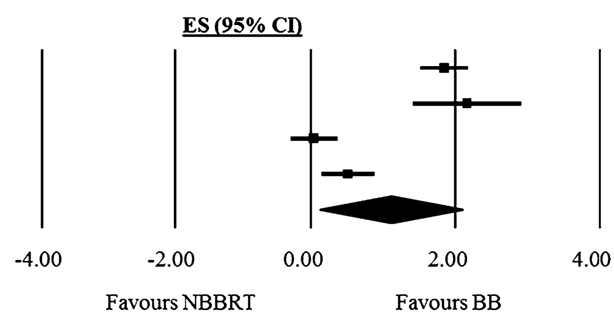

Fig. 5 Meta-analysis of the pooled effect of BB vs. NBBRT on the exercise dependence subscale of the Muscle Dysmorphia Inventory. *BB* bodybuilder, *CI* confidence interval, *ES* effect size, *NBBRT* non-bodybuilding resistance trainer

3.6.4 What Psychological Features are Associated with MD in BBs and Non-BB Resistance Trainers?

Of the studies included in the analyses, six examined the association (reporting correlation coefficient, r) between psychological features and MD symptoms in BBs [28, 37, 47–51] (see Table 5). A wide range of features were examined, although many of these were investigated in only one study [37, 48, 51]. Features most commonly examined were self-concept ($n = 4$), including general, physical, emotional, and academic–occupational self-concept [49, 50], and anxiety ($n = 3$) [47, 50, 51]. Other features reported were self-esteem [51], depression [47], neuroticism [48], extraversion [48], and perfectionism [36] ($n = 1$ for each). Features positively correlated with MD were academic–occupational self-concept ($r = 0.14$), anxiety

Reference	n	ES (95% CI)	p-Value
Baghurst et al. (2009) [27]	65	0.09 (-0.21 to 00.39)	0.557
Cella et al. (2012) [44]	119	1.63 (1.32 to 1.94)	<0.001
Hale et al. (20013) [26]	26	1.67 (1.0 to 2.35)	<0.001
Lantz et al. (2002) [19]	100	0.5 (0.19 to 0.81)	0.002
Skemp et al. (2013) [42]	51	0.37 (0.02 to 0.72)	0.040
Pooled estimate		0.83 (0.2 to 1.46)	0.010

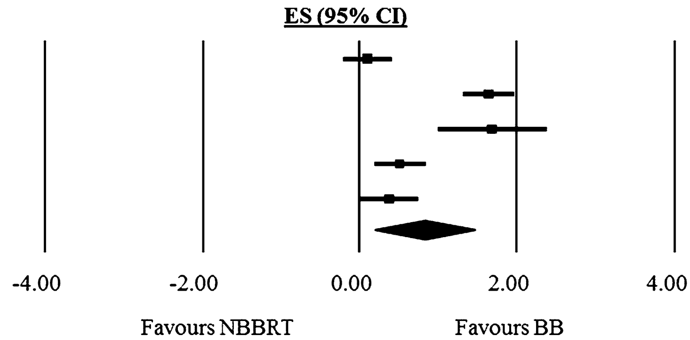

Fig. 6 Meta-analysis of the pooled effect of BB vs. NBBRT on the size/symmetry subscale of the Muscle Dysmorphia Inventory. *BB* bodybuilder, *CI* confidence interval, *ES* effect size, *NBBRT* non-bodybuilding resistance trainer

Reference	n	ES (95% CI)	*p* value
Baghurst et al. (2009) [27]	65	0.07 (-0.23 to 0.37)	0.654
Cella et al. (2012) [44]	119	1.13 (0.84 to 1.42)	<0.001
Hale et al. (2013) [26]	26	0.7 (0.1 to 1.3)	0.021
Lantz et al. (2002) [19]	100	0.5 (0.19 to 0.81)	0.002
Skemp et al. (2013) [42]	51	0.58 (0.23 to 0.94)	0.001
Pooled estimate		0.59 (0.2 to 0.98)	0.003

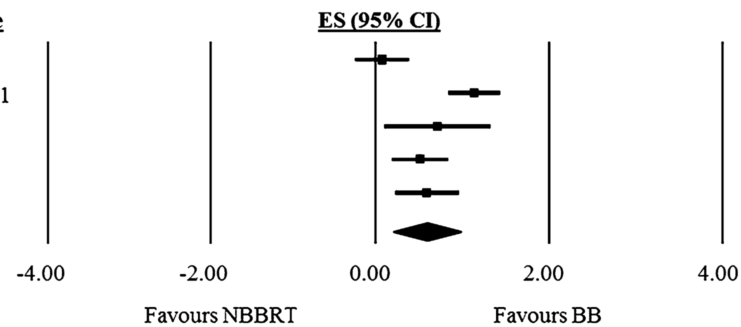

Fig. 7 Meta-analysis of the pooled effect of BB vs. NBBRT on the physique protection subscale of the Muscle Dysmorphia Inventory. *BB* bodybuilder, *CI* confidence interval, *ES* effect size, *NBBRT* non-bodybuilding resistance trainer

(*r* range 0.32–0.42), depression (*r* range 0.23–0.53), and neuroticism ($r = 0.38$) [47, 50, 51]. Factors negatively associated with MD were general, physical, and emotional self-concept, and self-esteem (*r* range –0.18 to –0.57) [49–51]. No association was found between extraversion and MD [48] or perfectionism and MD [37].

Six of 31 studies examined psychological features and MD in NBBRTs [38, 52–56] (see Table 5). Features most commonly reported were anxiety ($n = 3$) [52, 55, 56], perfectionism ($n = 2$) [53, 55], self-esteem ($n = 2$) [39, 53], and depression ($n = 2$) [54, 55]. The final feature reported was narcissism ($n = 1$) [53]. Features positively associated with MD were anxiety and social physique anxiety (*r* range 0.26–0.75) [52, 55, 56], perfectionism (*r* range 0.35–0.57) [53, 55], and depression (*r* range 0.36–0.53) [54, 55]. Self-esteem was negatively associated with MD (*r* range –0.12 to –0.42) [39, 53]. No association was reported between narcissism and MD [53].

3.6.5 Do Anabolic–Androgenic Steroid (AAS) Users Display More MD Symptoms than Non-AAS Users?

Four of 31 studies compared BBs based on steroid use (AAS users vs. non-users) [27, 37, 38, 44], using either the MDI ($n = 3$) or the MASS ($n = 2$). Insufficient data were available in these studies to calculate mean difference and 95 % CI. There was a lack of consistency in differences between users and non-users across these papers. Cella et al. [44] identified that steroid users scored higher than non-users on all MDI subscales except exercise dependence, while Baghurst and Lirgg [27] reported higher pharmacological use in non-natural BBs. Steroid users scored higher than non-users on the MASS total [37] and on all MASS subscales except muscle satisfaction [44]. Conversely, Davies and Smith [38] showed no significant difference on all MDI subscales between current steroid users and former steroid users.

Kanayama et al. [40] compared resistance-trained individuals based on AAS use on the three-item MD questionnaire and found AAS users responded significantly more affirmatively to MD symptoms questions than non-users.

3.6.6 Do Male and Female Non-BB Resistance Trainers Display Different MD Symptoms?

Three of 31 studies compared MD symptoms in male and female NBBRTs [42, 57, 58]. The MASS total score showed an ES favoring males in two studies [57, 58] (ES range 0.35–0.79), one of which was significant ($p \leq 0.04$) [57]. Skemp et al. [42] found a positive ES for males on the supplement use, pharmacological use, size/symmetry, and physique protection subscales of the MDI (ES range 0.28–0.99), and with significance for pharmacological use and size/symmetry ($p = 0.001$) [42]. There was no difference for dietary behavior and exercise dependence (ES 0) [42] (see Table 10).

3.6.7 *Do MD Symptoms Vary with the Proximity of Resistance Training?*

One of 31 studies examined the effect of proximity of resistance exercise on symptoms of MD. Thomas et al. [41] used the MDDI to assess symptoms of MD in resistance trained males on both a training and a rest day, finding a significant increase in scores for the drive for size subscale of the MDDI on the rest day (ES 0.52, $p < 0.05$). The appearance intolerance and functional impairment subscales also both showed an ES favoring higher scores on the rest day; however, neither of these was significant (ES range 0.18–0.35).

3.6.8 *How Severe are MD Symptoms?*

Four of 31 studies reported the severity of MD symptoms in NBBRTs, using the MASS ($n = 3$) and the Adonis Complex Questionnaire ($n = 1$) [59–62]. Mean scores were as follows: MASS total 66.5/133, muscle checking 11.62/28, bodybuilding dependence 18.46/35, substance use 12.43/28, injury risk 11.63/21, muscle satisfaction 12.61/21 [59]; body building dependence 12.15/35, and muscle satisfaction 8.49/21 [60]. Based on MASS score, 17 % were classified as ‘at risk’ of MD [59] and 17.4 % demonstrated ‘positive risk’ for MD [61]. Using the Adonis Complex Questionnaire, Valdes et al. [62] classified 56.3 % of males as of “mild concern” and 43.7 % as of “moderate concern”, while 53.4 % of females were of “mild concern” and 46.6 % of “moderate concern”.

3.6.9 *How do MD Symptoms Vary Between Non-BB Resistance Trainers Diagnosed with MD and Non-BB Resistance Trainers Without MD?*

Three of the 31 studies grouped NBBRTs based on a researcher-determined MD diagnosis [13, 63] or on variables associated with MD [52]. Three tools were used to assess MD symptoms in these studies: MDDI ($n = 2$), MASS ($n = 1$), and MDSQ ($n = 1$). Muscle dysmorphic NBBRTs scored higher than non-muscle dysmorphic NBBRTs on the bodybuilding dependence, muscle checking, and muscle satisfaction subscales of the MASS, the functional impairment subscale of the MDDI [63], all of the subscales of the MDDI [52], and all questions of the MDSQ [13].

4 Discussion

The aim of the present analysis was to first compare the existing evidence base pertaining to MD symptomatology in BBs versus NBBRTs and, second, to identify psychological and other characteristics associated with MD symptomatology in these respective groups. We collated data from 1895 BB participants (males, $n = 1597$; females, $n = 298$), 3523 non-bodybuilding resistance trainers (males, $n = 3341$; females, $n = 182$), and 462 non-training controls (males, $n = 360$; females, $n = 102$), making this the largest systematic review of the literature on MD. Given the ongoing conflation of bodybuilding and MD, and the potential scope for pathologizing normative muscularity-enhancing pursuits, this review is important. Critically, results illustrate that BBs reported greater MD symptomatology relative to NBBRTs, with consistently larger ESs on most indices of MD symptomatology. Although the inconsistent use of measures of MD symptomatology precluded a large-scale meta-analysis, the data available from studies using the MDI [64] showed a moderate to large ES (ES range 0.53–1.12, $p \leq 0.01$), where BBs reported greater MD symptom severity on all of the MDI subscales. Overall, the results indicate that BBs have a higher risk of MD symptomatology than NBBRTs and non-training controls. This study also assessed psychological features linked with MD. Several features, including anxiety, depression, and perfectionism were positively, and self-esteem was negatively, associated with MD. These associations were similar in both BBs and NBBRTs. However, the association between the psychological features and MD was not strong ($r \leq 0.53$), and a minority of the papers assessed psychological features, indicating there is scope to explore this further.

As anticipated, the male and female BBs had a higher BMI (males 29.7, females 27 kg/m^2) than the NBBRTs (males 27.2, females 23.6 kg/m^2). Similarly, male BBs were leaner than male NBBRTs (BBs 9.8, NBBRTs 12.9 % fat); however, no studies presented body composition data for females. None of the papers reported the weight class of bodybuilding competitors, and only 7 of 31 studies reported on the use of AAS in their cohorts. This limits our capacity to interpret the range of mass reported and also the variance in mass associated with participation in natural or non-natural competition. The mass and adiposity of the participants in this study were comparable to those reported in a recent systematic review on diet and supplement use in bodybuilding [21], indicating that the physique characteristics of the sample of BBs in this review and analysis are consistent with other published literature in this population. Although we identified few studies reporting on elite competitors, the body composition characteristics of this group would be expected to be more extreme. Timing of the body composition measurement is an important consideration for bodybuilding competitors, as extreme leanness is reported to be a feature only in the weeks and days immediately before competition [65–68]. Since phase of competition preparation is an important parameter for interpretation and assessment of body composition characteristics, it is possible that symptoms of MD vary across a competition cycle in conjunction with change in body composition. We identified no studies that had assessed this aspect. Failure to identify phase of training may likely limit the interpretation of MD scores.

4.1 BBs and Non-BBs

Of the eight studies comparing BBs with non-BBs included in this review, six used a resistance-trained comparison group (NBBRTs). Five of these comparison studies found greater MD symptomatology in BBs than in NBBRTs, demonstrated by significant ESs on most, if not all, subscales of the MD assessment tools used (ES range 0.03–2.35). The meta-analysis combined data from five studies, all of which used the MDI to compare a bodybuilding cohort (361 BBs in total) versus a resistance-trained, non-bodybuilding cohort (368 NBBRTs in total). The pooled estimate for each subscale of the MDI showed a medium to large effect of bodybuilding on MD symptoms (ES range 0.53–1.12). Significant heterogeneity was present in the meta-analysis, likely due to the small sample size in some of the included studies, variation in the caliber of participants, and variation in levels of engagement in bodybuilding behaviors. However, the calculated ES from the studies and the pooled data provide evidence to show MD symptomatology is more prevalent in BBs than in NBBRTs. When comparing the non-training control participants, their scores on the MD tools were generally lower than those of both BBs and NBBRTs. Overall, the data support that engagement in bodybuilding is associated with a higher risk of characteristics associated with MD. However, it is important to note that this association does not imply causality, and a plausible explanation may posit that those with a predisposition to MD may be attracted to bodybuilding, with participation in bodybuilding, in turn, potentially exacerbating symptoms. For instance, anecdotal reports and ethnographic studies illustrate accounts of those with predispositions towards body image concerns gravitating towards bodybuilding with the purpose of bolstering self-esteem or a sense of masculinity; involvement in bodybuilding gym culture may subsequently exacerbate MD symptomatology [69].

4.2 Psychological Features

Psychological features associated with MD were examined in 12 of the 31 identified studies. A range of features were investigated, with many often assessed in only a small number of studies. Associated features were similar across both BBs and NBBRTs. Anxiety, depression, neuroticism, and perfectionism were all associated with symptoms of MD, while low self-esteem was associated with greater MD symptoms.

The MD literature has focused primarily on BBs due to the seemingly similar pursuits of BBs and those with MD. This has led to a conflation of the two, and often a misrepresentation of bodybuilding as a sport. The psychological features associated with MD identified in this review are not always typical of BBs and NBBRTs. The frequency and intensity of symptoms of anxiety and social physique anxiety in BBs have been found to be less than, or comparable to, those in recreational weight trainers, recreationally active individuals, and non-exercisers [70–72]. Levels of depression are no different in BBs than in resistance-trained and non-resistance trained individuals [70, 73, 74]. Self-esteem levels in BBs have been reported to be higher than [72, 75], lower than [74], and no different to [74], those in active and inactive individuals. These differences in psychological characteristics of BBs with and without MD highlight an important difference between the participation in bodybuilding and MD, a difference that previously has not been well defined. These findings suggest that the pursuit of a lean, muscular physique in bodybuilding is not in itself associated with psychological comorbidity; rather, it is a non-pathological commitment to an intense training and nutrition plan. When individuals expressing these psychological characteristics take part in this intense program, the potential for developing MD may increase. The evidence to date suggests that, although MD symptomatology appears to be higher in BBs than in NBBRTs and non-training controls, BBs may not necessarily possess or acquire the psychological features associated with MD such as depression, anxiety, and low self-esteem, suggesting that distinct underlying factors underpin the greater MD symptomatology in the bodybuilding samples informing this study. By identifying the psychological characteristics associated with MD in BBs and NBBRTs, this review better enables clinicians and researchers to differentiate individuals committed to bodybuilding and resistance-training activities from individuals who may be experiencing, or at risk of, MD.

4.3 AAS

Use of AAS has been recognized as a component of MD, and hence has been included in proposed diagnostic criteria

[18]. Whether AAS use is a cause or an effect of MD has yet to be determined; however, evidence suggests AAS use is a perpetuating factor of MD [76]. Insufficient data were available to calculate ES in the five studies examining AAS use and MD. The available results are inconsistent regarding comparative rates of MD in AAS users and non-users. Five of the 31 studies, four of which were in a bodybuilding sample, compared users with non-users. As expected, the AAS users scored higher than non-users on MDI and MASS subscales related to pharmacological use [27, 37]. Other results varied, showing either no difference between users and non-users or increased symptoms in users. If indeed steroid use is a perpetuating factor in MD, individuals displaying symptoms of MD would likely turn to AAS use to address their perceived lack of size and muscularity. However, higher overall and subscale scores in AAS users suggest that use of appearance- and performance-enhancing drugs may not be an effective means of reducing other symptoms of MD. The increases in muscle mass and strength associated with AAS use may not reduce the poor self-perception of those with MD, only perpetuating the positive feedback loop. Users may continue to perceive their bodies as small, despite the expected gains in muscle mass, thus maintaining or even increasing MD symptoms, and potentially leading to increased AAS usage [76]. Cella et al [44] found that current steroid users did not score lower than former steroid users, which seems to support this assertion. In this study, the use of steroids did not alleviate MD symptoms, and cessation of steroid use did not result in a relapse of MD symptoms, indicating steroid use may not be an effective means of coping with MD.

4.4 Limitations

The present analysis has notable limitations. Some of the included studies only crudely defined the bodybuilding caliber of participants, and the body composition and training data suggest they were not highly engaged with the sport. Very few studies commented on the training or competition phase of participants, BBs were often not described as competitive or non-competitive, and only one study distinguished between training and non-training days. In addition, no longitudinal data were identified. This limits the assessment of how symptomatology may vary over a competition cycle. Longitudinal data may also provide information on how the competitive bodybuilding environment may exacerbate symptoms. Steroid use is common in bodybuilding [22]; however, 24 of the 31 studies included in the review did not state the drug-taking status of participants. There was also a risk of undisclosed steroid use in studies that did present drug-usage information (as it was self-reported). There was a sex bias towards recruitment of male BBs and resistance trainers, although this likely mirrors sex participation in competitive bodybuilding. Many of the mixed sex samples grouped the data rather than separating by sex. More mixed and female samples would provide better insight into differences between males and females in MD. Overall, the quality of the literature informing the study was low to moderate. Further to this, we were only able to conduct meta-analysis on 5 of the 31 studies, and significant heterogeneity was identified. This limits the strength of the evidence. Weaknesses, including inadequate assessment of athlete caliber, use of AAS, and the influence of competition phase on MD symptoms, limit the capacity to evaluate the influence of these factors.

5 Conclusions

This systematic review and meta-analysis supports that BBs have greater MD symptomatology than NBBRTs. Psychological characteristics associated with MD have been identified in BBs and NBBRTs. Nevertheless, those with severe MD symptomatology show a greater array of psychiatric comorbidity, including anxiety, depression, perfectionism, and low self-esteem, which may be relevant in delineating between pathological and non-pathological muscularity pursuits. We suggest that bodybuilding may attract susceptible individuals, and may also be relevant in cultivating advanced symptomatology in BBs with the cluster of psychological features associated with MD. Further evidence is required to definitively elucidate whether bodybuilding is a cause of MD, or whether the sport of bodybuilding attracts those predisposed to MD. Longitudinal studies, controlling for the effect of training and non-training days, would enable measurement of changes in MD symptoms over different stages of bodybuilding preparation and further explicate the nature of the relationship between bodybuilding and MD symptoms.

Compliance with Ethical Standards

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