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Identifying Components of Drive for Muscularity and Leanness Associated With Core Body Image Disturbance: A Network Analysis

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Alongside thin ideals, internalizing muscular and/or lean body ideals is associated with eating disorder (ED) symptomatology, especially among males. However, assessment of drive for muscularity (DM) and drive for leanness (DL) also captures attitudes and behaviors that are normative in the general population. The aim of this study was to identify components of DM and DL that are independently linked to core body image disturbance in EDs—shape/weight dissatisfaction, overvaluation ,and fear of weight gain—in community adolescents using network analysis. A representative sample of 4,975 Australian adolescents (53% females, M_{age} = 14.92) from Wave 1 of the EveryBODY study was included in the analyses. We estimated regularized and unregularized networks, identified communities of items, estimated bridge centrality between communities, and explored sex differences in network structure and connectivity with a Network Comparison Test. Results showed that items "feeling better about oneself if having a lean body" and "wishing to be muscular" had the highest bridge centralities, and network structures of male and females did not significantly differ. Importantly, some components of DM were negatively associated with body image disturbance. These findings suggest that, when investigating the role of DL and DM in EDs, it would be useful to further assess these constructs as multifaceted since relationships between these phenomena are likely more nuanced than previously speculated. Development and subsequent use of instruments for certain behaviors and/or attitudes more specifically associated with body image disturbance might be more informative than somewhat artificially confined focus on either thinness, leanness, or muscularity.

Public Significance Statement

Desire to obtain muscular and desire to obtain lean body are considered risk factors for body image disturbance and, in turn, eating disorder development, but typically used scales also capture aspects common in healthy individuals. By using network analysis in community adolescents, we observed both positive and negative associations between drive for muscularity, leanness, and body image disturbance, which suggests that these concepts might need to be assessed as multifaceted rather than uniform.

Keywords: eating disorders, dissatisfaction, overvaluation, fear of weight gain, adolescence

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Eating disorders (EDs) are characterised by consistent disturbances in eating-related behaviour or eating itself that lead to impaired physical health and/or psychosocial functioning (American Psychiatric Association [APA], 2013). The three major EDs include anorexia nervosa, bulimia nervosa, and binge ED, whose point prevalence fluctuates between 0.5% and 1.5% (Hay et al., 2017). Other Specified Feeding or Eating Disorder (OSFED) or Unspecified Feeding or Eating Disorder (UFED) are allocated as the diagnosis when the signs and symptoms a person exhibits do not match all the criteria for the main EDs, and yet are associated with distress and/or impairment in role functioning (Smink et al., 2014). Negative body image is a core disturbance across most EDs and is included among diagnostic criteria for anorexia nervosa and bulimia nervosa, although it is not a criterion nor specifier for binge ED (APA, 2013).

Body Image Disturbance in Eating Disorders

Body dissatisfaction, overvaluation of shape/weight, and fear of weight gain are considered by many authorities to be aspects of body image disturbance with distinct correlates and diagnostic significance (Fairburn et al., 2003; McLean & Paxton, 2019). They also play unique roles in explaining ED psychopathology concurrently (Grilo et al., 2019; Linardon et al., 2018; Lydecker et al., 2017) and prospectively (Prnjak et al., 2021). Body dissatisfaction is a widely researched aspect of body image disturbance that is thought to promote dieting and hence increase risk for ED development (Stice et al., 2011). It is, however, considered to be quite common, with reports showing that more than 80% of Australian women and 60% of Australian men are somewhat dissatisfied with their weight or shape, whereas moderate or marked dissatisfaction was reported by 33% and 15% of Australian women and men, respectively (Griffiths et al., 2016; Mond et al., 2013). Furthermore, overvaluation of shape/weight has historically been posited as a core transdiagnostic ED symptom, and it is aDiagnostic and Statistical Manual of Mental Disorders (DSM-5) diagnostic criterion for bulimia nervosa (APA, 2013), although it is becoming more prevalent and "normalized" in general population (Santana et al., 2019). Finally, fear of weight gain is a DSM-5 criterion for anorexia nervosa (APA, 2013), and it is considered to be a common, possibly maintaining factor in other EDs as well (Levinson et al., 2020).

Drive for Muscularity

Mentioned aspects of body image disturbance are traditionally thought to be preceded by the internalization of a thin body ideal, typically endorsed by women (Culbert et al., 2015; Thompson & Stice, 2001). Given EDs were for a long time considered as exclusively affecting females, the focus of body image research was almost entirely constrained to women. However, data show that the rate of ED behaviors is increasing more rapidly in males than females (Mitchison et al., 2014), and it is now considered that males account for at least one in four ED presentations which was earlier considered to be just one in ten (Dakanalis et al., 2014; Hudson et al., 2007). Yet, until recently, body idealizations were largely neglected in males (Rodgers et al., 2012), who in particular experience drive for muscularity (DM) rather than thinness. In men, it has been observed that the aspiration for increasing muscle mass and obtaining a highly muscular body can lead to an increased concern around body shape/weight and eating, which, when taken to an extreme, characterize ED symptomatology (Jones et al., 2008). Specifically, in males, DM is strongly linked to body dissatisfaction (Baker et al., 2019; Bucchianeri et al., 2014)—a risk factor for ED development (Prnjak et al., 2021; Stice et al., 2011)—which does not seem to be the case in females (Schaefer & Blodgett Salafia, 2014). Despite this, current ED classifications do not recognize muscularity-oriented attitudes and behaviors as potential markers of ED psychopathology. Rather, in current nomenclature, muscle dysmorphia—which is characterized by pathological DM—is included as a specifier for Body Dysmorphic Disorder in the DSM-5 "Obsessive-compulsive and Related Disorders" category (APA, 2013). Indeed, the current DSM-5 criteria for EDs do not directly include muscularity-oriented disordered eating behaviors, in which many body-dissatisfied males engage (Calzo et al., 2016; Compte et al., 2015).

Drive for Leanness

A similar construct to DM is drive for leanness (DL), which is characterized by a desire to have both low body fat and toned muscles. Although DL is still under-researched, findings from an early study suggested that gender differences in DL are not as pronounced as in DM (Smolak & Murnen, 2008) since it appears that both men and women increasingly prefer a lean physique more than simply thin or muscular bodies (Hartmann et al., 2018; Tylka, 2011). Moreover, it remains somewhat unclear whether DL also reflects an interest in having a healthy, physically well-functioning body beyond the motivation for specific appearance. For instance, DL was shown to be associated with exercising for health purposes, and it was independently unrelated to ED symptoms, depression, and anxiety in a community sample of young men and women (Lang & Rancourt, 2020). In addition, DL did not have an independent contribution in explaining ED symptoms in female bodybuilders above and beyond DM and drive for thinness (Hartmann et al., 2018). However, one study found that men and women high in DL reported significantly greater levels of body shame than those low in DL, albeit lower than groups characterized by high drive for thinness and DM (Smolak & Murnen, 2008). Another study reported DL to be positively associated with muscularity dissatisfaction and body fat dissatisfaction in adult men, indicating that DL could also have a salient role in emergence of male body dissatisfaction (Ryan & Morrison, 2013). Aforementioned findings suggest that the role of DL in ED onset may be somewhat more ambiguous than is the case with drive for thinness and DM, despite the fact that all three constructs tap into a desire to alter one's shape/weight in order to meet an internalized ideal.

It is critical to further clarify the role of DL and DM in EDs given the recent rise in popularity of "athletic ideals" often promulgated through social media (Robinson et al., 2017). DM and DL appear to be both similar and distinct in important ways, theoretically and empirically (Hartmann et al., 2018; Tod et al., 2012). For example, even though DL and drive for thinness share a similar emphasis on smaller body and low body fat, in some studies, DL was more strongly associated with DM than with drive for thinness, presumably due to their shared emphasis on muscle tone (Lang & Rancourt, 2020; Tod et al., 2012). Nonetheless, previous studies investigated DM and DL as unitary constructs, which limits understanding of the cognitive and behavioral aspects within these drives that may explain whether and how these constructs may be linked with

ED development. For this purpose, it is important to recognize that using internal consistency and even factor analysis can sometimes lead to erroneous conclusions about a measurement scale's unidimensionality (i.e., presence of a single factor; Sijtsma, 2009) and about construct validity, which additionally requires assessment of the construct's nomological network (i.e., a set of relationships with other constructs; Gerbing & Anderson, 1988). Network analysis can be used to investigate the latter.

The Utility of Network Analysis

Conceptualizing mental disorders and their symptoms as complex dynamic systems of interacting variables is a feature of the network approach, which aims to identify which symptoms play a central role in psychopathology (van Borkulo et al., 2015). Symptoms are not reflective of the underlying psychopathology according to network theory, but their mutual interactions are exactly what forms a specific psychopathology (Borsboom & Cramer, 2013; McNally, 2016). The network analysis also offers a potential solution to addressing properties of measurement. Specifically, if two very closely related items have the same association pattern with other items within a network, then one might conclude these represent the same construct; otherwise, they could be highly correlated yet distinct constructs (e.g., height and weight) and should be treated as separate variables (Fried & Cramer, 2017). In general, a high correlation between two variables A and B might reflect (a) a direct relationship between items/variables, (b) the presence of a third variable C that causes both variables A and B, or (c) conditioning on a common effect (collider) that induces a correlation between previously uncorrelated variables (see Schmittmann et al., 2013 for a more detailed overview). In the case of (a), it is possible that variable A causes variable B; that variable B causes variable A; or that both variables A and B mutually cause each other, although these directions cannot be inferred simply from a statistical model (Marsman et al., 2018).

In the field of EDs and body image, several studies have been conducted by applying the network approach (DuBois et al., 2017; Forbush et al., 2016; Goldschmidt et al., 2018; Levinson et al., 2017; Smith et al., 2019; Solmi et al., 2018). Across these studies, dissatisfaction with shape/weight—and even more so overvaluation of shape/weight and fear of weight gain—have been shown to be central symptoms in networks of ED symptoms (Calugi et al., 2020; Christian et al., 2020; DuBois et al., 2017; Goldschmidt et al., 2018; Levinson et al., 2017; Wang et al., 2019). Additionally, in a study that included aspects of DM into a network of ED symptoms in men, *feeling guilty for missing training* and *using supplements* were DM aspects that were among the most central symptoms in the network (i.e., strongly linked to other ED symptoms; Forrest et al., 2019). Interestingly, no study has yet included a number of DL components (e.g., those assessing attitudes towards lean body as ideal) when forming a network structure, and only a few studies in this field have focused on emergence of EDs in adolescent samples (Calugi et al., 2020; Goldschmidt et al., 2018).

The Present Study

Given the association between DM, DL, and ED symptomatology, and with many EDs peaking in onset during the adolescent years (Hoek & van Hoeken, 2003), there are significant gaps in the literature that need to be addressed. Muscle building behaviors among adolescents are common; studies show that up to 50% of adolescent boys and 20% of girls use protein powder, and up to 5% of both boys and girls use steroids (Dunn & White, 2011; Eisenberg et al., 2012; Yager & McLean, 2020). Hence, identifying components of DM and DL that link to core body image disturbance is important for assessing the risk for ED development at this crucial age. In that regard, health professionals would benefit from knowing which components of DM and DL are more likely to be linked to ED symptomatology, and which components reflect a more widespread motivation not necessarily indicative of this psychopathology. Network models, and in particular graphical models, can help us determine relationships between variables under the assumption that unconnected variables are conditionally independent given all other variables in the same network (Borsboom et al., 2021; Cox & Wermuth, 2014). This is useful for identifying which items within DM and DL are linked to body image disturbance when controlling for all other items in the network system. Although DM and DL have been referred to as unidimensional by some (de Carvalho et al., 2019; Ryan & Morrison, 2013), these constructs encompass attitudes, behaviors, and emotional responses which might show distinct patterns of relationships with other constructs such as shape/weight dissatisfaction, overvaluation, and fear of weight gain. Thus, it is important to break down DM and DL into their component parts by using network analysis to examine which aspects may and may not be independently linked to core aspects of body image disturbance during the critical period of adolescence.

To shed light on these gaps in the literature, our first aim of the present study was to inspect how different components of DM and DL are associated with each of the three core components of body image disturbance, namely shape/weight dissatisfaction, overvaluation, and fear of weight gain. In particular, we wanted to examine which specific components of DM and DL serve as a link to body image disturbance variables. This would potentially point to certain experiences that could be key contributors to the co-occurrence of DM, DL and body image disturbance, and thus might warrant more research attention in the future. The second aim was to compare these network structures between female and male adolescents to inspect whether some associations present differently due to sex given the above-outlined sex differences that were observed in DM–body image disturbance relationship (albeit not in the case of DL). Given the exploratory nature of this study and lack of a strong theory behind these relationships, we could not directly test hypotheses. However, we did expect that some items from DM that tap into negative emotionality (e.g., guilt) would show stronger associations with shape/weight dissatisfaction and fear of weight gain given the shared emphasis on emotional responses related to one's shape/weight. We also expected network structure of DM and body image disturbance to be stronger in male than female adolescents since muscularity-related attitudes and behaviors are involved in ED pathology of men more commonly than women (Darcy et al., 2012; Schaefer & Blodgett Salafia, 2014).

Method

Participants

Materials and analysis code for this study are available by emailing the corresponding author. We used the data from the first

wave (collected in 2017) of the EveryBODY Study, a longitudinal investigation of EDs and body image among Australian adolescents. This study was not preregistered. The study protocol was approved by the authors' local Human Research Ethics Committee. Overall, 13 schools participated at Wave 1 (N = 5,191). Exclusion of unacceptable rates of missing data, nonserious responses, and withdrawn consent led to N = 5,072. For details about the sampling procedures and data collection see Trompeter et al. (2018). Additionally, in the present study, another 97 participants were removed from the data due to having all missing values in this subset of variables, leaving a final sample size of N = 4,975.

Measures

Body Image Disturbance

The Eating Disorder Examination Questionnaire (EDE-Q; Fairburn, 2008) consists of 28 questions that assess ED attitudes and behaviors within the past 28 days. To assess specifically shape/weight dissatisfaction, overvaluation, and fear of weight gain, individual items were extracted from the EDE-Q. Two items *How dissatisfied have you been with your weight* and *How dissatisfied have you been with your shape* were averaged to represent weight/shape dissatisfaction. Items *Has your weight influenced how you think about (judge) yourself as a person* and *Has your shape influenced how you think about (judge) yourself as a person* were averaged to capture shape/weight overvaluation. Fear of weight gain was assessed with a single item *Have you had a definite fear that you might gain weight*. Participants had to estimate the number of days (for fear of weight gain) and severity (for dissatisfaction and overvaluation) on a 7-point Likert-type scale (0—*No days/not at all*; 6—*Every day/markedly*), with higher scores indicating greater body image disturbance. Previous studies showed these EDE-Q items are useful tools for assessment of shape/weight dissatisfaction, overvaluation, and fear of weight gain (Linardon et al., 2018; Mitchison et al., 2017). In the present study, Spearman-Brown coefficients for overvaluation and dissatisfaction scores were 0.934 and 0.928, respectively.

DM

The Drive for Muscularity Scale (DMS; McCreary et al., 2004) includes 15 items that assess attitudes and behaviors toward increasing muscularity (e.g., *I wish that I were more muscular*). Responses are provided on a 6-point Likert-type scale (1—*Never*; 6—*Always*), with higher scores indicating a higher DM. In order to include aspects of DM not captured in the DMS, items *I hate my body*, *I pass up social activities with friends because of my workout schedule*, and *I pass up chances to meet new people because of my workout schedule* from the Muscle Dysmorphic Disorder Inventory (MDDI; Hildebrandt et al., 2004) were presented alongside DMS questionnaire during data collection, as well as the item *I wish I were taller* from the Male Body Attitudes Scale (MBAS; Tylka et al., 2005). Previous studies demonstrated good reliability and validity of DMS scores in men (McCreary et al., 2004) and women (de Carvalho et al., 2019), as well as adolescents (Brunet et al., 2010). In the present study, the omega coefficient was .923, 95% CI [.920, .928], for the DM attitudes subscale, and .893, 95% CI [.884, .902], for the DM behaviors subscale.

DL

The original version of Drive for Leanness Scale (DLS; Smolak & Murnen, 2008) was used to assess attitudes toward having a lean, toned body (e.g., *My goal is to have well-toned muscles*). Participants responded to 10 items using a 6-point Likert-type scale (1—*Never*; 6—*Always*), with higher scores indicating a higher DL. Previous studies showed good internal consistency of DLS scores in men and women (Tod et al., 2012). In the present study, the omega coefficient was .927, 95% CI [.924, .930].

Statistical Analyses

Statistical software R (Developer Core Team. R., 2019) was used to carry out statistical analyses. All variables were initially positively skewed with varying standard deviations but were standardized before forming network to ensure that differences in standard deviations do not impact centrality estimates. Pairwise deletion (built into *bootnet* package) was used for handling missing data points (4%).

Topological Overlap

In network modeling, nodes represent individual variables (questionnaire items in the present study) and edges represent conditional associations between two variables/nodes in the network (Epskamp, Maris, et al., 2018). Network models can be either undirected (no direction of association is indicated) or directed (the direction of association is shown) and unweighted (associations are simply present or absent) or weighted (associations between nodes also differ in their strength; Dalege et al., 2017). We constructed undirected, weighted network models where edges reflect the pairwise conditional relation between two nodes when all other nodes in the network are held constant. In order to check for the presence of multicollinearity (very high overlap between nodes) before including all nodes in the network model, the *goldbricker* function in the *networktools* package (Jones, 2018) in R was used. *Goldbricker* suggested no reductions of nodes are necessary (no pairs of nodes with 75% of correlations with other nodes being the same). Therefore, no nodes were excluded prior to creating network models.

Network Estimation

Markov Random Fields (undirected network models) were constructed to identify conditional associations between variables. To account for nonnormality of distributions, analyses were based on Spearman correlations. We estimated the most commonly used network model, Gaussian Graphical Model (GGM), that captures conditional relationships between all observed variables, in which the linear effect of every other variable is controlled for (Fan et al., 2016). GGMs were estimated with thresholded *EBICglasso* (Epskamp & Fried, 2018). *EBICglasso* estimates network models using a regularization technique called graphical least absolute shrinkage and selection operator (graphical LASSO or glasso; Friedman et al., 2008), and extended Bayesian Information Criterion (EBIC; Chen & Chen, 2008) for selecting optimal regularization parameter. In general, *LASSO* regularization sets small edge-weights to be exactly zero in order to avoid false positives, resulting in a sparser network (i.e., less edges). This is controlled by adjusting the hypertuning parameter γ (gamma) to be between 0 (*less conservative*)

and 1 (*more conservative*). In this study, γ was set to be 0.5. As regularization is criticized to underperform in larger samples (Williams & Rast, 2020), we also estimated networks using a relatively novel method, *ggmModSelect,* which searches for an optimal unregularized GGM by minimizing Bayesian Information Criterion (BIC) based on *glasso* algorithm and stepwise estimation. Specifically, *ggmModSelect* runs *glasso* for 100 tuning parameters to obtain 100 networks, and then chooses the best model according to BIC by adding or removing edges. *ggmModSelect* was implemented in the package *qgraph* (version 1.5; Epskamp et al., 2012). In addition, all networks were plotted with the *ggnet2* function from the *GGally* package (Schloerke et al., 2018), using the Fruchterman–Reingold algorithm which places more strongly associated nodes closer to each other (Fruchterman & Reingold, 1991).

To check the precision of parameter estimates, R-package *bootnet* was used (Epskamp, Borsboom, & Fried, 2018). We performed 1,000 nonparametric bootstraps with 95% confidence interval to test edge weight stability, as recommended in the network psychometrics literature (Epskamp, Borsboom, & Fried, 2018). Nonparametric bootstraps were performed for both *EBICglasso* and *ggmModSelect* networks to compare the two estimation techniques. Correlation stability (CS) coefficients were also computed, which assess stability of centrality estimates by indicating a maximum drop proportion that can retain a correlation with original sample of 0.7 in 95% of simulated samples.

Community Detection and Bridge Nodes

In order to explore whether DM, DL, and body image disturbance items form clusters that correspond to these exact constructs, and which particular items might be "bridges" between these clusters, we used the R package *EGAnet* (Golino & Epskamp, 2017) and package *networktools* (Jones, 2018), respectively. Specifically, the Exploratory Graph Analysis (EGA) was conducted to detect communities among included variables. Communities are clusters of highly connected variables, equivalent to factors in the context of factor analysis (Christensen & Golino, 2021), although in some instances EGA was shown to outperform other techniques typically used for finding the best factor solution (Golino & Epskamp, 2017). *Triangulated Maximally Filtered Graph* (TMFG) estimates were used based on automatically computed zero-order correlations and *Walktrap* algorithm, chosen according to the lowest Entropy Fit index (fit index that shows how much a given structure deviates from the best representation of variables; Golino, Moulder, et al., 2020). TMFG was selected as it is not restricted to multivariate normal distributions and seems to perform equally well as the standard EGA with *glasso* estimation (Golino, Shi, et al., 2020). To estimate the median number of communities, 1,000 bootstrap samples were generated with the *bootEGA* function.

The *bridge* function from the R-package *networktools* (Jones, 2018) was used to identify important nodes that act as a "bridge" between detected communities. Edge weight matrices from both *EBICglasso* and *ggmModSelect* were used for identification of bridge nodes, and centrality indices (*bridge strength* and *bridge expected influence*) were reported in both cases. Bridge strength represents a sum of the *absolute value* of all edges between a given node and nodes that belong to a different community, indicating which nodes are more likely to activate nearby communities (Heeren et al., 2018). On the other hand, one-step and two-step bridge expected influence represent the sum of both *positive and negative* edge weights between a particular node and nodes in other communities and are recommended for networks where negative edges exist (Robinaugh et al., 2016). To inspect the stability of bridge centrality estimates and edge weight estimates, we computed 1,000 case-dropping subset bootstraps and 1,000 nonparametric bootstraps with 95% confidence interval, respectively.

Comparison of Male and Female Networks

The Network Comparison Test (NCT; van Borkulo et al., 2017) was used to compare networks of males and females. This permutation test explores whether the overall network structure differs between groups, and it can also report on differences being present in specific edges. Since this test cannot deal with any missing values, 112 male and 72 female participants had to be excluded, leaving a total of 4,791 participants. Sample size is involved in the penalty of regularized estimation methods and power is influenced by similarity in group sizes (van Borkulo et al., 2017). Thus, to ensure unequal sample sizes would not affect these estimates, we created a random subset of female participants (n = 2,227 instead of n = 2,564) that was the same size as the male subsample (n = 2,227). Overall, 1,000 iterations were performed with γ of 0.5 (default for gaussian data). We also correlated edge weight matrices of male and female adolescents to additionally inspect network structure similarity.

Results

Participant Characteristics

The final sample included 4,975 participants from the Wave 1 of the EveryBODY study. Of these, 53% were females (n = 2,636). Mean age of the sample was 14.92 years (range: 11.2–19.7). Eighty nine percent (n = 4,448) of participants were from Australia, 5.6% (n = 278) from Asia, 2.1% (n = 105) from Europe, and the remainder of 2.9% (n = 142) from either America, Africa or Oceania (other than Australia). Descriptive statistics of all other variables used in this study are presented in Table 1.

Community Detection

EGA detected four communities, that is clusters of variables (median of bootstrapped communities), which approximately correspond to used scales/subscales, with few exceptions. Specifically, weight/shape dissatisfaction overvaluation and fear of weight gain were detected as a single community, alongside the "I hate my body" item from the MDDI. All DL items were detected as one community which is in accordance with its presumed single-factor structure (Ryan & Morrison, 2010). DM items were split into two communities (one for behavioral and one for attitudinal items), which also corresponded to its factor structure (McCreary et al., 2004), except for the items "I think that I would look better if I gained 10 pounds in bulk" and "I think about taking anabolic steroids" which loaded onto behavioral rather than attitudinal factor.

Bridge Nodes

Four detected communities served as a foundation for estimating bridge centrality of nodes that link these communities. *Z*-score transformed bridge centrality based on *EBICglasso* estimation is shown in Figure 1. Of note, bridge centrality based on

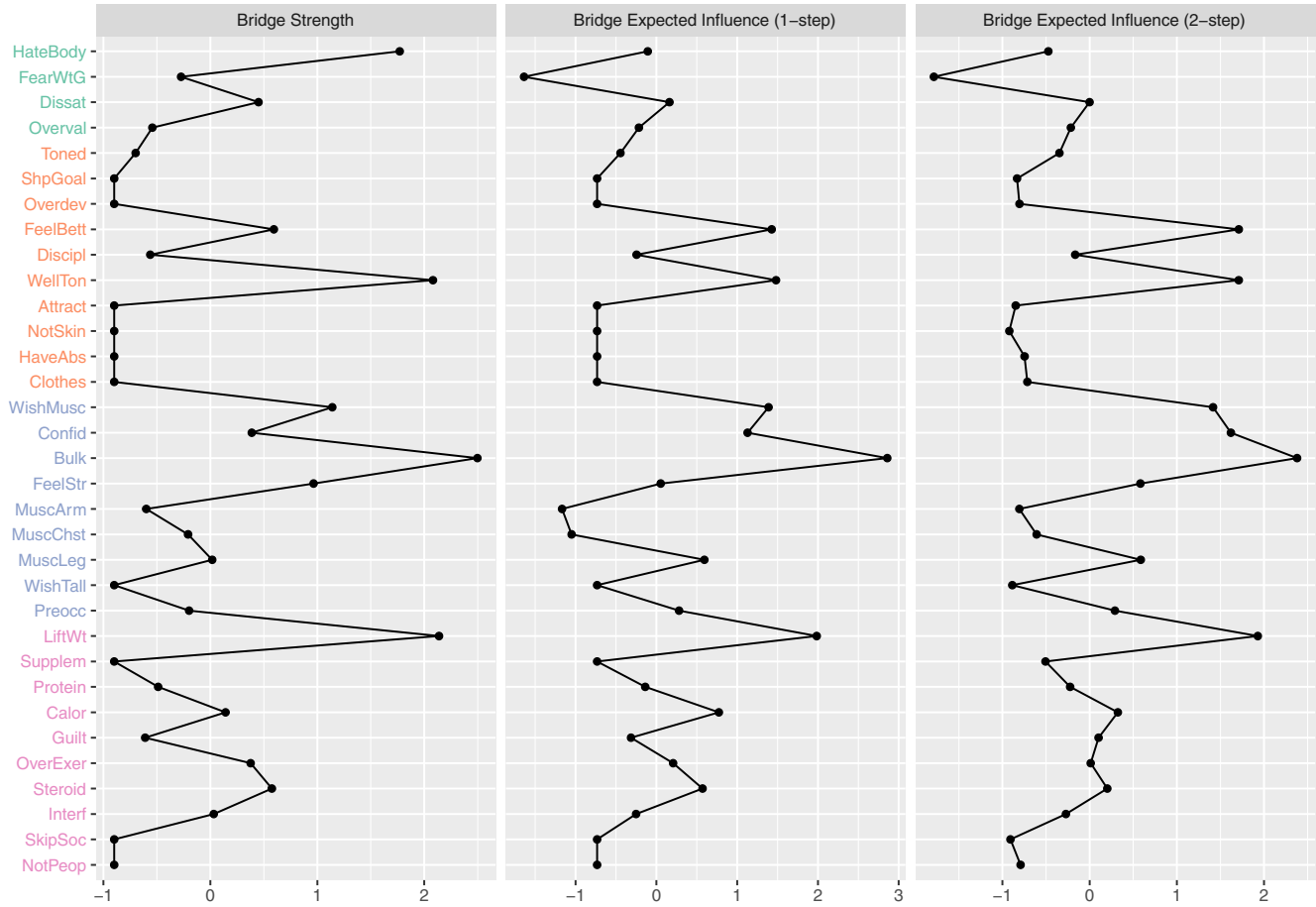
Table 1
Descriptive Statistics of Variables Prior to Standardization

Node name	Item	Range	*M*	*SD* Males	*Mdn*	*M*	*SD* Females	*Mdn*
DMS								
*HateBody	I hate my body	1–6	1.81	1.26	1	2.97	1.64	3
WishMusc	I wish that I were more muscular	1–6	3.12	1.64	3	2.66	1.51	2
LiftWt	I lift weights to build up muscle	1–6	2.60	1.65	2	1.81	1.23	1
Supplem	I use protein or energy supplements	1–6	1.79	1.39	1	1.44	0.99	1
Protein	I drink weight gain or protein shakes	1–6	1.63	1.29	1	1.25	0.77	1
Calor	I try to consume as many calories as I can in a day	1–6	1.70	1.25	1	1.33	0.81	1
Guilt	I feel guilty if I miss a weight training session	1–6	1.93	1.53	1	1.70	1.29	1
Confid	I think I would feel more confident if I had more muscle mass	1–6	2.71	1.67	2	2.16	1.43	2
OverExer	Other people think I work out with weights too often	1–6	1.52	1.15	1	1.23	0.70	1
Bulk	I think I would look better if I gained 10 pounds (4.5 kg) in bulk	1–6	2.15	1.62	1	1.27	0.77	1
Steroid	I think about taking anabolic steroids	1–6	1.27	0.93	1	1.08	0.44	1
FeelStr	I think that I would feel stronger if I gained a little more muscle mass	1–6	2.67	1.67	2	1.90	1.33	1
Interf	I think that my weight training schedule interferes with other aspects of my life	1–6	1.58	1.23	1	1.31	0.86	1
MuscArm	I think that my arms are not muscular enough	1–6	2.66	1.68	2	2.17	1.49	2
MuscChst	I think that my chest is not muscular enough	1–6	2.54	1.66	2	1.43	0.99	1
MuscLeg	I think that my legs are not muscular enough	1–6	2.29	1.59	2	2.15	1.48	1
*SkipSoc	I pass up social activities with friends because of my workout schedule	1–6	1.47	1.11	1	1.32	0.88	1
*NotPeop	I pass up chances to meet new people because of my workout schedule	1–6	1.45	1.12	1	1.25	0.79	1
*WishTall	I wish I were taller	1–6	2.73	1.84	2	2.52	1.72	2
*Preocc	How much of your time each day (on average) is occupied by thoughts of being too small or not muscular enough?	1–5	1.62	0.88	1	1.64	0.91	1
DLS								
Toned	I think the best looking bodies are well-toned.	1–5	2.44	1.33	2	2.68	1.34	2
ShpGoal	The goal of working out should be to get in shape	1–5	2.92	1.40	3	2.99	1.35	3
Overdev	People's muscles should be toned but not overdeveloped	1–5	2.85	1.45	3	2.92	1.43	3
FeelBett	Having lean, hard body would make me feel better about myself	1–5	2.46	1.41	2	2.53	1.48	2
Discipl	When a person's body is hard and firm, it says they are well-disciplined	1–5	2.13	1.27	2	2.00	1.19	2
WellTon	My goal is to have well-toned muscles	1–5	2.58	1.45	2	2.42	1.43	2
Attract	Athletic looking people are the most attractive people	1–5	2.31	1.30	2	2.32	1.27	2
NotSkin	It is best to be thin but not skinny	1–5	2.50	1.38	2	2.87	1.41	3
HaveAbs	It is important to have well-defined abs	1–5	2.34	1.37	2	2.25	1.32	2
Clothes	People with well-toned muscles look good in clothes	1–5	2.55	1.39	2	2.60	1.36	2
EDE-Q								
FearWtG	On how many days of the past 4 weeks (28 days) have you had a definite fear that you might gain weight?	0–6	0.75	1.66	0	2.06	2.37	1
†Dissat	Over the past 4 weeks (28 days), how dissatisfied have you been with your weight/shape?	0–6	0.93	1.54	0	2.39	2.12	2
†Overval	Over the past 4 weeks (28 days), has your shape/weight influenced how you think about (judge) yourself as a person?	0–6	0.91	1.53	0	2.30	2.11	2

Note. Nodes with asterisk (*) were extracted from other instruments. Nodes with obelisk (†) represent an average score of two items (one referring to *weight* and one referring to *shape*). DMS = Drive for Muscularity Scale; DLS = Drive for Leanness Scale; EDE-Q = The Eating Disorder Examination Questionnaire.

Figure 1

Bridge Strength, One-Step and Two-Step Bridge Expected Influence Centrality Estimates for Each Node in the Regularized Network



Note. Estimates are *z*-score transformed and ordered by communities [green—drive for muscularity (behavioral component); orange—drive for muscularity (attitudinal component); blue—drive for leanness; pink—body image disturbance]. In bridge strength centrality absolute values of edges are summed, whereas in bridge expected influence centrality both positive and negative values are taken into account. See the online article for the color version of this figure.

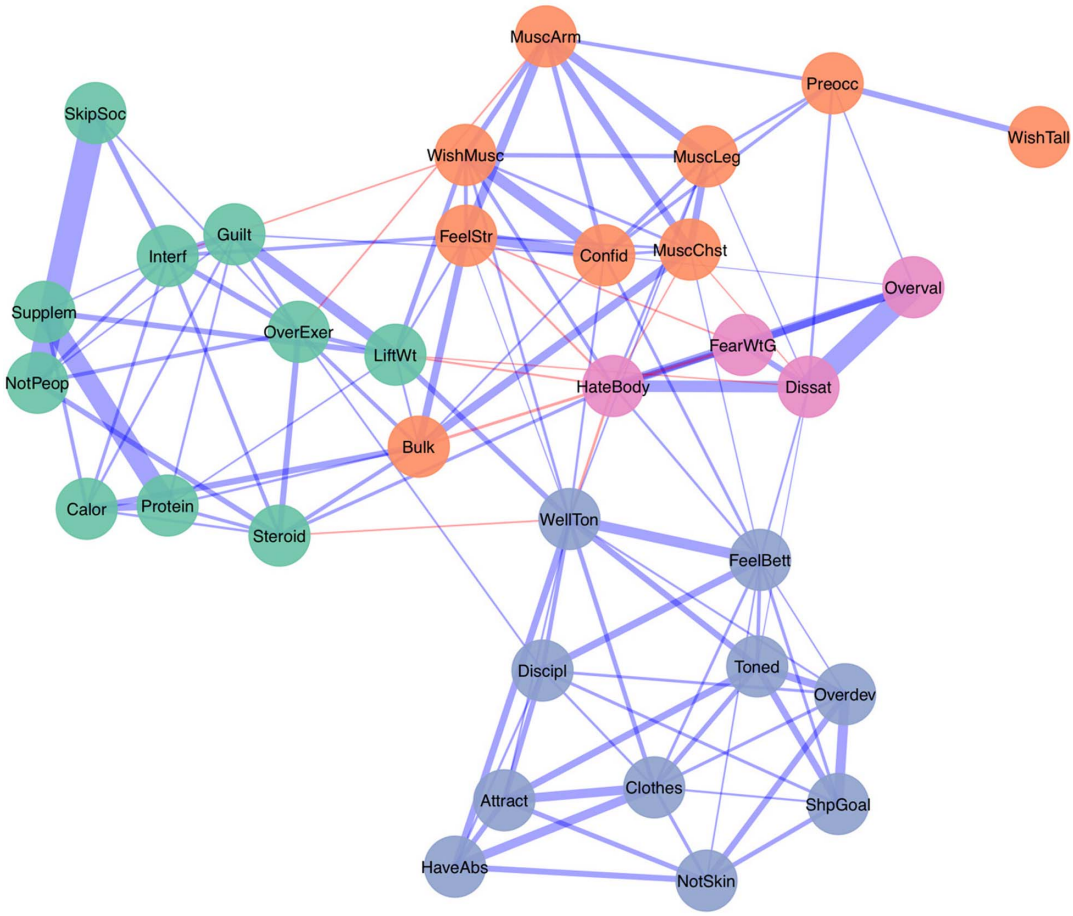
ggmModSelect estimation is depicted in Supplemental Figure S1. To interpret centrality metrics, we focus primarily on bridge expected influence given that there were several edges with negative values (Robinaugh et al., 2016). "Thinking one would look better if gained 10 pounds in bulk," "lifting weights to build up muscle," "well-toned muscles being a goal," "wishing to be more muscular," "feeling better about oneself if having a lean body," "feel more confident if having more muscle mass," etc., were nodes with relatively higher bridge centrality. This indicated that these variables had the highest connectivity with other communities (to which they do not belong). According to case-dropping bootstrapping, the average correlation between centrality indices of the original sample and bootstrapped sample was slightly higher than 0.75 even when only 30% of the original sample was retained (Supplemental Figures S5 and S6). Importantly, however, bootstrapping results suggest that a large number of differences in bridge centrality between nodes were not stable (Supplemental Figures S3 and S4). Therefore, it is not possible to distinguish between bridge centrality of nodes with similar estimates. Of note, one should bear in mind that these centrality metrics do not point to a specific community, so the interpretation of bridge centrality is not straight-forward when more than two communities are present (Christensen et al., 2021).

Network Structure and Stability

Spearman correlation between regularized and unregularized edge weight matrices was .847 ($p < .001$), suggesting these networks are very similar. *EBICglasso* found 246 and *ggmModSelect* estimation found 370 nonzero edges. In the main text, we present findings based on the regularized model (*EBICglasso*) because it had a simpler structure, whereas all results based on *ggmModSelect* estimation are shown in the Supplemental material. The regularized network structure based on *EBICglasso* estimation is shown in Figure 2. Among DL items, only "feeling better if having a leaner body" was positively associated with body image disturbance community, whereas among DM items "wishing to be more muscular," "feeling more confident if having more muscle mass," "thinking one's legs are not muscular enough," "thinking about taking steroids," and being preoccupied with muscularity were items linked to body image disturbance community.

Figure 2

Regularized Network of Body Image Disturbance, Drive for Muscularity, and Drive For Leanness



Note. Thicker edges represent stronger regularized conditional dependence relations, whereas colors blue and red depict positive and negative edge weights, respectively. Colors of the nodes denote four detected communities [pink—body image disturbance; blue—drive for leanness; orange—drive for muscularity (attitudinal component); green—drive for muscularity (behavioral component)]. See the online article for the color version of this figure.

In nonparametric bootstrap analyses, both *EBICglasso* and *ggmModSelect* estimator showed good stability (Figure S8 and S9). Overall, edge weight CIs were relatively narrow for both estimation techniques and differences between edge weights were for the most part significant. CS coefficients for bridge strength and expected influence using *ggmModSelect* were both 0.75 (0.672–1) and using *EBICglasso* 0.75 (0.672–1) and 0.672 (0.594–0.75), respectively. Usually values over 0.5 suggest a good stability of centrality of indices (Epskamp, Borsboom, & Fried, 2018).

Differences in Networks of Males and Females

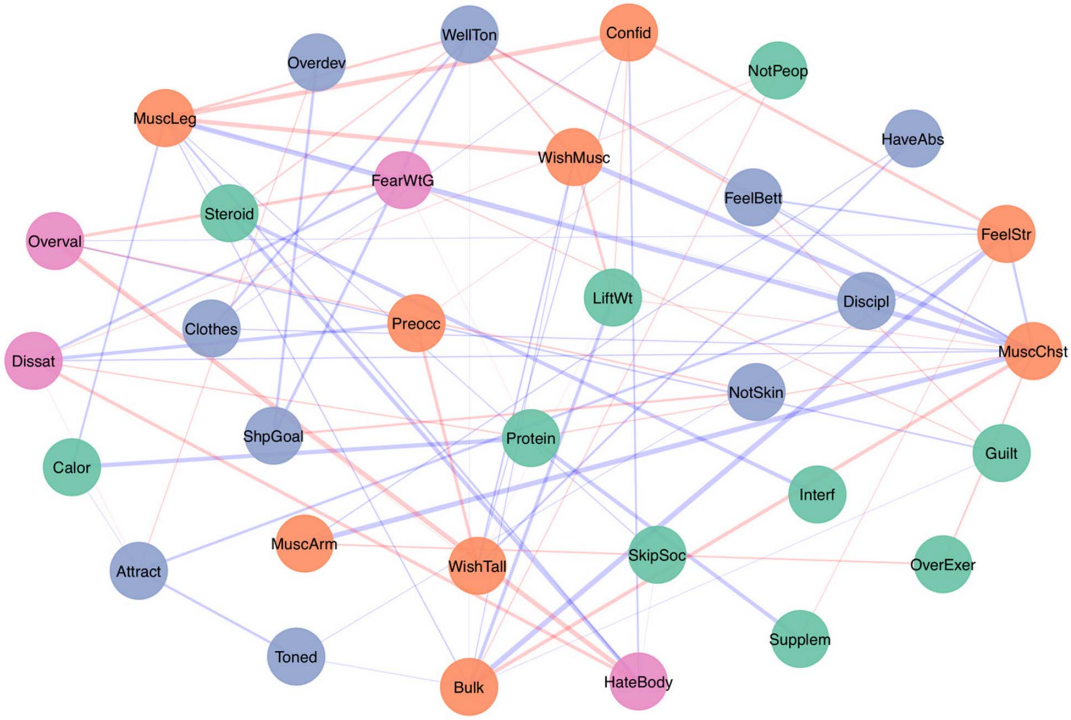
The NCT test showed that global differences between network structures (patterns of associations) of females and males did not reach significance ($M = 0.141$; $p = .064$). However, the global strength invariance test showed a significant difference ($S = 1.07$; $p = .012$) indicating greater overall connectivity in the network of males. Further, the edge invariance test showed significant local differences in 75 edges (out of 528 tested edges). For simplicity purposes, a delta network of only edge weights that significantly ($p < .05$) differ between females and males was created and is depicted in Figure 3, whereas networks with all tested edges are shown in the Supplemental material (Figure S12). Most of the links between dissatisfaction, overvaluation, fear of weight gain, and hating one's body were stronger in the network of females, except for dissatisfaction and fear of weight gain being more strongly associated in males. These nodes were also more linked with DM nodes in males; specifically, dissatisfaction and overvaluation were more connected to being preoccupied with muscularity, and hating one's body with thinking about taking steroids. The Spearman correlation coefficient between the edge weights of the two networks was .699 ($p < .001$) suggesting a strong association between edge weights of male and female networks.

Discussion

Previous studies implementing network analyses to disentangle the roles of muscularity-oriented attitudes and behaviors in

Figure 3

Delta network of edge weights that significantly differ between male and female networks



Note. Blue edges depict edge weights that are stronger in males, whereas red nodes depict edge weights stronger in females. Thicker edges represent a greater difference between a particular edge weight in male and female networks. Colors of the nodes denote four detected communities [pink—body image disturbance; blue—drive for leanness; orange—drive for muscularity (attitudinal component); green—drive for muscularity (behavioral component)]. See the online article for the color version of this figure.

maintaining ED psychopathology have been mostly in adults and have been limited by not including all components of DL. The primary aim of the present study was to employ network analysis to identify components of DM and DL that are associated with core body image disturbance in EDs—dissatisfaction, overvaluation, and fear of weight gain—in a large population-based sample of adolescents. The secondary aim was to inspect how these associations between DM, DL, and body image disturbance might differ between female and male adolescents.

In the present study, items were clustered into communities as expected—almost entirely based on the questionnaires from which they were extracted, with *hating one's body* (MDDI item) belonging to body image disturbance community alongside dissatisfaction, overvaluation, and fear of weight gain (EDE-Q items). The findings showed, based on bridge centrality estimates, that "thinking one would look better if gained 10 pounds in bulk," "lifting weights to build up muscle," "well-toned muscles being a goal," "wishing to be more muscular," "feeling better about oneself if having a lean body," and "feeling more confident if having more muscle mass" were some of the DM and DL items that were linked to other communities to which they statistically do not belong. Importantly, some of these items were in fact *negatively* linked to body image disturbance community, such as "thinking one would look better if gained 10 pounds in to bulk," "lifting weights to build up muscle," and "well-toned muscles being a goal." Also, only some of the mentioned items with relatively high bridge centrality were directly and positively related to body image disturbance community. In particular, "feeling better about oneself if having a lean body" was associated with dissatisfaction with weight/shape and hating one's body; "feeling more confident if having more muscle mass" was associated with overvaluation; and "wishing to be more muscular" was linked to hating one's body. Additionally, fear of weight gain was negatively associated with "thinking one would look better if gained 10 pounds in bulk" and "thinking one would feel stronger if gained a little more muscle mass," which is expected given the antithetical motivations these items aim to capture.

The NCT test showed that networks of male and female adolescents did not significantly differ in their overall structure but that the level of connectivity was higher in males, which could be a result of many more items tapping into muscularity-oriented attitudes and behaviors. Specifically, most of items within body image disturbance community—dissatisfaction, overvaluation, fear of weight gain, hating one's body—were more interconnected in the network of female adolescents (with the exception of dissatisfaction and fear of weight gain having a stronger link in males), which may not be surprising given majority of research that established these components of body image disturbance to be central in EDs were conducted among females. However, associations between these items and DM items seem to be somewhat stronger in males. For instance, dissatisfaction and overvaluation were more strongly associated

with being preoccupied with muscularity in males, as well as hating one's body with "thinking about taking steroids." It is possible that, in males, body image disturbance is more grounded in concerns related to muscularity than in female adolescents, as observed in several studies (e.g., Girard et al., 2018; Hoffmann & Warschburger, 2017). Findings of the present study suggest that, although overall network structure was not significantly different between the male and female adolescents, body image disturbance items seem to be more strongly interconnected in females, and have slightly stronger associations with DM, in males.

Collectively, the findings of the present study show that, although their items are highly inter-related, DM and DL are not necessarily uniform constructs, with their components being distinctly associated with three core aspects of ED-specific body image disturbance. Indeed, even though communities that were detected by EGA mainly "justify" the underlying scales and subscales (or simply are an artefact of these), some items emerged as more strongly associated with one or more aspects of body image disturbance, such as "feeling better about themselves if having a lean body" and "feeling more confident if having more muscle mass." These DM and DL items assess how important one's leanness and/or muscularity is for self-value, which (broadly speaking) reflects overvaluation of weight/shape. This belief that one needs to be lean or muscular for adequate self-esteem requires careful consideration, perhaps more so than other attitudes and behaviors assessed with these specific scales. On the contrary, these items could tap into experiences that increase risk for mental health problems in general (i.e., not feeling good about yourself, or not being confident enough).

Although DM may be seen as uniform, the current findings suggest that some components of this construct, such as drinking protein shakes and using legal supplements could be less indicative of extreme body image disturbance found in EDs. These behaviors are generally considered to be relatively common in athletes (Knapik et al., 2016) and community adolescents (Yager & McLean, 2020) and are not necessarily associated with poorer psychological well-being in men (Strübel & Petrie, 2019). Yet, these items contribute to composite DM and DL scale scores as much as other items that are seemingly more indicative of body image disturbance. Thus, reducing DM and DL to a single sum score when assessing body image disturbance in the context of EDs might be misleading—or not very informative at best—as people can achieve equal sum scores by endorsing different items (Fried & Nesse, 2015) and hence experience a different set of more or less severe attitudes and behaviors. This is specifically concerning given many negative edges being estimated in the present study; in other words, some items are negatively and some positively associated with ED-related body image disturbance and yet, across ED research, all of them are usually combined into a unique score which is subsequently used to represent a single construct. When this is the practice, one might conclude that all attitudes and behaviors assessed by DM and DL questionnaires are contributing to ED symptomatology, even if only specific items are driving this relationship.

Strengths of this study include a large sample size, inclusion of female *and* male adolescents, and examination of underresearched motivation and attitudes toward leanness. Another advantage is using *state-of-the-art* method, namely, network analysis, to answer research questions (Contantini et al., 2015; Jones et al., 2019; van Borkulo et al., 2017) as well as reporting statistical robustness of obtained results. Nonetheless, there are several caveats that ought to be considered when interpreting these findings. First, since centrality depends upon selection of nodes/variables that are included in the model (Bringmann et al., 2019), conclusions could be somewhat different had we used other scales and/or included additional scales such as those that more closely assess drive for thinness. Conversely, including too many nodes increases a possibility of conditioning on a collider (Elwert & Winship, 2014), and consequently misinterpreting the network structure (Fried & Cramer, 2017). Second, edge weight strength could be influenced by factors other than the true relationship between underlying constructs, such as similarity in how the nodes were assessed (e.g., if are they from the same questionnaire, have the same response scale and/or timeframe, have similar wording, are placed next to each other in a questionnaire, etc.). Whether nodes have the same common cause is also an important factor to consider, or if they cause a third node thus forming a collider structure (which leads to spurious negative relations between the two nodes in the presence of a third one; Greenland et al., 1999). That said, nonzero edge weights do not necessarily imply conditional dependencies between the nodes, thus should be interpretated with caution and by taking into account the overall network structure. Relatedly, in cross-sectional models, nodes with high centrality do not point to a good intervention target, nor should edge weights be interpreted as directed within-subject trajectories (e.g., *if one thinks leaner body would make them feel better about themselves, they will become more dissatisfied with their body*; Fried, 2020). In particular, directly drawing inference to existing theories should be very tentative as this study is exploratory, and results are based on cross-sectional analyses which provide no insight into how dynamics between these variables change across time. Moreover, while the recruitment of a large, general population sample of adolescents is a notable strength of the study, the relatively narrow age range of participants limits generalizability of findings to adults. Another limitation is the reliance on scores in single items and two-item measures when assessing body image disturbance which, although commonly used approach across research, has unknown reliability and validity. Finally, the skewed distribution of scores (i.e., average responses were near the minimum value of response scales) is reflective of this sample being nonclinical, which could have influenced the strength of connectivity between these psychological variables as well (Levinson et al., 2018).

These limitations notwithstanding, a number of important implications arise from the present study. First and foremost, DL and DM might be more informative if assessed as multifaceted constructs, for instance with questionnaires that separate more and less extreme behaviors and/or attitudes into subscales. Alternatively, it would be beneficial to segregate components of DM and DL that tap into feelings of self-worth being associated with one's body shape/weight in a form of a stand-alone questionnaire, and thus better equip researchers seeking to measure specific aspects of body image disturbance (i.e., beyond global measures or the ubiquitous use of single-item measures). That is, future assessment instruments could perhaps be developed based on a unique underlying attitude, motivation, or behavior that would be more indicative of potential body image disturbance and have a greater predictive power of future ED development more broadly, rather than artificially construed focus on either thinness, leanness, or muscularity. This is not to say that some other aspects of DM and DL are necessarily benign

and should be neglected in either research or clinical practice, but rather to underscore a need to look more deeply into what these scales actually assess and how can this information be utilized for ED prevention in the most effective way possible.

The present findings could be viewed through the lens of the transdiagnostic cognitive behavioral theory of EDs which posits that core low self-esteem interferes with recovery through (a) thinking negatively about oneself due to inability to control shape/weight and (b) having a general negative view of oneself that constitutes one's identity (Fairburn, 2008). However, despite the prominence of this theory to spell out ED maintaining processes, it remains unclear how grounding one's self-worth in shape/weight and the ability to control these plays a role in ED onset among healthy individuals. The theory behind motivational drives for specific body ideals and body image disturbance is ambiguous at best, especially when moving away from thinness as a typical ideal for people with EDs. DM and even more so DL are much less understood and have been understudied until recent years. This calls for development of a theory to guide statistical models, since statistical models by themselves cannot provide any explanations of the phenomena in focus (Fried, 2020). Development of stronger (possibly *formal*) theories of ED development could provide a better framework for explaining findings such as those in the present study within the context of adolescence as a critical developmental stage. In addition, it could enrich existing ED prevention and health promotion practices that to date have predominantly focused on addressing only thinness-oriented attitudes and behaviors.

In conclusion, findings of the present study indicate the need to take a closer look at attitudes and behaviors that constitute psychological constructs DM and DL when examining their role in body image disturbance and EDs, as relationships between all these phenomena are likely more nuanced than previously speculated. Among DL items, "feeling better about oneself if having a leaner body" might be particularly of interest for researchers and clinicians to examine as a potential link between a pervasive desire to alter one's body shape, that is so ubiquitous in modern societies, and worrisome disturbance in how one's body shape and weight are experienced, that could downgrade one's mental health and well-being in general.

References

American Psychiatric Association [APA]. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Baker, J. H., Higgins Neyland, M. K., Thornton, L. M., Runfola, C. D., Larsson, H., Lichtenstein, P., & Bulik, C. (2019). Body dissatisfaction in adolescent boys. *Developmental Psychology*, *55*(7), 1566–1578. https://doi.org/10.1037/dev0000724

Borsboom, D., & Cramer, A. O. (2013). Network analysis: An integrative approach to the structure of psychopathology. *Annual Review of Clinical Psychology*, *9*, 91–121. https://doi.org/10.1146/annurev-clinpsy-050212-185608

Borsboom, D., Deserno, M. K., Rhemtulla, M., Epskamp, S., Fried, E. I., McNally, R. J., Robinaugh, D. J., Perugini, M., Dalege, J., Costantini, G., Isvoranu, A.-M., Wysocki, A. C., van Borkulo, C. D., van Bork, R. & Waldorp, L. J. (2021). Network analysis of multivariate data in psychological science. *Nature Reviews Methods Primers*, *1*(1), 1–18. https://doi.org/10.1038/s43586-021-00055-w

Bringmann, L. F., Elmer, T., Epskamp, S., Krause, R. W., Schoch, D., Wichers, M., Wigman, J. T. W., & Snippe, E. (2019). What do centrality measures measure in psychological networks?. *Journal of Abnormal Psychology*, *128*(8), 892–903. https://doi.org/10.1037/abn0000446

Brunet, J., Sabiston, C. M., Dorsch, K. D., & McCreary, D. R. (2010). Exploring a model linking social physique anxiety, drive for muscularity, drive for thinness and self-esteem among adolescent boys and girls. *Body Image*, *7*(2), 137–142. https://doi.org/10.1016/j.bodyim.2009.11.004

Bucchianeri, M. M., Serrano, J. L., Pastula, A., & Corning, A. F. (2014). Drive for muscularity is heightened in body-dissatisfied men who socially compare. *Eating Disorders: The Journal of Treatment & Prevention*, *22*(3), 221–232. https://doi.org/10.1080/10640266.2013.874825

Calugi, S., Sartirana, M., Misconel, A., Boglioli, C., & Dalle Grave, R. (2020). Eating disorder psychopathology in adults and adolescents with anorexia nervosa: A network approach. *International Journal of Eating Disorders*, *53*(5), 420–431. https://doi.org/10.1002/eat.23270

Calzo, J. P., Horton, N. J., Sonneville, K. R., Swanson, S. A., Crosby, R. D., Micali, N., Eddy, K. T., & Field, A. E. (2016). Male eating disorder symptom patterns and health correlates from 13 to 26 years of age. *Journal of the American Academy of Child & Adolescent Psychiatry*, *55*(8), 693–700.e2. https://doi.org/10.1016/j.jaac.2016.05.011

Chen, J., & Chen, Z. (2008). Extended Bayesian information criteria for model selection with large model spaces. *Biometrika*, *95*(3), 759–771. https://doi.org/10.1093/biomet/asn034

Christensen, A. P., Garrido, L. E., & Golino, H. (2021). What is bridge centrality? A comment on Jones, Ma, and McNally (2019). *PsyArXiv Preprints*. https://doi.org/10.31234/osf.io/a8svr

Christensen, A. P., & Golino, H. (2021). Estimating the stability of psychological dimensions via bootstrap exploratory graph analysis: A Monte Carlo simulation and tutorial. *Psych*, *3*(3), 479–500. https://doi.org/10.3390/psych3030032

Christian, C., Perko, V. L., Vanzhula, I. A., Tregarthen, J. P., Forbush, K. T., & Levinson, C. A. (2020). Eating disorder core symptoms and symptom pathways across developmental stages: A network analysis. *Journal of Abnormal Psychology*, *129*(2), 177–190. https://doi.org/10.1037/abn0000477

Compte, E. J., Sepulveda, A. R., & Torrente, F. (2015). A two-stage epidemiological study of eating disorders and muscle dysmorphia in male university students in Buenos Aires. *International Journal of Eating Disorders*, *48*(8), 1092–1101. https://doi.org/10.1002/eat.22448

Costantini, G., Epskamp, S., Borsboom, D., Perugini, M., Mõttus, R., Waldorp, L. J., & Cramer, A. O. (2015). State of the aRt personality research: A tutorial on network analysis of personality data in R. *Journal of Research in Personality*, *54*, 13–29. https://doi.org/10.1016/j.jrp.2014.07.003

Cox, D. R., & Wermuth, N. (2014). *Multivariate dependencies: Models, analysis and interpretation*. Chapman and Hall/CRC. https://doi.org/10.1201/9781498710398

Culbert, K. M., Racine, S. E., & Klump, K. L. (2015). Research review: What we have learned about the causes of eating disorders—a synthesis of sociocultural, psychological, and biological research. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *56*(11), 1141–1164. https://doi.org/10.1111/jcpp.12441

Dakanalis, A., Timko, C. A., Clerici, M., Zanetti, M. A., & Riva, G. (2014). Comprehensive examination of the trans-diagnostic cognitive behavioral model of eating disorders in males. *Eating Behaviors*, *15*(1), 63–67. https://doi.org/10.1016/j.eatbeh.2013.10.003

Dalege, J., Borsboom, D., van Harreveld, F., & van der Maas, H. L. J. (2017). Network analysis on attitudes: A brief tutorial. *Social Psychological & Personality Science*, *8*(5), 528–537. https://doi.org/10.1177/1948550617709827

Darcy, A. M., Doyle, A. C., Lock, J., Peebles, R., Doyle, P., & Le Grange, D. (2012). The eating disorders examination in adolescent males with anorexia nervosa: How does it compare to adolescent females?.

International Journal of Eating Disorders, *45*(1), 110–114. https://doi.org/10.1002/eat.20896

de Carvalho, P. H. B., Oliveira, F. D. C., Neves, C. M., Meireles, J. F. F., & Ferreira, M. E. C. (2019). Is the drive for muscularity scale a valid and reliable instrument for young adult women? *Body Image*, *29*, 1–5. https://doi.org/10.1016/j.bodyim.2019.02.001

Developer Core Team. R. (2019). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing.

DuBois, R. H., Rodgers, R. F., Franko, D. L., Eddy, K. T., & Thomas, J. J. (2017). A network analysis investigation of the cognitive-behavioral theory of eating disorders. *Behaviour Research and Therapy*, *97*, 213–221. https://doi.org/10.1016/j.brat.2017.08.004

Dunn, M., & White, V. (2011). The epidemiology of anabolic-androgenic steroid use among Australian secondary school students. *Journal of Science and Medicine in Sport*, *14*(1), 10–14. https://doi.org/10.1016/j.jsams.2010.05.004

Eisenberg, M. E., Wall, M., & Neumark-Sztainer, D. (2012). Muscle-enhancing behaviors among adolescent girls and boys. *Pediatrics*, *130*(6), 1019–1026. https://doi.org/10.1542/peds.2012-0095

Elwert, F., & Winship, C. (2014). Endogenous selection bias: The problem of conditioning on a collider variable. *Annual Review of Sociology*, *40*, 31–53.

Epskamp, S., Borsboom, D., & Fried, E. I. (2018). Estimating psychological networks and their accuracy: A tutorial paper. *Behavior Research Methods*, *50*(1), 195–212. https://doi.org/10.3758/s13428-017-0862-1

Epskamp, S., Cramer, A. O., Waldorp, L. J., Schmittmann, V. D., & Borsboom, D. (2012). qgraph: Network visualizations of relationships in psychometric data. *Journal of Statistical Software*, *48*(4), 1–18. https://doi.org/10.18637/jss.v048.i04

Epskamp, S., & Fried, E. I. (2018). A tutorial on regularized partial correlation networks. *Psychological Methods*, *23*(4), 617–634. https://doi.org/10.1037/met0000167

Epskamp, S., Maris, G., Waldorp, L., Borsboom, D., Irwing, P., Hughes, D., & Booth, T. (2018). Handbook of psychometrics. *Network psychometrics*. Wiley-Blackwell.

Fairburn, C. G. (2008). *Cognitive behavior therapy and eating disorders*. Guilford Press.

Fairburn, C. G., Cooper, Z., & Shafran, R. (2003). Cognitive behaviour therapy for eating disorders: A "transdiagnostic" theory and treatment. *Behaviour Research and Therapy*, *41*(5), 509–528. https://doi.org/10.1016/S0005-7967(02)00088-8

Fan, J., Liao, Y., & Liu, H. (2016). An overview of the estimation of large covariance and precision matrices. *The Econometrics Journal*, *19*(1), C1–C32. https://doi.org/10.1111/ectj.12061

Forbush, K. T., Siew, C. S., & Vitevitch, M. S. (2016). Application of network analysis to identify interactive systems of eating disorder psychopathology. *Psychological Medicine*, *46*(12), 2667–2677. https://doi.org/10.1017/S003329171600012X

Forrest, L. N., Perkins, N. M., Lavender, J. M., & Smith, A. R. (2019). Using network analysis to identify central eating disorder symptoms among men. *International Journal of Eating Disorders*, *52*(8), 871–884. https://doi.org/10.1002/eat.23123

Fried, E. I. (2020). Lack of theory building and testing impedes progress in the factor and network literature. *Psychological Inquiry*, *31*(4), 271–288. https://doi.org/10.1080/1047840X.2020.1853461

Fried, E. I., & Cramer, A. O. J. (2017). Moving forward: Challenges and directions for psychopathological network theory and methodology. *Perspectives on Psychological Science*, *12*(6), 999–1020. https://doi.org/10.1177/1745691617705892

Fried, E. I., & Nesse, R. M. (2015). Depression sum-scores don't add up: Why analyzing specific depression symptoms is essential. *BMC Medicine*, *13*(1), Article 72. https://doi.org/10.1186/s12916-015-0325-4

Friedman, J., Hastie, T., & Tibshirani, R. (2008). Sparse inverse covariance estimation with the graphical lasso. *Biostatistics (Oxford, England)*, *9*(3), 432–441. https://doi.org/10.1093/biostatistics/kxm045

Fruchterman, T. M., & Reingold, E. M. (1991). Graph drawing by force-directed placement. *Software, Practice & Experience*, *21*(11), 1129–1164. https://doi.org/10.1002/spe.4380211102

Gerbing, D. W., & Anderson, J. C. (1988). An updated paradigm for scale development incorporating unidimensionality and its assessment. *Journal of Marketing Research*, *25*(2), 186–192. https://doi.org/10.1177/002224378802500207

Girard, M., Chabrol, H., & Rodgers, R. F. (2018). Support for a modified tripartite dual pathway model of body image concerns and risky body change behaviors in French young men. *Sex Roles*, *78*(11), 799–809. https://doi.org/10.1007/s11199-017-0850-z

Goldschmidt, A. B., Crosby, R. D., Cao, L., Moessner, M., Forbush, K. T., Accurso, E. C., & Le Grange, D. (2018). Network analysis of pediatric eating disorder symptoms in a treatment-seeking, transdiagnostic sample. *Journal of Abnormal Psychology*, *127*(2), 251–264. https://doi.org/10.1037/abn0000327

Golino, H., Moulder, R., Shi, D., Christensen, A. P., Garrido, L. E., Nieto, M. D., Nesselroade, J., Sadana, R., Thiyagarajan, J. A., & Boker, S. M. (2020). Entropy fit indices: New fit measures for assessing the structure and dimensionality of multiple latent variables. *Multivariate Behavioral Research*, 1–29. https://doi.org/10.1080/00273171.2020.1779642

Golino, H., Shi, D., Christensen, A. P., Garrido, L. E., Nieto, M. D., Sadana, R., Thiyagarajan, J. A., & Martinez-Molina, A. (2020). Investigating the performance of exploratory graph analysis and traditional techniques to identify the number of latent factors: A simulation and tutorial. *Psychological Methods*, *25*(3), 292–320. https://doi.org/10.1037/met0000255

Golino, H. F., & Epskamp, S. (2017). Exploratory graph analysis: A new approach for estimating the number of dimensions in psychological research. *PLOS ONE*, *12*(6), Article e0174035. https://doi.org/10.1371/journal.pone.0174035

Greenland, S., Pearl, J., & Robins, J. M. (1999). Causal diagrams for epidemiologic research. *Epidemiology*, *10*(1), 37–48. https://doi.org/10.1097/00001648-199901000-00008

Griffiths, S., Hay, P., Mitchison, D., Mond, J. M., McLean, S. A., Rodgers, B., Massey, R., & Paxton, S. J. (2016). Sex differences in the relationships between body dissatisfaction, quality of life and psychological distress. *Australian and New Zealand Journal of Public Health*, *40*(6), 518–522. https://doi.org/10.1111/1753-6405.12538

Grilo, C. M., Ivezaj, V., Lydecker, J. A., & White, M. A. (2019). Toward an understanding of the distinctiveness of body-image constructs in persons categorized with overweight/obesity, bulimia nervosa, and binge-eating disorder. *Journal of Psychosomatic Research*, *126*, Article 109757. https://doi.org/10.1016/j.jpsychores.2019.109757

Hartmann, A. S., Steenbergen, F., Vocks, S., Büsch, D., & Waldorf, M. (2018). How healthy is a desire to be fit and strong? Drives for thinness, leanness, and muscularity in women in weight training. *Journal of Clinical Sport Psychology*, *12*(4), 544–561. https://doi.org/10.1123/jcsp.2018-0022

Hay, P., Mitchison, D., Collado, A. E. L., González-Chica, D. A., Stocks, N., & Touyz, S. (2017). Burden and health-related quality of life of eating disorders, including Avoidant/Restrictive Food Intake Disorder (ARFID), in the Australian population. *Journal of Eating Disorders*, *5*(1), Article 21. https://doi.org/10.1186/s40337-017-0149-z

Heeren, A., Jones, P. J., & McNally, R. J. (2018). Mapping network connectivity among symptoms of social anxiety and comorbid depression in people with social anxiety disorder. *Journal of Affective Disorders*, *228*, 75–82. https://doi.org/10.1016/j.jad.2017.12.003

Hildebrandt, T., Langenbucher, J., & Schlundt, D. G. (2004). Muscularity concerns among men: Development of attitudinal and perceptual measures. *Body Image*, *1*(2), 169–181. https://doi.org/10.1016/j.bodyim.2004.01.001

Hoek, H. W., & van Hoeken, D. (2003). Review of the prevalence and incidence of eating disorders. *International Journal of Eating Disorders*, *34*(4), 383–396. https://doi.org/10.1002/eat.10222

Hoffmann, S., & Warschburger, P. (2017). Weight, shape, and muscularity concerns in male and female adolescents: Predictors of change and

influences on eating concern. *International Journal of Eating Disorders*, *50*(2), 139–147.

Hudson, J. I., Hiripi, E., Pope, H. G., Jr., & Kessler, R. C. (2007). The prevalence and correlates of eating disorders in the National Comorbidity Survey Replication. *Biological Psychiatry*, *61*(3), 348–358. https://doi.org/10.1016/j.biopsych.2006.03.040

Jones, D. C., Bain, N., & King, S. (2008). Weight and muscularity concerns as longitudinal predictors of body image among early adolescent boys: A test of the dual pathways model. *Body Image*, *5*(2), 195–204. https://doi.org/10.1016/j.bodyim.2007.12.001

Jones, P. (2018). *Networktools: Tools for identifying important nodes in networks*. [Computer software]. https://CRAN.R-project.org/package=networktools

Jones, P. J., Ma, R., & McNally, R. J. (2019). Bridge centrality: A network approach to understanding comorbidity. *Multivariate Behavioral Research*, *56*(2), 1–15. https://doi.org/10.1080/00273171.2019.1614898

Knapik, J. J., Steelman, R. A., Hoedebecke, S. S., Austin, K. G., Farina, E. K., & Lieberman, H. R. (2016). Prevalence of dietary supplement use by athletes: systematic review and meta-analysis. *Sports Medicine*, *46*(1), 103–123.

Lang, B., & Rancourt, D. (2020). Drive for leanness: Potentially less maladaptive compared to drives for thinness and muscularity. *Eating and Weight Disorders*, *25*(5), 1213–1223. https://doi.org/10.1007/s40519-019-00753-1

Levinson, C. A., Vanzhula, I. A., Brosof, L. C., & Forbush, K. (2018). Network analysis as an alternative approach to conceptualizing eating disorders: Implications for research and treatment. *Current Psychiatry Reports*, *20*(9), Article 67. https://doi.org/10.1007/s11920-018-0930-y

Levinson, C. A., Williams, B. M., & Christian, C. (2020). What are the emotions underlying feeling fat and fear of weight gain?. *Journal of Affective Disorders*, *277*, 146–152. https://doi.org/10.1016/j.jad.2020.08.012

Levinson, C. A., Zerwas, S., Calebs, B., Forbush, K., Kordy, H., Watson, H., Hofmeier, S., Levine, M., Crosby, R. D., Peat, C., Runfola, C. D., Zimmer, B., Moesner, M., Marcus, M. D., & Bulik, C. M. (2017). The core symptoms of bulimia nervosa, anxiety, and depression: A network analysis. *Journal of Abnormal Psychology*, *126*(3), 340–354. https://doi.org/10.1037/abn0000254

Linardon, J., Phillipou, A., Castle, D., Newton, R., Harrison, P., Cistullo, L. L., Griffiths, S., Hindle, A., & Brennan, L. (2018). The relative associations of shape and weight over-evaluation, preoccupation, dissatisfaction, and fear of weight gain with measures of psychopathology: An extension study in individuals with anorexia nervosa. *Eating Behaviors*, *29*, 54–58. https://doi.org/10.1016/j.eatbeh.2018.03.002

Lydecker, J. A., White, M. A., & Grilo, C. M. (2017). Form and formulation: Examining the distinctiveness of body image constructs in treatment-seeking patients with binge-eating disorder. *Journal of Consulting and Clinical Psychology*, *85*(11), 1095–1103. https://doi.org/10.1037/ccp0000258

Marsman, M., Borsboom, D., Kruis, J., Epskamp, S., van Bork, R., Waldorp, L. J., van der Maas, H. L. J. & Maris, G. (2018). An introduction to network psychometrics: Relating Ising network models to item response theory models. *Multivariate Behavioral Research*, *53*(1), 15–35. https://doi.org/10.1080/00273171.2017.1379379

McCreary, D. R., Sasse, D. K., Saucier, D. M., & Dorsch, K. D. (2004). Measuring the drive for muscularity: Factorial validity of the drive for muscularity scale in men and women. *Psychology of Men & Masculinity*, *5*(1), 49–58. https://doi.org/10.1037/1524-9220.5.1.49

McLean, S. A., & Paxton, S. J. (2019). Body image in the context of eating disorders. *Psychiatria Clinica*, *42*(1), 145–156. https://doi.org/10.1016/j.psc.2018.10.006

McNally, R. J. (2016). Can network analysis transform psychopathology?. *Behaviour Research and Therapy*, *86*, 95–104. https://doi.org/10.1016/j.brat.2016.06.006

Mitchison, D., Hay, P., Griffiths, S., Murray, S. B., Bentley, C., Gratwick-Sarll, K., Harrison, C., & Mond, J. (2017). Disentangling body image: The relative associations of overvaluation, dissatisfaction, and preoccupation with psychological distress and eating disorder behaviors in male and female adolescents. *International Journal of Eating Disorders*, *50*(2), 118–126. https://doi.org/10.1002/eat.22592

Mitchison, D., Hay, P., Slewa-Younan, S., & Mond, J. (2014). The changing demographic profile of eating disorder behaviors in the community. *BMC Public Health*, *14*(1), Article 943. https://doi.org/10.1186/1471-2458-14-943

Mond, J., Mitchison, D., Latner, J., Hay, P., Owen, C., & Rodgers, B. (2013). Quality of life impairment associated with body dissatisfaction in a general population sample of women. *BMC Public Health*, *13*(1), Article 920. https://doi.org/10.1186/1471-2458-13-920

Prnjak, K., Hay, P., Mond, J., Bussey, K., Trompeter, N., Lonergan, A., & Mitchison, D. (2021). The distinct role of body image aspects in predicting eating disorder onset in adolescents after one year. *Journal of Abnormal Psychology*, *130*(3), 236–247. https://doi.org/10.1037/abn0000537

Robinaugh, D. J., Millner, A. J., & McNally, R. J. (2016). Identifying highly influential nodes in the complicated grief network. *Journal of Abnormal Psychology*, *125*(6), 747–757. https://doi.org/10.1037/abn0000181

Robinson, L., Prichard, I., Nikolaidis, A., Drummond, C., Drummond, M., & Tiggemann, M. (2017). Idealised media images: The effect of fitspiration imagery on body satisfaction and exercise behaviour. *Body Image*, *22*, 65–71. https://doi.org/10.1016/j.bodyim.2017.06.001

Rodgers, R. F., Ganchou, C., Franko, D. L., & Chabrol, H. (2012). Drive for muscularity and disordered eating among French adolescent boys: A sociocultural model. *Body Image*, *9*(3), 318–323. https://doi.org/10.1016/j.bodyim.2012.03.002

Ryan, T. A., & Morrison, T. G. (2013). Psychometric evaluation of the Drive for Leanness Scale in a sample of Irish men. *Eating Behaviors*, *14*(1), 21–25. https://doi.org/10.1016/j.eatbeh.2012.10.002

Ryan, T. A. M., & Morrison, T. G. (2010). Psychometric properties of the Muscle Appearance Satisfaction Scale among Irish and British men. *Body Image*, *7*(3), 246–250. https://doi.org/10.1016/j.bodyim.2010.02.008

Santana, D. D., Mitchison, D., Griffiths, S., Appolinario, J. C., da Veiga, G. V., Touyz, S., & Hay, P. (2019). Ten-year time trends in mental and physical health correlates of weight/shape overvaluation. *European Eating Disorders Review*, *27*(5), 531–540. https://doi.org/10.1002/erv.2672

Schaefer, M. K., & Blodgett Salafia, E. H. (2014). The connection of teasing by parents, siblings, and peers with girls' body dissatisfaction and boys' drive for muscularity: The role of social comparison as a mediator. *Eating Behaviors*, *15*(4), 599–608. https://doi.org/10.1016/j.eatbeh.2014.08.018

Schloerke, B., Crowley, J., Cook, D., Briatte, F., Marbach, M., Thoen, E., Elberg, A., & Larmarange, J. (2018). *Ggally: Extension to ggplot2*. https://CRAN.R-project.org/package=GGally

Schmittmann, V. D., Cramer, A. O., Waldorp, L. J., Epskamp, S., Kievit, R. A., & Borsboom, D. (2013). Deconstructing the construct: A network perspective on psychological phenomena. *New Ideas in Psychology*, *31*(1), 43–53. https://doi.org/10.1016/j.newideapsych.2011.02.007

Sijtsma, K. (2009). On the use, the misuse, and the very limited usefulness of Cronbach's alpha. *Psychometrika*, *74*(1), 107–120. https://doi.org/10.1007/s11336-008-9101-0

Smink, F. R., van Hoeken, D., Oldehinkel, A. J., & Hoek, H. W. (2014). Prevalence and severity of DSM-5 eating disorders in a community cohort of adolescents. *International Journal of Eating Disorders*, *47*(6), 610–619. https://doi.org/10.1002/eat.22316

Smith, K. E., Mason, T. B., Crosby, R. D., Cao, L., Leonard, R. C., Wetterneck, C. T., Smith, B. E. R., Farrell, N. R., Riemann, B. C., Wonderlich, S. A., & Moessner, M. (2019). A comparative network analysis of eating disorder psychopathology and co-occurring depression and anxiety symptoms before and after treatment. *Psychological Medicine*, *49*(2), 314–324. https://doi.org/10.1017/S0033291718000867

Smolak, L., & Murnen, S. K. (2008). Drive for leanness: Assessment and relationship to gender, gender role and objectification. *Body Image*, *5*(3), 251–260. https://doi.org/10.1016/j.bodyim.2008.03.004

Solmi, M., Collantoni, E., Meneguzzo, P., Degortes, D., Tenconi, E., & Favaro, A. (2018). Network analysis of specific psychopathology and

psychiatric symptoms in patients with eating disorders. *International Journal of Eating Disorders*, *51*(7), 680–692. https://doi.org/10.1002/eat.22884

Stice, E., Marti, C. N., & Durant, S. (2011). Risk factors for onset of eating disorders: Evidence of multiple risk pathways from an 8-year prospective study. *Behaviour Research and Therapy*, *49*(10), 622–627. https://doi.org/10.1016/j.brat.2011.06.009

Strübel, J., & Petrie, T. A. (2019). Appearance and performance enhancing drug usage and psychological well-being in gay and heterosexual men. *Psychology and Sexuality*, *10*(2), 132–148. https://doi.org/10.1080/19419899.2019.1574879

Thompson, J. K., & Stice, E. (2001). Thin-Ideal internalization: Mounting evidence for a new risk factor for body-image disturbance and eating pathology. *Current Directions in Psychological Science*, *10*(5), 181–183.

Tod, D., Hall, G., & Edwards, C. (2012). Gender invariance and correlates of the drive for leanness scale. *Body Image*, *9*(4), 555–558. https://doi.org/10.1016/j.bodyim.2012.06.004

Trompeter, N., Bussey, K., Hay, P., Mond, J., Murray, S. B., Lonergan, A., Griffiths, S., Pike, K., & Mitchison, D. (2018). Fear of negative evaluation and weight/shape concerns among adolescents: The moderating effects of gender and weight status. *Journal of Youth and Adolescence*, *47*(7), 1398–1408. https://doi.org/10.1007/s10964-018-0872-z

Tylka, T. L. (2011). Refinement of the tripartite influence model for men: Dual body image pathways to body change behaviors. *Body Image*, *8*(3), 199–207. https://doi.org/10.1016/j.bodyim.2011.04.008

Tylka, T. L., Bergeron, D., & Schwartz, J. P. (2005). Development and psychometric evaluation of the Male Body Attitudes Scale (MBAS). *Body Image*, *2*(2), 161–175. https://doi.org/10.1016/j.bodyim.2005.03.001

van Borkulo, C., Boschloo, L., Borsboom, D., Penninx, B. W., Waldorp, L. J., & Schoevers, R. A. (2015). Association of symptom network structure with the course of depression. *JAMA Psychiatry*, *72*(12), 1219–1226. https://doi.org/10.1001/jamapsychiatry.2015.2079

van Borkulo, C. D., Boschloo, L., Kossakowski, J., Tio, P., Schoevers, R. A., Borsboom, D., & Waldorp, L. J. (2017). *Comparing network structures on three aspects: A permutation test*. Journal of Statistical Software.

Wang, S. B., Jones, P. J., Dreier, M., Elliott, H., & Grilo, C. M. (2019). Core psychopathology of treatment-seeking patients with binge-eating disorder: A network analysis investigation. *Psychological Medicine*, *49*(11), 1923–1928. https://doi.org/10.1017/S0033291718002702

Williams, D. R., & Rast, P. (2020). Back to the basics: Rethinking partial correlation network methodology. *British Journal of Mathematical & Statistical Psychology*, *73*(2), 187–212. https://doi.org/10.1111/bmsp.12173

Yager, Z., & McLean, S. (2020). Muscle building supplement use in Australian adolescent boys: Relationships with body image, weight lifting, and sports engagement. *BMC Pediatrics*, *20*(1), Article 89. https://doi.org/10.1186/s12887-020-1993-6

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