UNIVERSITY OF PAVIA – IUSS SCHOOL FOR ADVANCED STUDIES PAVIA

Department of Brain and Behavioral Sciences (DBBS)
MSc in Psychology, Neuroscience and Human Sciences

UNIVERSITÀ
DI PAVIA

IUSS

Body Representation in Women with Anorexia Nervosa

(A Narrative Review)

Supervisors:
Prof. Gerardo Salvato

Thesis written by
Bahar Behrad

Academic year 2024/2025

Index

Abstract

Disturbance of body representation is a central and enduring characteristic of anorexia nervosa (AN), remaining present after weight restoration and posing a risk for relapse. A narrative literature review informed by PRISMA guidelines was conducted, which synthesised the available empirical evidence on body representation in women with AN over 40 years (1980–2025). We reviewed 40 peer-reviewed studies that covered perceptual, cognitive-affective, multisensory, and body-schema levels.

Results are relatively consistent in suggesting that impairments of AN are not primarily related to core deficits in perceptual abilities. Although patients frequently appear not to be seriously impaired in their ability to estimate their objective bodily size, they often manifest striking cognitive-emotional distortions, such as a relatively stable sense of body dissatisfaction and fear of weight gain alongside maladaptive beliefs about the shape of one's own body. However, multisensory and embodiment paradigms also indicate changes in the weighting of visual, tactile and proprioceptive cues, as well as abnormal body-scaled action which reflect more subtle perturbation in body schema and ownership. Developmental trajectories point towards enhanced plasticity of body representation in adolescence, while chronic adult AN is characterised by inflexible and frequently delusional beliefs concerning the body.

Altogether, these findings are in line with a model according to which body representation disturbance in AN is predominantly driven by cognitive-affective mechanisms, with secondarily involvement of multisensory and sensorimotor factors. These results emphasize the clinical significance of early, multimodal interventions to address both the emotional meaning and embodied experience of the body. Future longitudinal and intervention studies are needed to elucidate developmental trajectories and tailor efficacious treatment approaches.

Keywords: anorexia nervosa; body representation; body image disturbance; multisensory integration.

1. Introduction

Anorexia Nervosa is a serious psychiatric illness signified not only by dietary restriction and low body weight, but also by an intense disturbance in the experience of one's body, the evaluation of it, and engagement with it (Waldman et al., 2013; Zucker et al., 2015; Calugi et al., 2018).

Body image disturbance is a hallmark psychopathological feature of AN and was demonstrated to be resistant to weight gain even after weight restoration in patients with AN, leading to increased relapse risk and higher mortality rates (Sala et al., 2012; Zucker et al., 2015; Zucker et al., 2023 Brusa et al., 2023).

In the past, BID in AN was understood to be predominantly a problem of perception-so that women and girls did not see their body accurately (Hennighausen et al., 1999).

However, evidence is beginning to accumulate that in AN individuals show relative preservation of visual perception of body size, at least when judging other bodies or objective dimensions (and gross distortion when judging their own body) (Phillipou et al., 2016; Bang et al., 2020; Waldman et al., 2013).

This dissociation has contributed toward a reconceptualization of body image disturbance as primarily cognitive-affective, rather than sensorial in nature, entailing maladaptive beliefs, emotions and self-evaluative processes, rather than sensory impairments (Provenzano et al., 2020; Ambrosecchia et al., 2023).

Conversion and childhood models According to modern theories of body representation, body representation seems as a multidimensional structure including perceptual, cognitive-affective and multisensory aspects (Spitoni et al., 2015; Keizer et al., 2012).

Within this model, the perceptual body representation corresponds to subjective experience and perception of size and shape of own body, cognitive-affective body representation concerns beliefs, attitudes and affect toward the body, and multisensory body representation includes integration between visual, tactile, proprioceptive and interoceptive inputs that underlie feelings of ownership over the own body (Spitoni et al., 2015; Keizer et al., 2014; Meregalli et al., 2023).

Multisensory and embodiment paradigms have started to create an experimental foundation on these processes in AN.

AN patients are more vulnerable to body ownership illusions (as the rubber hand illusion and full-body virtual reality tasks), which imply an altered weighting of sensory cues as well as a reduced weight on proprioceptive signals vs. visual input in self-bodily representation (Keizer et al., 2014; Keizer et al., 2016; Provenzano et al., 2020).

At an action level, disturbances in the body schema are observed during locomotion and spatial navigation tasks of which patients act as if they are larger than their actual size, whereas they have real time knowledge of their size (Keizer et al., 2013; Keizer et al., 2016).

Notably these disruptions seemed to be affected by age and duration of the disease.

Individuals with AN during adolescence typically present with a more flexible Level of Holding Rigid Body-related Delusions (LHRBD) that may resolve upon weight restoration or through targeted body image interventions, whereas individuals with chronic AN in adulthood frequently have inflexible, delusional-type beliefs about their bodies associated with less insight and resistance to change (Boehm et al., 2016; Roy & Meilleur, 2010; Choquette et al., 2023).

This development course reveals the clinical importance of early interventions aimed at body representation processes in AN (Biney et al., 2021; Boehm et al., 2016).

Notwithstanding an increasing research interest in this topic, the literature on body representation in AN is methodologically heterogeneous with respect to a range of experimental paradigms, self-report measures, and clinical samples recruited for studies making it difficult to integrate findings across studies (Espeset et al., 2011; Keizer et al., 2019).

Taken together, a full synthesis of the theoretical as well as empirical underpinnings regarding body representation in women with AN is therefore needed.

The current review is thus intended to fill this gap and systematically survey the four decades of empirical studies on body representation in female AN patients, harmonizing available results across perceptual, cognitive-affective and multisensory dimensions in order to elucidate emerging patterns as well as developmental influences and their potential implications on treatment pathways and future research directions (Spitoni et al., 2015; Provenzano et al., 2020; Ambrosecchia et al., 2023).

In the context of this thesis, we defined “body image” as the cognitive and affective appraisal of body including beliefs, attitudes, dissatisfaction and emotions related to weight and shape.

The more inclusive term of "body representation" is mainly adopted as an umbrella concept that subsumes perceptual, cognitive-affective and multisensory dimensions of body experience.

"Body schema" is the mostly unconscious, sensorimotor representation of one's body used to direct spatial orientation and movement, while "body ownership," refers to the subjective sense that a body or body part belongs to oneself.

These differences are preserved throughout the thesis in order to prevent terminological interference and to improve conceptual clarity.

2. Methods

This article set out to explore how body representation was studied and conceptualized in AN in four decades. This paper is a narrative literature review motivated by PRISMA- based principles to maximise transparency of how studies were identified, screened and selected, and from that tracking how researchers have studied ways people with AN personally experience their bodies.

2.1. Literature Search Strategy

The literature review was designed in PubMed for articles published from 1980 to March 2025. Key search terms were: ((Body representation OR body image OR body schema) AND (body ownership)) AND anorexia nervosa with limits set for human studies and English-language publications.

Reference lists of relevant articles were manually screened to identify additional eligible studies not retrieved in the database search.

2.2. Study Selection Criteria

We included papers that (1) were published in peer reviewed journals, (2) investigated body representation in people with a diagnosis of AN (according to DSM or ICD criteria), (3) studied individuals who were at least 10 years old, (4) reported empirical original data either quantitative or qualitative; and, finally, that provided evidence on specific perspective on body representation stemming from perceptual, cognitive-affective- and multisensory-based

models. We excluded studies that did not report results for AN in mixed samples and those whose focus was predominantly eating behaviors rather than body image. Grey literature (i.e., dissertations, non-peer-reviewed abstracts) was omitted in order to maintain quality and replicability. One might wonder if results are similar for other types of AN samples. The review is limited to only female subjects. This decision was taken in order to keep conceptual and methodological uniformity, as most of the body image measures have female samples from which they were mainly validated, and data solely with male subjects are scarce.

2.3. Screening and eligibility

Selection criteria - an English-language full text publication of a study of the effect on health inequalities of health and health-related interventions.

The process of screening was conducted in two stages. We initially screened titles and abstracts and excluded clearly unrelated articles. Those that were found to be possibly relevant after reading the title and abstract were read in full. Figure 1, PRISMA flow chart of the screening process. 260 articles were identified (245 database searches, and 15 reference lists). After deduplication, 240 unique papers were screened based on title and abstract for eligibility. at last, a hundred and thirty were rejected as not germane to the subject. We reviewed 110 full-text articles for eligibility; of these, 70 were eliminated based on inclusion criteria or methodological quality. Finally, 40 (for female only) studies were eligible for the last qualitative synthesis. These 40 studies are the most rigorously conducted studies included in our sample, and we retained these to ensure a broad range of methodologies and aspects of body representation in AN.

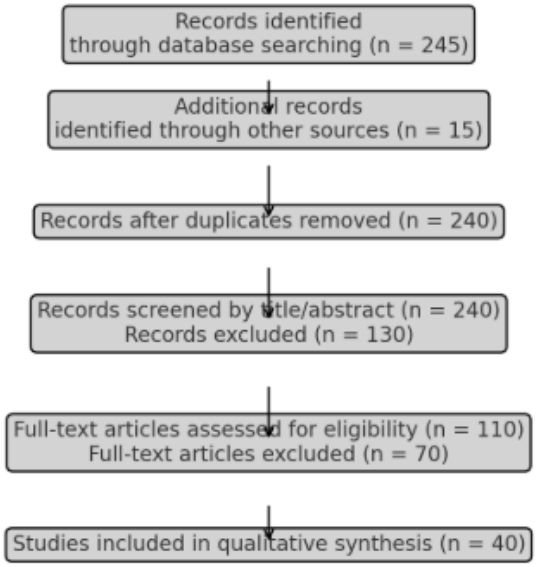

Figure 1. PRISMA flow diagram for article selection for review.

2.4. Data Extraction and Synthesis

We extracted the core characteristics of participant (age, diagnosis type and duration), tool/task to assess body representation (e.g., Body Size Estimation Task, questionnaires, VR or multisensory paradigms) and details on the results concerning body representation in each included study. Given the differences in study methods as well as endpoints, we did not perform a meta-analysis. Instead, we used narrative synthesis to look for themes that repeatedly emerged and differences between studies to inform our review. With this approach we were able to integrate specific outcomes of empirical research in all three concepts (e.g., the estimation of visual and tactile body size, self-ratings of body image & attitude), methodology (illusion-based paradigms) in one framework. Considering a narrative synthesis enabled us to remain close to the material in each study and at the same time interpret broader, more general patterns.

2.5. Scope of the Review

The 40 studies included ranged in the range of methodological and theoretical aspects of body representation in AN. Others tested perceptual accuracy (altering body image distortions using computer-generated avatars, measurement of adjustment visual/tactile size estimation) using experimental tasks (Hennighausen et al., 1999; Byul Bang et al., 2020). Others used

interviews and questionnaires to explore other cognitive-affective aspects of BI, such as body dissatisfaction, delusional beliefs or self-focused attention (Zucker et al., 2015; Keizer et al., 2022; Choquette et al., 2023). Other experimental investigations adopted multisensory and embodiment paradigms (i.e., VR, body illusions, motor tasks) in order to investigate how AN patients integrate visual, tactile and proprioceptive information on their own body (Provenzano et al., 2019; Keizer et al., 2014; Meregalli et al., 2023). The variety of methods contributed to the broad range of evidence that we were able to synthesise in order to form an understanding of body representation disturbances in AN. All included studies were conducted exclusively with female individuals with AN, reflecting the sex-biased pattern obviously present in many research fields and our selection criterion (i.e., men's data were collected but not presented separately by sex). Themes are presented in an order of increasing abstraction and detail; literature directly relating to each theme is linked, referencing the studies by their study ID reporting relevant findings related to each one.

2.6. Synthesis of the results

Data presented in the tables were plotted directly corresponding to the aim of this review, i.e., sate a comparison of demographic and clinical features of individuals with anorexia nervosa vs. healthy control participants in experimental body-image investigations. Studies were classified according to anorexia subtype (restricting, binge-eating/purging, mixed or unspecified), sample size and presence of control group. Mean age and BMI for both anorexia nervosa and control samples were also included as further grouping variables. This classification structure allowed for an orderly comparison of studies, which revealed discrepancies in the profile of AN subtypes and recruited participants' characteristics as well as differences between study designs and age-BMI patterns across clinical and control groups. For a full review of the studies that were included and their properties, see Table 1.

Table 1. Characteristic and results of the studies included in the review

Note. NR = Not Reported. AN-R = Restricting subtype; AN-BP = Binge-Purge subtype.

Article Citation	Anorexia Type	AN Number	Control Number	AN Mean Age	Control Mean Age	AN BMI	Control BMI
Biney et al., 2020	other	40	0	14	0	17.93	NR
Gledhill et al., 2017	Other	20	20	18.5	19	24.5	23.9
Provenzano et al., 2019	AN-R	20	20	23.3	23.85	15.87	18.98
Phillipou et al., 2016	AN-R	24	24	23.07	22.72	16.52	22.26
Ambrosecchia et al., 2023	AN-R	25	27	23	23	16.1	21.5
Zucker et al., 2015	AN-BP	24	24	17.5	NR	17.4	22.6
Bijsterbosch et al., 2022	0ther	70	127	24.5	22	16.5	21.57
Spitoni et al., 2015	AN-R	18	32	24.8	23.9	16	22.1
Espeset et al., 2011	Other	32	NR	27.3	NR	16.3	NR
Cazzato et al., 2015	Both	13	13	26.92	24.46	16.44	21.68
Hennighausen et al., 1999	Other	36	18	16.15	16.8	14.3	20.7
Keizer et al., 2019	Other	26	19	23	21.21	19.8	20.8
Bang et al., 2020	Other	26	53	23.35	22.34	17.13	16.62
Boehm et al., 2016	Other	76	NR	15.84	NR	15.23	NR
Melea et al., 2016	Both	20	20	15.45	15.3	16.57	20.65

Calugi et al., 2018	Other	66	NR	26.1	NR	14.7	NR
Guardia et al., 2012	Both	25	25	23.84	24.48	15.64	22.06
Keizer et al., 2013	AN-R	19	20	23.68	21.9	18.32	21
Keizer et al., 2014	AN-R	30	30	26.37	21.8	17.5	21.19
Mauri et al., 2013	AN-R	9	NR	25.8	12.2	NR	NR
Mölbert et al., 2017	Other	24	104	23.29	24.7	15.07	23.9
Brockmeyer et al., 2018	Other	40	40	23.73	23.98	16.8	21.26
Keizer et al., 2012	Other	25	28	24.16	22.54	18.96	21.3
Keizer et al., 2016	Other	30	29	22.03	21.07	18.11	20.77
Schloesser et al., 2023	Both	33	36	23	24	22	22.5
Choquette et al., 2023	Both	45	NR	20	NR	16.4	NR
Brusa et al., 2023	Both	72	NR	NR	NR	17	NR
Meregalli et al., 2023	Both	52	62	19.1	20.45	15.87	20.78
Chastan et al., 2024	Both	17	NR	35	NR	15	NR
Ambrosecchia et al., 2023	AN-R	25	27	23	22.7	16.1	22.5
Junne et al., 2019	Other	242	NR	NR	NR	> 15	NR
Key et al., 2002	AN-BP	15	NR	25	NR	20.5	NR
Martínez et al., 2020	Other	12	NR	14.6	NR	19.6	NR

Steina et al., 2002	Both	21	20	14.8	16	19	21.5
Roy et al., 2010	AN-R	10	NR	14.93	NR	16.74	NR
Waldman et al., 2013	Other	30	31	26.5	26.9	16.42	23.46
Sala et al., 2012	Both	68	NR	28	NR	15	NR
Mergen et al., 2018	Other	16	15	27.44	25.6	15.7	21.48
Case et al., 2012	Other	10	10	29.1	25.8	17.1	21.7
Calugi et al., 2021	Other	62	NR	16.4	NR	NR	NR

3. Results

Forty peer-reviewed studies were included in this review, which all focused on body representation in females with AN. Despite considerable diversity of methodology, there was a convergence in findings around some common themes of how individuals with AN make sense of and engage with their bodies. Overall, results showed intact performance on the objective estimations but high levels of self-reported BD and fear of weight gain (Waldman et al., 2013) and in fact studies within the multisensory domain, visual-tactile for instance, were evidence to suggest that patients with AN could have an abnormal experience of how visual-tactile cues combine (Keizer et al., 2014; Case et al., 2014). Other treatments mirror exposure (Key etal., 2022), Pilates (Martínez et al., 2020) CBT-E (Junne et al, 2019) showed a very small change at best to an improvement in body image. Adolescents also attained higher levels of flexibility in the correction of errors (Roy & Meilleur, 2010), but participants with chronic delusions showed a more rigid belief system (Choquette et al., 2023). Hereafter, when appropriate, we review evidence from these studies indicating those findings that were confirmed or diverged. We emphasize that these studies cover three of the predominant levels of body representation: perceptual (perception on size/shape of body parts), cognitive-affective (beliefs, attitudes and emotions in daily life about the body), and multi-sensory (sharing information from several sensory modalities and sense of ownership over the body). For the sake of simplicity, we report results in thematic sub-sections, although note that many of the studies contributing are informative to several domains.

3.1. Age, duration of disease and body representation plasticity

Younger age at onset, or a shorter duration of illness showed less fixed body representation disturbance, compared to more severe in chronic patients or with longer duration of the illness. The adolescents with AN did however present relatively high and varied levels of body image disturbances that in some cases could be improved due to treatment and/or weight gain. As an example of such discrepancy, the majority (85%) of hospitalized adolescent females in a sample (mean-age 15.8) showed perceptual Body Size Overestimation (BSI) upon admission (Lucinda et al., 2011) yet those who gained weight early in treatment had better global versus poor outcome after 3.7 years follow-up status respectively tended to show earlier and greater change on eating disorder pathology with no differences observed relative to dimensional measures of anxiety or depression severity levels (Boehm et al., 2016). A substantial reduction in distortion early (decreased BoP index) predicted better physical and psychosocial recovery at a later stage of care (Boehm et al., 2016). These findings suggest that

the body image might be more amenable to change and subsequently affect the way in which an individual represents their body. Consistent with this, another study in adolescent AN inpatients found that patients who reported greater baseline perceptual distortion and who improved quickly after re-nutrition (within the first month) were more likely to have a good long-term outcome (Boehm et al., 2016). The younger the AN patients, the more predictable their response to treatments specifically targeting body image. For example, adolescents were shown to change in body satisfaction and body avoidance behaviours from pre to post- 10-session treatment (SMILES) for adolescent girls including body image therapy involving exposure with mirror for two weeks among other CB-based interventions. These results suggest that adolescents body image is relatively malleable and may be amenable to change.

Contrastingly, body image disturbances among adults with an adult-onset course were more rigid. In several studies, it was identified that in adult AN patients (particularly those who had been ill >5-10 years), deep seated cognitive errors/false beliefs/perceptual biases about the body could occur and were resistant to change. For example, a study of people with Chronic AN (mean duration ~12 years) existing at one end of the Eating Disorder Examination – Questionnaire (EDE-Q) measured range – 18% met criteria for delusional body image intensity in their body-size beliefs while 34% exhibited very poor insight into their body-size beliefs (Choquette et al., 2023). They -each in their late 20s and early 30s- clung to the belief that they were fat even though they had become clearly emaciated, a conviction all too redolent of delusional body dysmorphic disorder (Beilharza et al., 2029; Demartini et al., 2021; Schloesser et al., 2023). These fixed beliefs were related to longer illness duration, and the authors inferred that with chronicity, cognitive-affective biases (e.g., delusional body image beliefs) are increasingly difficult to overcome (Choquette et al., 2023). Likewise, studies that merged current and former AN patients suggest that, notwithstanding the apparent alleviation of body image disturbances once a normal weight has been restored in adulthood, certain attitudinal characteristics may remain stable. For instance, recovering AN women still demonstrated significantly elevated body concern and self-focus on appearance relative to healthy controls (Zucker et al., 2015), but less so than acutely ill women. This implies that also residual symptoms of the body image disturbance (e.g., feeling anxious when scrutinizing oneself, surviving body dissatisfaction) may remain after achieving clinical recovery can be observed, especially in individuals where AN has developed early on and could move over years with the disease (Zucker et al., 2015; Metral et al., 2014; Beilharz et al., 2019). Overall, the literature suggests an age-related continuum; larger and more modifiable distortions have

been identified in adolescents with AN, while older or more chronic patients show fixed beliefs that are also difficult to change. These results emphasize the importance of early intervention – by addressing body image concerns during adolescence, it may be possible to halt the calcification of maladaptive body representations that is often observed in chronic AN (Biney et al., 2020; Boehm et al., 2016; Choquette et al., 2023).

3.2. Gender Considerations

Almost all studies examining body representation in AN are performed on female participants, and this was the only group included in our review. Thus, we could not directly compare females and males with AN in our synthesis. But "there's not much data on men, as well," is a refrain in the literature too. Some of the studies in our initial selection had few male AN patients; we did not include them however, to guarantee that we could remain homogeneous in female AN for our final 40. These studies found that male AN also does not seem to limit body image concerns to thinness, but rather focus on muscularity or leanness (Schloesser et al., 2023). Although the male number in the AN groups were small and therefore no strong statements can be made, it is a fact that males with anorexia nervosa may suffer from body image disturbance issues related to muscular or fitness ideals which are not captured fully by traditional measures of female body image. The absence of male participants in this set of studies points to a gap in the literature. Therefore, despite the fact that our results may be relevant to women with AN, it is important not to overgeneralize in the study of this topic by using GSP. In summary, gender-specific differences could not be examined in the included studies; all results presented above are for women with AN. We note this as a limitation in the literature and highlight the importance for the investigation of body representation to be extended toward male AN populations.

3.3. Cognitive-Affective versus Perceptual Disorganization

Most importantly, these and similar challenging methods have taught us that disruption of body representation in AN is not the product of frank perceptual weaknesses but rather mediated by cognitive-affective aspects. Some studies utilizing more complex perception tasks have found that although people with AN feel and believe their own bodies to be larger than they are, when required to make judgments regarding the size of bodies outside of themselves, Effect Sizes can produce judgements similar to non-AN individuals. For example, in a study with point-light biological motion stimuli, AN patients did not overestimate the bodies of others (Phillipou et al., 2016) – they were as accurate as healthy controls in

estimating other peoples' body sizes. However, despite feeling that they are fatter than their ideal, obese patients reported the size of their own body as indicating something phenomenologically significantly greater than they can see with pictures (Phillipou et al., 2012). In an additional investigation women with AN provided accurate estimates of the sizes of distorted images of human bodies relative to controls, demonstrating preserved body size perception in general. Although when asked to rate their own perception, AN women showed the greatest difference between how they perceived themselves and that which they aimed for suggesting severe body image dissatisfaction (Phillipou et al., 2016; Hennighausen, 1999). Crucially in a quasi-experimental study comparing AN with a control group who were constitutionally thin women (equally underweight but without an eating disorder), it was only the AN patients, not the naturally thin participants, whose body image distortion and dissatisfaction was extreme – they saw their body as it really is and felt proportionately satisfied (Byul Bang et al., 2020). Both groups described having an extremely low BMI (~16–17), but the AN group rated themselves as more "fat" than these equally-euphemistically described thin controls, and wanted an even thinner ideal body (Byul Bang et al., 2020; Cornelissen et al., 2017; Ambrosecchia et al., 2023). This finding is crucial as it suggests that the distortion does not only reflect an epiphenomenon of low weight, but that it relates to the psychological profile of AN. The so-called constitutionally thin women were not cognitively affectively disturbed (no overestimation and no excessive dissatisfaction), while the AN patients were, despite body size similarity. This would indicate that disordered body experience in AN is most likely caused by cognitive-affective distortions (the feeling of fatness, thinking incessantly about the body and appearance loss) rather than an incapability of interoceptive processing.

This is confirmed in a number of research. In a third study, individuals with AN rescaled adaptive body images to the entire body of themselves and did not evidence global overestimation of true width compared to controls (their estimates of their actual size were not globally inflated) (Hennighausen et al., 2019). However, these same patients overestimated the size of others (their thighs) and underestimated some parts of themselves (their chest), compared to controls, which suggests that they have strong attitudinal disturbances: they were more dissatisfied with their body image than their control counterparts, and held deviant beliefs regarding some of its components (Hennighausen et al., 2019). Indeed, those patients even choose an ideal figure whose body was closer to his own size compared to the controls – actually, both groups endumatically wanted a thinner body than their own but the AN patients

were also not very far from what they thought would be ideal (Hennighausen et al., 2019). These paradoxical findings suggest that even if subjects with AN look at their body more or cardinally differently, they may not over-estimate it's shape and size. They may feel "I am very thin," but they also suffer from thoughts like "but I am still too fat," or have dissatisfactions with the contour; this would be a disjunction between perception and affect. AN patients one can intellectually be aware of their body size under some circumstances, but emotionally not own it. For instance, one phenomenological study characterized types characterized according to individuals' combining of subjective vs. object reality (e.g., some who categorized with AN knew they were underweight but experienced themselves as fat); so-called 'dissociative' or 'delusional type') and who did not Generate Thematic Awareness (GTA) those two modes; others showed linkage between the two modalities showing superior improvement when the cognitive content from their imaginal experience was more easily integrated into waking consciousness (Fassino et al., 2002). This is in line with the hypothesis that cognitive insight may fluctuate but emotional certainty of being overweight may be high.

In summary, the stricter studies reveal an AN-specific body representation disorder: patients have preserved perception of other persons and the 'real' own body but altered self-evaluative body picture and affect. They "see" but don't "feel" appropriately about their own bodies. As suggested in a review (Provenzano et al., 2019), body image disturbances may be "…more attitudinal (cognitive-emotional) than perceptual" in terms of AN. Notably, it is also congruent with experimental data indicating that automatic sensorimotor processing (i.e. when mentally rotating body parts or identifying one's own hand) is only mildly affected in AN while explicit self-recognition and appraisal are disrupted to a greater extent (Ambrosecchia et al., 2023). More severe is the impairment and the difference with control are by no means limited to that between own body parts vs others, but they also involved both a slower and less accurate recognition of own body-parts compared to those of other's and objective evidences seem to suggests that they concern even space in which objects may occupy. They also exhibited an attenuated ''self- advantage'' (the usual speed/accuracy advantage for recognizing one's own body) in the two implicit tasks, indicative of a fine-grained disruption of their sensorimotor representation of self. The extent of these attentional effects was, however, relatively small in comparison to the pronounced group differences for explicit self–other discrimination and attitude scores which were also observed; in these measures AN patients showed significantly worse performance compared to controls. When providing an interpretation for ambiguous body-related sentences patients with AN consistently endorsed a

strong negative interpretation bias, picking the more self-defeating reading of the body approximately 55% of the time as opposed to about 10% among controls even when they received identical perceptual input (Brockmeyer et al., 2018). This automatically-biased negativity was a good predictor of how body-dissatisfied they were. Components of these findings (Phillipou et al., 2016; Ambrosecchia et al., 2023; Hennighausen et al., 1999; Byul Bang et al., 2020; Brockmeyer et al., 2018) converge to demonstrate that individuals with AN do not universally have a distorted perception of their body size but that their perception and internal experience of their own bodies are heavily caused by cognitive-emotional factors.

3.4. Multimodal and Embodied Results

Beyond visual perception and cognition, some of the above researches investigated how AN perceives visuo-tactile or visuo-motor integration, whether body ownership or schema is distorted. These studies employed techniques including the rubber hand illusion, virtual reality body ownership illusions, mirror-matched touch, and body movement/balance power tasks. These results would seem to suggest that basic brain processes involved in the interoceptive processing of bodily signals are intact in AN, but that either the gain on, or structure of this response is aberrant causing suboptimal body image related effects although perhaps relatively indirectly.

For example, individuals with AN have been found to be more prone to experiencing a sense of ownership over a rubber hand compared with healthy controls (Kleizer et al., 2014) using the RHI paradigm (Rubber Hand Illusion). In one study, AN patients reported a stronger experience that the rubber hand was their body during synchronous stroking and they showed increased ‘proprioceptive drift’ (movement of the perceived position of their hand towards the position of the rubber hand) as compared to controls. This augmented susceptibility to the RHI suggests that AN patients have less well-defined or weaker body ownership boundaries. Most crucially, AN patients judged their own hand and the rubber hand differently post illusion (see data of Keizer et al., 2014) which might imply that such a deficit in terms of multisensory integration may temporarily ameliorate or exacerbate feeling the size illusively contributed to AN by default. Ultimately, although the RHI is a transient laboratory phenomenon, these data imply that those with AN may be disproportionately reliant on visual input that in real life should have some equivalence (e.g., an overestimate of their mirrors, photos) when it comes to modulating one's bodily awareness.

This hypothesis is consistent with studies on interpersonal multisensory stimulation. Indeed, in a VR environment combining vision, touch and motion data, both AN patient as HCs were found to show some feeling of embodiment of an avatar when visual information was matched by tactile input (Provenzano et al., 2019). Group differences in the lowest order ability to feel indeed "Concepts" The question of weather we acted as "natural stokers" or own. And There were no significant group differences in the basic ability to experience 'ownership' could be perceived for a seen body (which was being stroked synchronously with the participant's own) were also not observed. The emotional charge of the illusion was, however, modulated as a function of the content of the illusion: AN patients experiencing their body in an avatar slightly bigger than its real size experienced a profound negative affective state (anxiety-discomfort) that controls did not experience (Provenzano et al., 2019). This implies that while multisensory integration may in fact be intact, the judgment of the resultant bodily state (e.g., “larger” during the illusion) seems to be highly imprecise in AN. In other terms, AN patients are on average physiologically able to adapt to altered Body Congruence Illusion (BIC) in VR, but by acting not only Over-Concern is implicated emotional factor (phobia-related—fear of fatness) into the process of perceiving/interacting with VR (Provenzano et al., 2019). This is consistent with previous virtual reality research in AN, where AN patients observed a 3D image of themselves at a larger body weight experienced distress but did not immediately communicate an update of their satisfaction despite acknowledging the new shape of their body visually.

A helpful related perspective may be that offered in the body schema (the unconscious representation of the body in space for action) literature. In one clever experiment, patients with AN were asked to attempt walking through door-like openings of different sizes and it was shown that the brain’s ‘internal model’ of body size was impaired (Keizer et al., 2013). Result was startling: people with AN began to ideally orient themselves by turning their shoulders when the door was only 40% wider than they are; whereas, healthy controls didn’t even begin to turn until the door spanned almost shoulder width (~25% larger) (Keizer et al., 2013; Keizer et al., 2016; Phillipou et al., 2016). In fact AN patients therefore functioned in some respect as if they inhabited bodies hundreds of times larger than reality when moving about consciously: an automatized motor effect echoing an inflated body schema. This has occurred at a time when patients were nominally reporting accurate measurements and might reflect somatosensory prediction failure and loss of conscious body image. Furthermore the extent of this distortion in action (the margin by which they were overestimating their body

extended) was related to the degree to which they overestimated their body in perceptual terms (Ambrosecchia et al., 2023; Keizer et al., 2016). This indicated a link between the cognitive-perceptual (static body) and sensorimotor (moving body) levels of BR ("the bigger the stronger, the poorer her cognition-perception but more cautious her sensorimotor system; as if larger") (Keizer et al., 2013). These disturbances of body schema can be observed in the course of everyday activity, such as thinking that there is no room to push oneself into when one actually can or underestimating the space through which one must pass and thus sustaining this idea of bigness.

Tactile sensation findings are also discussed here. When compared to controls, in a task where AN patients estimated the distance between two points of their body (skin), patients judged distances between paired points delivered on the abdomen and thighs to be bigger than did control participants (i.e., they "overfelt" a given distance on these areas of the body) (Spitoni et al., 2015). They required a further separation to detect two touch points on the respective portions of those regions implicated, suggesting altered somatosensory processing for the affected anatomical locations (Spitoni et al., 2015). This decreased acuity here and altered perception of the location of parts of the body for some may then have a knock-on destabilization effect to one's overall internal representation/ map 15 of their own person – so if our 'map' or sense we have for where we exist in our body is fuzzy, or blown up for some areas this might alter how one feels sensations from say, one's belly feeling larger than it actually does. But low-level touch and proprioception was preserved (no difference in simple touch detection thresholds), again indicative of a selective distortion related to emotionally salient body parts.

Overall the multisensory feeding and embodiment literatures (Provenzano et al., 2019; Spitoni et al., 2015; Keizer et al., 2013, 2014; Meregalli et al., 2023) seem to indicate that basic sensory integration is intact in AN, although we might weight up bodily input a bit differently. Patients with AN may external on the one hand be more 'plastic' in terms of what counts as my body (e.g., when using a rubber hand or body ownership illusion) (for reviews containing this technique see Blanke and Metzinger, 2009; Ehrsson et al., 2007), their enactive movement fails to maintain a realistic representation of bodily dimensions. Also dispreferred are peripheral sensors for signals reporting a change in body size, including exogenous compounds or extracts. These findings provide further support for the cognitive-affective profile and suggest that disordered sex will increasingly come to be experienced as something to feel in, and act with, on within the body — rather than merely form part of pre-planned

judgment. But not only this, in many instances the sensory-derived distortion will "disappear" or not be experienced if the emotional "overlay" is gone – i.e., synchronous multisensory input can (temporarily) knockout perception (a repeated feedback body-size training study observed that body size perception did improve, but without cognitive-emotional elements added into the training mix used above it might risk being unaware for how a patient feels about her/his own body; (as shown by Lucinda et al., 2017). The emerging message from strong multisensory research is that AN reflects a failure to be influenced by sensory input where it contradicts prior beliefs in body size. Multisensory interventions such as mirror exposure with touch and virtual reality body adaptation offer some hope of graded realignment of patients' internal body model but emotional resistance in AN to a larger body size can interfere with this (Provenzano et al., 2019).

3.5. Intervention and Response to Treatment

A part of the included studies assessed effects of interventions, or addressed the association between disturbed BR and treatment response. These results suggest that body image treatments may have a beneficial impact on both perceptual and affective symptoms, and changes in body representation mirror general correlates of recovery. However, the extent to which such interventions impact upon core AN psychopathology is unclear in the literature.

On the other hand, there has been some success in targeted body image treatments. Biney et al 2020 have piloted a Practical Body Image therapy (involving mirror exposure and cognitive-behavioural therapy) for adolescent AN inpatients, with greater reductions in body image anxiety and avoidance behaviour found in their treatment compared to treatment as usual group. They also reported feeling less anxious than they had 10 weeks earlier, and were more confident and felt greater control over their body, suggesting that relationships between body representation and anxiety might be amenable to influence even within a relatively short time frame. Similarly, in 2017, Lucinda applied a cognitive bias modification training to retrain perception of body sizes of AN patients. After training, patients shifted further away from categorical perception of body size in the direction of considering 'too large' bodies as normal and correlated with reduced self-report of body dissatisfaction. These increases were maintained at follow-up. Interestingly this might suggest some resilience of outcomes in relation to alteration in perceptual bias (Lucinda et al., 2017). In a pilot intervention with tactile and proprioceptive retraining (patients had to pass their body through diminishing hoops), also improvements in the realm of tactile distance overestimation could be found: Patients increased precision while judging their own body boundaries, and post-training

outcomes of the tactile distance overestimation was lessened. More specifically, both cognitive (questionnaire) and perceptual (tactile and action-based) body image disturbance measures that were employed in that smaller study (Keizer et al., 2019) ameliorated. These observations indicate that multi-modal interventions aimed at the visual and tactile body image may produce changes in patients' body representation.

Other studies looked more broadly at treatment, and what happens to body image. For example, Boehm et al. 2016, highlighted that patients who had exhibited an early gain in weight from inpatient treatment (which could have been characterized as adherence and physical recovery) tended to have stronger longer-term psychosocial outcomes whereas focus on the physical might well also impact body image results and vice-versa (Boehm et al., 2017). Interestingly, the amount of self-attention on the body is greatest among weight-restored individuals in comparison to patients and has previously been interpreted to reflect that post treatment, patients are more sensitive to their body status and perhaps remaining challenges as well compared with actively ill patients who may be in denial or suffer from cognitive blunting (Zucker et al., 2015). Perhaps recovering patients might provide to benefit from another therapy to help them consolidate this increased self-consciousness with now a healthier body image.

But not all of the interventions were clear successes. A randomized-controlled trial on high-frequency rTMS over the parietal lobe (involved in body representation) was ineffective in reducing body worries compared to sham (Chastan, Lhommée & Verin, 2024). In those with an acute episode (n = 17), there was no significant difference in scores on the Body Shape Questionnaire with ten sessions of rTMS vs placebo, but the study was underpowered. That is, direct stimulation of brain areas did not address the strongly entrenched body image disturbance, at least with that set of parameters. Overall, general psychiatric treatment is not even able to cure body dissatisfaction: in a recent trial, a cohort of patients received intensive multidisciplinary treatment (weight restoration + psychotherapy etc.) achieved a dramatic recovery from broad body uneasiness and psychopathology until discharge. Moreover, also in this case, some of the Body Image Investment (BII) (i.e., single “problem” body parts) were not (Brusa et al., 2023), and a subgroup of patients continued to report persistent reduced Quality of Life. This highlights that while weight gain and symptom improvement may be achievable, the idiosyncratic body image (particularly attitudinal) perturbations may necessitate specialized and prolonged adversities.

Crucially, increasing the degree to which patients felt ownership of their body was also linked to improvements in a broad range of other outcomes. Significant reductions in body image disturbance (as assessed by the Body Uneasiness Test) were significantly related to reductions in both eating disordered symptoms and psychological distress (Brusa et al., 2023). Both, Choquette and colleagues in 2023, found that patients with lower levels of delusional body beliefs endorsed less body checking behaviour and fewer features of eating disorder severity (Choquette et al., 2023) And a study of the link between interpretation bias and symptom severity found that modifying the individual's automatic thoughts about her body would reduce overall ED psychopathology (Brockmeyer et al., 2018). These findings indicate that body representation may not be a unitary concept, rather one that is closely influenced by AN clinical status. However, overall clinical improvement is often correlated with positive change in out-patients perception or ideation of their body. Alternatively, chronic misshape disrupts treatment response – the more extreme body-size delusionality a person reports the more unresponsive to treatment response and the less able to become unglued from his/her AN disordered habits she becomes (Choquette et al., 2023).

In conclusion, heterogeneous interventions and outcome findings notwithstanding, treatment of body representation appears to be a core feature in AN treatment. Interventions targeting body image (such as cognitive restructuring, exposure, multisensory feedback) directly, can reduce body dissatisfaction and distortion (Biney et al., 2020; Gledhill et al., 2017; Keizer et al., 2019), and the eventual recovery to restoration of function. Presumably this has the largest chance of success if modalities are combined, as in the multidisciplinary program of Brusa and co-workers (Brusa et al., 2023) or hoop training added to standard care as performed by Keizer and co-workers (Keizer et al., 2019). While there is no definitive evidence yet for therapeutic efficacy of exclusive pharmacological and neural interventions in this field, behavioral and cognitive methods do appear to be promising. In the review of the referred studies results, motivation to continue the body representation targeted clinical work in treatment is strengthened; patients who start to see their body more correctly and friendly, are perhaps in the best conditions to be able to sustain recovery.

3.6. Methodological thoughts and constraints

The 40 studies included in this review can be viewed as coverage of the most definitive high quality research regarding this topic, they were diverse in terms of their study designs and reports which might affect our interpretation of those results. Some of these studies have good control features such as healthy comparison subjects, high sound or psychometric measures

that are used for assessment and large number of subjects. We have therefore tried to counteract methodological biases in this respect by focusing on these higher quality studies. There are, to be sure, barriers in the field. First, for instance, most of the studies we reviewed were cross-sectional investigations; they measured body representation once and at a single time. While a dissociation between AN and healthy control groups could be inferred from such studies, they cannot infer causality. This has been controlled for in some but not all studies by assessment of longitudinal dimensions; there are, for example, those that have demonstrated the level of body image distortion early in the course of illness to predict subsequent body image symptoms-thought he absence of any prospective (as opposed to non-prospective or retrospective) study to date should be mentioned. Second, while we limited our review to higher-quality studies, sample sizes in this rarefied domain of research tend to be small. Some studies contained AN participants in the tens. Some of the most well-made experimental ones, for example, involved only 13–20 AN patients so one might be concerned regarding statistical power of such studies. The more robust statistical power of the two large multi-site studies (of 50–70 AN subjects) improves confidence in generalizability. However, the parallelism across small samples of AN's deficits did contribute a great deal to their credibility e.g. that the source of AN's distortions is attitude not percept did emerge very clearly from at least half a dozen independent small samples. However, it should be taken into account that the present findings cannot be extrapolated to all AN patients and particularly not to men, patients of old age or atypical AN ones who quite frequently were excluded.

Third, we found heterogeneity in the tools and definitions of "body representation." One examined perceptual accuracy (discrepancies between estimated and actual body width), one affective evaluation (questionnaire responses to dissatisfaction, anxiety), and the others behaviors (checking, avoidance). This multidimensionality is quite reasonable in light of the fact that representation of body itself is complex, but it does mean that not all studies might be tapping precisely the same construct. Implications were drawn in relation to the formulation of operational definitions. That the methods were mixed but still seemed to have a consistent story to tell was comforting – it's an indication that results are resting on some sort of convergent validity. For example, in adolescents global overestimation did not emerge in a computer-distortion method (Hennighausen et al., 2019) but has emerged previously using the simple silhouette presentation though possibly to inferior quality or older sample. The more recent and comprehensive experiments generally conclude that some lower form of consciousness is retained.

In conclusion, the results of this narrative synthesis provide a coherent picture of the body representation in AN: perception is disconnected from patients' belief/emotion and they can verify body related information as correct, but not up-date their false mental self-body model. Distortions based on multiple senses as well as on adaptation of recently performed actions, are also operative but subtle and likely reflect the effects of deeply-based cognitive-affective schemata about the body. Yet, there are intervention efforts that can strengthen the accuracy and value of body representations in AN, particularly if applied early in the course of the disorder. All reviewed studies had only female participants so these findings need to be interpreted with the focus on women with AN and future studies should be conducted considering male patients to check for similar patterns. A review of the 40 papers – ranging from experimental psychology and clinical trials to neurocognitive approaches – argues that in ecology successful treatment must target not only the body, but also our mind's eye view of it. In practice, that could involve therapy to help recalibrate body-image perception and dial down the extreme fear and self-loathing so many patients feel for their bodies. In doing so, we are targeting a key psychopathological symptom of AN and one which may in fact be promoting a fuller or more lasting remission.

4. Discussion

The review offers a comprehensive summary of four decades of empirical work on body representation in anorexia nervosa (AN) in women, which we cover under perceptual, cognitive-affective and multisensory rubrics.

In 40 methodologically sound peer-reviewed studies, results are consistent with the conclusion that body representation disturbance in AN is primarily not due to basic perceptual impairments but reflects more enduring cognitive-affective distortions in how bodily signals are identified, valued and experienced emotionally (Waldman et al., 2013; Phillipou et al., 2016; Provenzano et al., 2020).

4.1. Cognitive-affective dominance in the experience of body representation disturbance

One of the strongest findings emanating from the reviewed studies has been the disjunction in intact perceptual ability despite distorted self-placement in women with AN.

Patients can judge the size of external bodies and in some instances, even their own body relatively precisely (Hennighausen et al., 1999; Phillipou et al., 2016; Bang et al., 2020);

however, they also endorse extreme dissatisfaction with their body appearance, fear of putting on weight, and fear of "being fat" despite having gotten emaciated.

This disconnection lends itself to models of body image disturbance in AN that contend the anomaly stems from attitudes not perceptual (Waldman et al., 2013; Provenzano et al., 2020).

Additional support for the cognitive-affective primacy of body representation disturbances comes from studies that compare AN patients and constitutionally thin women.

Even when matched for BMI, only those with AN experienced severe body dissatisfaction and overvaluation of weight and shape; such reports thus suggest that low weight is not enough to explain pathology in the experience of one's own body (Bang et al., 2020; Ambrosecchia et al., 2023).

These results suggest that body representation disruption in AN is driven by disorder-specific psychopathology and not simply attributable to starvation.

4.2. Multisensory integration and embodiment abnormalities

Outside of cognition and perception, the current studies report subtle but important changes in multisensory and embodied aspects of body representation.

Women with AN also showed an enhanced susceptibility to body ownership illusions, such as rubber hand illusion and full-body VR paradigms, indicating that these patients assign a different weight to visual-tactile-proprioceptive information inputs (Keizer et al., 2014; Keizer et al., 2016; Provenzano et al., 2020).

Crucially, such paradigms demonstrated that while the fundamental multisensory integration remains barely preserved, the emotional appraisal of bodily states (in particular those associated with an increased body size) induces raised anxiety and distress levels in AN patients (Provenzano et al., 2020).

Disturbances were also evident at the body schema level, which is responsible for action and movement.

Studies of body-scaled action have shown that women with AN perceive their bodies to be larger than they really are, act as if they were larger, for example, by turning our shoulders when passing through objectively wide doorways (suggesting an overestimation of body size during locomotion) (Keizer et al., 2013; Keizer et al., 2016).

These results indicate that altered body representation in AN reaches deeper than conscious evaluation into sensorimotor planning and action, perpetuating maladaptive bodily beliefs through everyday interaction with the environment (Meregalli et al., 2023).

4.3. Developmental and illness-duration effects

The review further found that age and duration of illness were key moderators for 383 body representation disturbance.

In AN adolescents, for example -who often presented with more amplified but manipulable distortions in this study (Roy & Meilleur, 2010; Boehm et al., 2016) -distortions partially ameliorated as a response to restoration of weight or specialized body-image interventions.

By contrast, we also saw that adults with longer illness duration more frequently exhibited delusional-level- body beliefs associated with lack of insight and resistance to change (Choquette et al., 2023; Zucker et al., 2015).

Such developmental discrepancies may indicate a path where early deviations in body representation are hardened over time, especially if left untreated.

The presence of attitudinal body image disturbances in those weight-restored or remitted serves as evidence that the normalization of weight is not enough to correct the core body representation pathology present in AN (Sala et al., 2012; Zucker et al., 2015).

4.4. Implications for treatment

Intervention studies demonstrate the clinical relevance of an intervention focused directly on body representation in treatments for AN.

Body image specific interventions that focused on transparency exposure, cognition modification and multisensory training were reported to reduce body dissatisfaction, avoidance behaviors and perceptual distortions (Biney et al., 2021; Gledhill et al., 2017; Keizer et al., 2019), especially for the younger participant groups.

Presumably, training that combines cognitive-affective work with sensory or movement-based relearning also seems a particularly promising approach to repattern distorted internal body representations (Keizer et al., 2019; Brusa et al., 2023).

However, not all interventions demonstrated significant effects.

However, the transcranial modulation of parietal regions involved in body representation did not result in any significant influence on body image disturbance hence confirming the resistance of its (cognitive-affective) “distortedness” and emphasizing how ineffective an exclusive neurobiological based treatment approach can be when the emotional/belief-based conditions are left unchanged (Chastan et al., 2024).

Overall, these findings suggest that interventions for body representation disturbance need to be multimodal in targeting perceptual experience, emotional meaning and maladaptive beliefs simultaneously (Junne et al., 2019; Brusa et al., 2023).

4.5. Methodological considerations and limitations

Although the findings in general are coherent, the literature suffers from some methodological limitations.

Several studies were conducted with cross-sectional design and relatively small sample sizes, reducing the possibility for causal inference and generalizability (Keizer et al., 2019; Mergen et al., 2018).

Moreover, there is substantial heterogeneity in the way body representation has been operationalized, either on perceptual estimation tasks or self-report questionnaires and multisensory paradigms which hinders a straightforward comparison among studies (Spitoni et al., 2015; Espeset et al., 2011).

The near complete emphasis on female samples is another limitation.

Although this mirrors the historical gender bias in AN research, it limits conclusions to women and emphasizes a call for further work investigating disturbances of body representation in male and gender-diverse individuals with AN (Schloesser et al., 2023).

5. Conclusions and future directions

This review synthesizes perceptual, cognitive-affective, cross-modal, and body-coherence accounts of disturbed body representation in women with anorexia nervosa. Drawing on four decades of empirical findings, the paper shows that disturbances are essentially sustained by cognitive-affective processes, although less pronounced multisensory- and action-based changes contribute to distorted body experience.

Patients may correctly receive bodily signals, but their failure to integrate them emotionally into a coherent and acceptable own-representation might result in their dissatisfaction and fear as well as maladaptive behaviors (Waldman et al., 2013; Provenzano et al., 2020; Ambrosecchia et al., 2023).

Prospective research is recommended to use longitudinal designs from early adolescence, in order to investigate the development of body schema and distortions in cognitive-affective processes across time. Standardized operational definitions of body representation components are needed to improve comparability between studies. Novel interventions that combine multisensory recalibration and cognitive restructuring need to be evaluated systematically in double-blind controlled trials.

Intervening on these disturbances early in the course of illness might be essential to prevent their consolidation and improve long-term outcomes in AN (Boehm et al., 2016; Biney et al., 2021; Choquette et al., 2023).

References

Ambrosecchia, M., Ardizzi, M., Russo, E. C., Ditaranto, F., Speciale, M., Vinai, P., Todisco, P., Maestro, S., & Gallese, V. (2023). Bodily self-recognition and body size overestimation in restrictive anorexia nervosa: Implicit and explicit mechanisms. Frontiers in Psychology, 14, Article 1197319. https://doi.org/10.3389/fpsyg.2023.1197319

Bang, E. B., Ko, J. K., Kwag, K. H., Lee, G. Y., & Kim, Y.-R. (2020). A comparison of patients with anorexia nervosa and women who are constitutionally thin. European Eating Disorders Review, 28(6), 633–642. https://doi.org/10.1002/erv.2777

Bijsterbosch, J. M., Keizer, A., Boelen, P. A., van den Brink, F., & Sternheim, L. C. (2022). Understanding relations between intolerance of uncertainty and body checking and body avoiding in anorexia nervosa. Journal of Eating Disorders, 10, Article 122. https://doi.org/10.1186/s40337-022-00647-1

Biney, H., Astbury, S., Haines, A., Grant, J., Malone, N., Hutt, M., Matthews, R., Morgan, J. F., White, S., & Lacey, J. H. (2021). A novel "practical body image" therapy for adolescent inpatients with anorexia nervosa: A randomised controlled trial. Eating and Weight Disorders – Studies on Anorexia, Bulimia and Obesity, 26, 1825–1834. https://doi.org/10.1007/s40519-020-00997-2

Boehm, I., Finke, B., Tam, F. I., Fittig, E., Scholz, M., Gantchev, K., Roessner, V., & Ehrlich, S. (2016). Effects of perceptual body image distortion and early weight gain on long-term outcome of adolescent anorexia nervosa. European Child & Adolescent Psychiatry, 25, 1319–1326. https://doi.org/10.1007/s00787-016-0854-1

Brockmeyer, T., Anderle, A., Schmidt, H., Febry, S., Wünsch-Leiteritz, W., Leiteritz, A., & Friederich, H.-C. (2018). Body image related negative interpretation bias in anorexia nervosa. Behaviour Research and Therapy. Advance online publication. https://doi.org/10.1016/j.brat.2018.03.003

Brusa, F., Scarpina, F., Bastoni, I., Villa, V., Castelnuovo, G., Apicella, E., Savino, S., & Mendolicchio, L. (2023). Short-term effects of a multidisciplinary inpatient intensive rehabilitation treatment on body image in anorexia nervosa. Journal of Eating Disorders, 11, Article 178. https://doi.org/10.1186/s40337-023-00906-9

Calugi, S., Dametti, L., Chimini, M., Dalle Grave, A., & Dalle Grave, R. (2021). Change in eating-disorder psychopathology network structure in patients with anorexia nervosa treated

with intensive cognitive behavior therapy. International Journal of Eating Disorders, 54(10), 1800–1809. https://doi.org/10.1002/eat.23590

Calugi, S., El Ghoch, M., Conti, M., & Dalle Grave, R. (2018). Preoccupation with shape or weight, fear of weight gain, feeling fat and treatment outcomes in patients with anorexia nervosa: A longitudinal study. Behaviour Research and Therapy. Advance online publication. https://doi.org/10.1016/j.brat.2018.04.001

Case, L. K., Wilson, R. C., & Ramachandran, V. S. (2012). Diminished size–weight illusion in anorexia nervosa: Evidence for visuo-proprioceptive integration deficit. Experimental Brain Research, 217, 79–87. https://doi.org/10.1007/s00221-011-2974-7

Cazzato, V., Mian, E., Mele, S., Tognana, G., Todisco, P., & Urgesi, C. (2016). The effects of body exposure on self-body image and esthetic appreciation in anorexia nervosa. Experimental Brain Research, 234, 695–709. https://doi.org/10.1007/s00221-015-4498-z

Chastan, N., Achamrah, N., Etard, O., Nathou, C., Piquet, M.-A., Guillaume, S., Attal, J., Gillibert, A., Dechelotte, P., Guillin, O., & Welter, M.-L. (2024). Effects of repetitive transcranial magnetic stimulation of the right inferior parietal lobe on the body image perception in anorexia nervosa: A pilot randomized controlled study. Brain and Behavior, 14, e3617. https://doi.org/10.1002/brb3.3617

Choquette, E. M., Flux, M. C., Moseman, S. E., Chappelle, S., Naegele, J., Upshaw, V., Morton, A., Paulus, M. P., Feinstein, J. S., & Khalsa, S. S. (2023). The impact of floatation therapy on body image and anxiety in anorexia nervosa: A randomised clinical efficacy trial. eClinicalMedicine, 64, 102173. https://doi.org/10.1016/j.eclinm.2023.102173

Espeset, E. M. S., Nordbø, R. H. S., Gulliksen, K. S., Skårderud, F., Geller, J., & Holte, A. (2011). The concept of body image disturbance in anorexia nervosa: An empirical inquiry utilizing patients' subjective experiences. Eating Disorders, 19(2), 175–193. https://doi.org/10.1080/10640266.2011.551635

Gledhill, L. J., Cornelissen, K. K., Cornelissen, P. L., Penton-Voak, I. S., Munafò, M. R., & Tovée, M. J. (2017). An interactive training programme to treat body image disturbance. British Journal of Health Psychology, 22(1), 60–76. https://doi.org/10.1111/bjhp.12217

Guardia, D., Conversy, L., Jardri, R., Lafargue, G., Thomas, P., Dodin, V., Cottencin, O., & Luyat, M. (2012). Imagining one's own and someone else's body actions: Dissociation in anorexia nervosa. PLOS ONE, 7(8), e43241. https://doi.org/10.1371/journal.pone.0043241

Hennighausen, K., Enkelmann, D., Wewetzer, C., & Remschmidt, H. (1999). Body image distortion in anorexia nervosa – Is there really a perceptual deficit? European Child & Adolescent Psychiatry, 8, 200–206.

Junne, F., Wild, B., Resmark, G., Giel, K. E., Teufel, M., Martus, P., Ziser, K., Friederich, H.-C., de Zwaan, M., Löwe, B., Dinkel, A., Herpertz, S., Burgmer, M., Tagay, S., Rothermund, E., Zeeck, A., Herzog, W., & Zipfel, S. (2019). The importance of body image disturbances for the outcome of outpatient psychotherapy in patients with anorexia nervosa: Results of the ANTOP-study. European Eating Disorders Review, 27(1), 49–58. https://doi.org/10.1002/erv.2623

Keizer, A., Engel, M. M., Bonekamp, J., & Van Elburg, A. (2019). Hoop training: A pilot study assessing the effectiveness of a multisensory approach to treatment of body image disturbance in anorexia nervosa. Eating and Weight Disorders – Studies on Anorexia, Bulimia and Obesity, 24, 953–958. https://doi.org/10.1007/s40519-018-0585-z

Keizer, A., Smeets, M. A. M., Dijkerman, H. C., Uzunbajakau, S. A., van Elburg, A., & Postma, A. (2013). Too fat to fit through the door: First evidence for disturbed body-scaled action in anorexia nervosa during locomotion. PLOS ONE, 8(5), e64602. https://doi.org/10.1371/journal.pone.0064602

Keizer, A., Smeets, M. A. M., Dijkerman, H. C., van Elburg, A., & Postma, A. (2012). Aberrant somatosensory perception in anorexia nervosa. Psychiatry Research, 200, 530–537. https://doi.org/10.1016/j.psychres.2012.05.001

Keizer, A., Smeets, M. A. M., Postma, A., van Elburg, A., & Dijkerman, H. C. (2014). Does the experience of ownership over a rubber hand change body size perception in anorexia nervosa patients? Neuropsychologia, 62, 26–37. https://doi.org/10.1016/j.neuropsychologia.2014.07.003

Keizer, A., van Elburg, A., Helms, R., & Dijkerman, H. C. (2016). A virtual reality full body illusion improves body image disturbance in anorexia nervosa. PLOS ONE, 11(10), e0163921. https://doi.org/10.1371/journal.pone.0163921

Key, A., George, C. L., Beattie, D., Stammers, K., Lacey, H., & Waller, G. (2002). Body image treatment within an inpatient program for anorexia nervosa: The role of mirror exposure in the desensitization process. International Journal of Eating Disorders, 31(2), 185–190. https://doi.org/10.1002/eat.10027

Martínez-Sánchez, S. M., Martínez-García, C., Martínez-García, T. E., & Munguía-Izquierdo, D. (2020). Psychopathology, body image and quality of life in female children and adolescents with anorexia nervosa: A pilot study on the acceptability of a Pilates program. Frontiers in Psychiatry, 11, Article 503274. https://doi.org/10.3389/fpsyt.2020.503274

Mauri, M., Miniati, M., Mariani, M. G., Ciberti, A., & Dell'Osso, L. (2013). Haloperidol for severe anorexia nervosa restricting type with delusional body image disturbance: A nine-case chart review. Eating and Weight Disorders – Studies on Anorexia, Bulimia and Obesity, 18, 329–332. https://doi.org/10.1007/s40519-013-0052-9

Mele, S., Cazzato, V., Di Taranto, F., Maestro, S., Fabbro, F., Muratori, F., & Urgesi, C. (2016). Altered exposure-related reshaping of body appreciation in adolescent patients with anorexia nervosa. Body Image, 19, 113–121. https://doi.org/10.1016/j.bodyim.2016.08.014

Meregalli, V., Tenconi, E., Madan, C. R., Somà, E., Meneguzzo, P., Ceccato, E., Zuanon, S., Sala, A., Favaro, A., & Collantoni, E. (2023). Beyond body image: What body schema and motor imagery can tell us about the way patients with anorexia nervosa experience their body. Psychiatry and Clinical Neurosciences, 77, 94–101. https://doi.org/10.1111/pcn.13501

Mergen, J., Keizer, A., Koelkebeck, K., van den Heuvel, M. R. C., & Wagner, H. (2018). Women with anorexia nervosa do not show altered tactile localization compared to healthy controls. Psychiatry Research. Advance online publication. https://doi.org/10.1016/j.psychres.2018.06.007

Phillipou, A., Rossell, S. L., Gurvich, C., Castle, D. J., Troje, N. F., & Abel, L. A. (2016). Body image in anorexia nervosa: Body size estimation utilising a biological motion task and eyetracking. European Eating Disorders Review, 24(2), 131–138. https://doi.org/10.1002/erv.2423

Provenzano, L., Porciello, G., Ciccarone, S., Lenggenhager, B., Tieri, G., Marucci, M., Dazzi, F., Loriedo, C., & Bufalari, I. (2020). Characterizing body image distortion and bodily self-plasticity in anorexia nervosa via visuo-tactile stimulation in virtual reality. Journal of Clinical Medicine, 9(1), 98. https://doi.org/10.3390/jcm9010098

Roy, M., & Meilleur, D. (2010). Body image distortion change during inpatient treatment of adolescent girls with restrictive anorexia nervosa. Eating and Weight Disorders – Studies on Anorexia, Bulimia and Obesity, 15(1–2), e108–e115.

Sala, L., Mirabel-Sarron, C., Pham-Scottez, A., Blanchet, A., Rouillon, F., & Gorwood, P. (2012). Body dissatisfaction is improved but the ideal silhouette is unchanged during weight recovery in anorexia nervosa female inpatients. Eating and Weight Disorders – Studies on Anorexia, Bulimia and Obesity, 17(2), e109–e115.

Schloesser, L., Lotter, L. D., Offermann, J., Borucki, K., Biemann, R., Seitz, J., Konrad, K., & Herpertz-Dahlmann, B. (2023). Sex-dependent clinical presentation, body image, and endocrine status in long-term remitted anorexia nervosa. European Eating Disorders Review, 31(5), 696–708. https://doi.org/10.1002/erv.2997

Spitoni, G. F., Serino, A., Cotugno, A., Mancini, F., Antonucci, G., & Pizzamiglio, L. (2015). The two dimensions of the body representation in women suffering from anorexia nervosa. Psychiatry Research. https://doi.org/10.1016/j.psychres.2015.08.036

Stein, D., Orbach, I., Shani-Sela, M., Har-Even, D., Yaruslavsky, A., Roth, D., Meged, S., & Apter, A. (1999). Suicidal tendencies and body image and experience in anorexia nervosa and suicidal female adolescent inpatients. Journal of the American Academy of Child & Adolescent Psychiatry, 38(6), 709–715.

Thaler, A., Piryankova, I., Stefanucci, J. K., Pujades, S., de la Rosa, S., Streuber, S., Romero, J., Black, M. J., & Mohler, B. J. (2018). Visual perception and evaluation of photo-realistic self-avatars from 3D body scans in males and females. Frontiers in ICT, 5, Article 18. https://doi.org/10.3389/fict.2018.00018

Waldman, A., Loomes, R., Mountford, V. A., & Tchanturia, K. (2013). Attitudinal and perceptual factors in body image distortion: An exploratory study in patients with anorexia nervosa. Journal of Eating Disorders, 1, Article 17. https://doi.org/10.1186/2050-2974-1-17

Zucker, N. L., Wagner, H. R., Merwin, R., Bulik, C. M., Moskovich, A., Keeling, L., & Hoyle, R. (2015). Self-focused attention in anorexia nervosa. International Journal of Eating Disorders, 48(1), 9–14. https://doi.org/10.1002/eat.22307