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BMI, weight concern, body size perception, dieting and mental distress in adolescents - The HUNT Study

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Abstract

Objective: We examined the associations between BMI, weight concern, body size perception, dieting and mental distress in a population-based study of 7 350 adolescents. **Design:** Cross-sectional. **Settings:** Data from a Norwegian population-based cohort, The Young-HUNT3 (2006-08) from the county of Nord-Trøndelag, Norway. **Participants:** A total of 7 350 adolescents (13-19 years) who had both self-reported questionnaire data and anthropometric measures. **Primary outcome measures:** Odds for mental distress given sex, BMI, weight concern, body size perception, and dieting. Analyses were performed in binomial logistic regression models. **Results:** Compared to being overweight/obese, having weight concern, irrespective of body mass index (BMI), was associated with higher odds ratio (OR) for mental distress (MD) amongst

boys and girls. Body size overestimation was associated with a dramatic increase in the OR for MD, in participants who were overweight/obese, had weight concern or dieted. This effect was more pronounced in boys. **Conclusions:** Weight concern and body-size estimation are strongly associated with mental health in adolescent boys and girls. Routine assessment of adolescents' attitudes towards their weight and body size is advised.

Keywords: Adolescents, body size overestimation, weight concern, dieting, BMI, mental health, Cognitive dissonance theory, HUNT.

Strength and limitations of this study:

- Our findings were based on a study of a large, population-representative dataset of male and female adolescents.
- Stratification of our study population into smaller groups based on their body size perception and weight concern allowed for inferences being made on the interaction terms between the two, which had clear methodological advantage in making inferences as to which component seemed to contribute more to the outcome variable.
- The relationship of weight concern, body-size estimation and mental distress has been discussed within the framework of the Cognitive Dissonance Theory.
- A limitation of this study was the cross-sectional design that is not suitable for study of causality between exposure and outcome variables.

Introduction

Long-term negative effects of pediatric obesity on the physical and mental wellbeing are widely known. Preventing obesity has however, proved difficult [1-3]. To lose weight, many adolescents resort to dieting; whose effectivity and long-term health consequences are debated [4-7]. In order to strive to achieve (or maintain) normal weight, it is necessary for individuals, to have awareness of their own body.

Previous studies in adolescent populations, have collectively pointed at inter-related and multifaceted relationships between body awareness, BMI and dieting [4-7]. High BMI and having concerns about one's weight or body size have been associated with poorer mental health amongst adolescents, but what contributes to this association is not fully understood [6].

Body awareness is a human construct, formed by comparisons made between individuals' perception of their own body (body-image) to that of others (body-ideal)[8]. The definition of body-ideals may vary depending on the context within which it is applied. In medical terms, there is a preference for normal BMI (defined by the World Health Organization as between 18.5–24.9). Societal body-ideals, which seems to be culturally dependent, is what advance individuals towards goals such as being liked or being successful [9]. In a societal context, emphasis is often put on body shape/size [9]. For instance, in western societies, there is a preference for overly thin bodies in girls [10] and masculine and lean bodies in boys [11-14]. Individuals may also compare their weight (or BMI) to what they consider most prevalent (hence normal) by looking at their peers [13].

In the past few decades, there has been a significant increase in the obesity rate and mean population BMI amongst both adults and adolescents [15]. This is contrary to the current societal

preference for overly thin body-ideals many adolescents find unattainable [9]. In today's western societies, the perceived distance between BMI in overweight/obese individuals and societal or medical body-ideals has increased compared to previous situations. In contrast, due to the increase in mean population BMI, the perceived distance between BMI in overweight/obese individuals and the population norm has decreased. It is known that holding contradictory elements of cognition causes psychological discomfort (Cognitive Dissonance theory)[16, 17].

Psychological theories have provided a scientific framework for studying body-image [16]. For instance, in the field of eating behavior, Cognitive Dissonance Theory (CDT) has been applied to study body acceptance in female adolescents and adults [18]. CDT suggests that humans have an inert drive to create and maintain harmony between their attitudes and behavior, because disharmony (or cognitive dissonance) causes psychological discomfort. Accordingly, incongruency between the body-ideals themselves, as well as incongruency between individuals' body-image and their body-ideals, could create psychological discomfort, which may then be reduced by making changes in cognition or behavior (such as dieting).

In the current study, we have explored associations between body-image, dieting and mental distress in 7 350 Norwegian adolescents who had taken part in The Young-HUNT3 Survey (2006-08). Body-ideals were defined as, 1- being of normal weight BMI (medical preference), and 2- being closer to societal thinner/leaner body-ideals. Taking advantage of data available on a range of health-related issues, we divided our participants into groups based on their BMI, body-image, and dieting behavior. Body-image consisted of two elements: individuals' perception of their weight (weight concern) and body size (body size under- and overestimation). Odds for mental distress were then estimated across these groups. By cross-comparing the odds

we made inferences as to which body-ideals seem to be playing a greater part in increasing psychological discomfort amongst adolescents.

We hypothesized that adolescents with excess weight, experience higher psychological discomfort due to an increase in the discrepancy between their weight perception and societal preference for thinness and medical preference for lower BMI. We hypothesized that body size overestimation is associated with higher psychological discomfort because overestimation puts adolescents in a less favorable position compared to the societal body-ideal. Due to greater societal preference for thinness in girls, we expected this association to be stronger in the female group. We hypothesized that body size underestimation in adolescents is associated with lower psychological discomfort because the underestimation puts the adolescents in a more favorable position compared to the societal body-ideal. Within the context of CDT, behavioral changes such as dieting are expected to reduce psychological discomfort caused by cognitive dissonance between body-image and body-ideals. We therefore hypothesized that dieting is associated with lower odds for MD, in both girls and boys.

To our best knowledge, this is the first time CDT is used as a theoretical framework to infer the relative significance of societal definitions of body-ideals for body-awareness at adolescence.

Methods

Participants

Data from The Young-HUNT3 Survey (YH3) (2006-08) was used in the present study. YH3 is the third wave of the adolescent arm of the Trøndelag Health Study (The HUNT Study). The Young-HUNT surveys were carried out at the Nord-Trøndelag Region County's schools, and comprises three cross-sectional surveys: Young-HUNT1, YH1 (1995–97), Young-HUNT3, YH3

(2006–08) and Young-HUNT4, YH4 (2016-2019). Cohort profiles of The HUNT Study are previously described elsewhere [19, 20].

After completion of YH3, data on 17 820 adolescent research participants (13-19 years old, response rate 78% - 90%) were collected [19, 20].

YH3 data included self-administered questionnaires, structured interviews, collection of biological samples and clinical measurements, carried out by trained personnel . For anthropometric measurements of height, weight, hip and waist circumference, standard procedures were followed [19]. In the present study, questionnaire data and anthropometric measurements have been used.

In total, 8 202 individuals in junior and senior high schools participated in YH3 (78% response rate) [19]. Of those, 7 718 individuals had both answered the YH3 questionnaire and had anthropometric measurements data available. Due to missing data on body size perception, dieting or mental distress, 386 participants were excluded from our study, totaling study population to 7 350 participants (3 806 boys and 3 544 girls).

Measurements

Mental distress

The five-item Hopkins Symptom Checklist (SCL-5)[21] was used to evaluate participants' level of mental distress. SCL-5, a valid and reliable measure of mental distress [21, 22] consists of the following question items: "Feeling blue", –"Feeling fearful", –"Feeling hopeless about the future", –" Worrying too much about things" and –" Experiencing nervousness or shakiness

inside". Participants recorded their answer on a four-point Likert scale from 1 ('not bothered') to 4 ('very much bothered').

Only participants who had answered four or more questions were included. The mean scores for each question were summed up to a total score that was then divided by the number of questions answered. Based on a previously defined cut-off point [21], participants with "high" mental distress (≥ 2) were identified and compared to those with "low" (< 2) levels of mental distress. In this paper, adolescents with high mental distress are referred to as those with mental distress.

Anthropometric measures

Participants' weight was measured to the nearest half kilo and height to the nearest cm [19]. BMI (body mass index) was calculated as weight (kg)/height^2 (m^2). The adolescent BMI-based weight categories were defined using the age-specified and sex-specified International Obesity Task Force cut-off values [23, 24], participants were grouped into four categories; obese, overweight, normal weight or underweight. In the analyses, overweight and obese in addition to underweight and normal weight were collapsed into groups.

Weight concern and dieting

The research participants were asked, "Are you trying to lose weight?", to which they could choose one of the following answers: "No, I am comfortable with my weight"(1), "No, but I need to lose weight"(2) or "Yes"(3).

This question provided information on whether participants had weight concern or dieted. By pairing this information with participants' actual BMI-based weight category, we stratified

participants into the following groups (also see Figure 1 and2) that bore information on participants' BMI-based weight category, weight concern or dieting behavior (or the lack of).

1. Unnecessary weight concern (UC): Normal or underweight adolescents with unnecessary weight concern, but without dieting behavior (answer option 2).
2. Unnecessary dieting (UD): Normal or underweight adolescents with weight concern and dieting behavior (answer option 3).
3. Healthy dieting (HD): Overweight/obese adolescents with weight concern and dieting behavior (answer option 3).
4. Lack of weight concern (LC): Overweight/obese adolescents who neither were concerned about their weight, nor dieted (answer option 1).
5. Reference: Normal or underweight adolescents with no weight concern or dieting behavior (answer option 1).

Body size perception

Study participants were asked about how they perceived their body size as follows: "Do you consider yourself to be: "very fat", "quite fat", "about the same as others", "quite thin" or "very thin"?

By combining individuals' body size perception (BSP) with their BMI-based weight category, we defined three BSP groups: BSP overestimation (normal- underweight who consider themselves "very fat", "quite fat"), BSP underestimation (overweight/obese who consider themselves "about the same as others", "quite thin" or "very thin"), and accurate BSP estimation (for instance, overweight-obese who thought they were quite fat or very fat).

Statistical analysis

A three-way log-linear analysis was performed to determine which model components (individuals' BMI-based weight category, weight concern, body size perception, dieting and sex) were necessary to retain in order to best account for the data. The log-linear analysis suggested a hierarchical unsaturated model for the associations between sex, weight concern/dieting, and body size perception. An unsaturated model was chosen using SPSS Statistics' hierarchical log-linear model selection procedure with a backwards elimination stepwise procedure. This produced a model that included all main effects and two two-way associations of weight concern/dieting and body size perception. The Log-linear analysis did not recommend including interaction terms between sex and other factors. The model had a likelihood ratio of $\chi 2(14) < 0.001$ $p = 1$.

Binomial logistic regression was employed to study the associations between BMI, weight concern/dieting, body size perception, and mental distress amongst adolescents. Analyses were performed in groups stratified according to weight concern, body size perception (BSP over- and underestimation), and dieting. After stratification on BSP over- and underestimation, groups with BSP underestimation had very few participants; hence excluded from the final analyses. All association analyses were adjusted for age. All association analyses were performed against the group with least cognitive dissonance. i.e. adolescents with normal weight, no weight concern, with accurate BSP, and not dieting.

Results are reported as Odds Ratio (OR) for mental distress (MD), with 95% confidence intervals. Overall missingness (< 5%) was considered as missing at random (MAR). A complete case analyses were performed. IBM SPSS Statistics 26 was used for the analyses.

Application of Cognitive Dissonance Theory (CTD)

According to CDT, discrepancies between adolescents' body-image and their body-ideals should be associated with increased mental distress. Emergence of divergent sets of body-ideals would inevitably lead to discrepancy between how adolescents view their weight and body size in different context within which body-ideals are defined. Accordingly, individuals' sum of cognitive dissonance (CD) due to discrepancy between body-image and body-ideals (See Figure 1 and 2), can be considered as the sum of:

1- CD due to weight concern as a mismatch between person's actual BMI and medical body-ideal (normal weight BMI).
2- CD due to discrepancy between person's body size estimation and their societal body-ideal.

For instance, in a normal weight person who thinks she/he is overweight, CD may be, in part, due to as discrepancy between what the person thinks they weigh and their ideal weight. This ideal weight, however, is defined based on medical and societal expectations. On the other hand, ideal weight may be, in part, relative to the population mean BMI that has been changing upwards in the past few decades. Similarly, changes in CD are expected due to discrepancies between individuals' perception of their body size and an increasingly thin societal body-ideal.

By comparing the odds for mental distress across groups defined according to their BMI-based weight category, weight concern, body size perception (BSP under- and overestimation), and dieting, authors made inferences as to which of these possible discrepancies seem to have higher impact on the total CD.

Ethics

The Young-HUNT Study was approved by the Norwegian Data Inspectorate. The present study was approved by the Regional and National Committees for Medical and Health Research Ethics (2009/740-2) as well as by the HUNT Data Access Committee. All study procedures were in accordance with the Helsinki Declaration, as of 1975, and revised in 2000.

Participants signed written consents before they were enrolled in The Young-HUNT Study. In Norway, legal age for providing informed consent is 16 years. Written consents were obtained from participants aged 16 years or older and from their parents or legal guardians if participants were younger than 16 years.

Patient and Public Involvement statement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this study.

Results

Population characteristics

Study participant's characteristics of main variables are summarized in Table 1. In total, 7 350 adolescents (3 806 boys and 3 544 girls) were included in the current study (mean age: 15.82 years old).

Most boys (70.9%) and girls (72.9%) were of normal weight BMI. The prevalence of overweight/obesity was slightly higher amongst boys than girls (25.9% vs. 22.3%). Being underweight was slightly more prevalent in girls than boys (4.7% vs. 3.2%).

More girls than boys showed unnecessary weight concern (overestimation of weight in UC & UD groups, 6.6% in boys vs. 25.2% in girls). More boys showed lack of weight concern/dieting despite being overweight/obese (underestimation of weight in LC group, 19.8% of boys vs. 13.6% of girls).

More boys misperceive their body size as thinner (BSP underestimation in 19.8% of boys vs. 13% of girls), and more girls misperceived their body size as fatter (BSP overestimation in 16.8% of boys vs. 22.3% of girls) . In boys, BSP overestimation was more prevalent than weight overestimation (UC and UD groups) (Table 1).

The majority of boys and girls were happy with their weight, hence not dieting. Compared to their female counterparts, fewer overweight/obese boys had weight concern or tried to lose weight by dieting (weight underestimation seen in LC group: 19.8 % of boys vs. 13.6 % of girls). Compared to boys, and irrespective of BMI-based weight category, more girls resorted to dieting in order to lose weight, as expressed by the prevalence of dieting in HD group (9.3% of girls vs. 6.7 % of boys) and UD group (12.8 % of girls vs. 2.6% of boys). The higher prevalence of dieting in girls paralleled their higher tendency of BSP overestimation (Table 1).

Mental distress was prevalent in both genders, more so in girls than boys (27% vs. 10.2%, Table 1). The Relative Risk for mental distress in girls compared to boys was 2.66, CI 95% 2.38 - 2.96, p-value < 0.0001 (data not shown).

Table1. Population characteristics.

		Boys		Girls	
		N	%	N	%
BMI based weight categories	Obese	244	6.4	179	4.7
	Overweight	741	19.5	668	17.6
	Normal weight	122	3.2	179	4.7
	Underweight	2699	70.9	2765	72.9
Are you trying to lose weight?	No, I am happy with my weight	2998	79.8	2206	58.3
	No, but I need to lose weight	423	11.3	760	20.1
	Yes	338	9	819	21.6
Weight concern/dieting	Unnecessary concern but not dieting in normal- /underweight (UC)	146	4	440	12.4
	Unnecessary concern and dieting in normal- /underweight (UD)	95	2.6	455	12.8
	Weight concern and dieting in overweight/obese (HD)	241	6.7	331	9.3
	Lack of concern, no dieting in overweight/obese (LC)	714	19.8	483	13.6
	Lack of concern, no dieting in normal- /underweight (reference)	2413	66.9	1835	51.8
Body size perception	Very fat	58	1.6	122	3.2
	Quite fat	676	18.1	1008	26.6
	Like others	721	19.3	534	14.1
	Quite thin	66	1.8	41	1.1
	Very thin	2212	59.3	2080	55.0
Body size perception	BSP underestimation	687	19.8	455	13.0
	BSP overestimation	585	16.8	783	22.3
	BSP accurate	2204	63.4	2272	64.7
Mental distress(SCL-5)	Low mental distress (score < 2)	3330	89.8	2780	73.0
	High mental distress (score ≥ 2)	377	10.2	1030	27.0

BMI-based weight categories are age and sex adjusted in accordance with Cole et al. [23, 24]. BSP: Body size perception. HD: Healthy dieting, LC: Lack of weight concern, MD: Mental distress, UC: Unnecessary weight concern, UD: Unnecessary dieting, SCL-5: The five-item Hopkins Symptom Checklist.

Association between participants' BMI, weight concern/dieting, body size perception and mental distress

Confirming findings from the initial log-linear analysis, The discrepant number of participants in each BMI-based weight category compared with the size of groups with presumed correlated weight concern or body size perception (Table 1) showed that weight concern and body size perception do not entirely measure the same thing.

In both boys and girls, being overweight/obese was associated with increased odds for mental distress, independent of the presence of weight concern or dieting (Table 2 and Table 3; OR for mental distress in HD and LC groups). Likewise, comparable size effects were observed in the in normal-/underweight groups with unnecessary weigh concern and dieting (in Table 2 and Table 3; higher odds for mental distress in UC and UD groups).

In both boys and girls, analyses based on BSP overestimation had even larger effects on the associations between all the various weight concern/dieting groups and mental distress. (Table 3).

Interestingly, overweight/obese adolescents with weight concern and dieting had much lower odds for mental distress (HD group, OR: 6.8, 95% CI 5.3-8.8 and 6.1, CI 4.3-8.5, boys and girls respectively) compared to overweight/obese with lack of weight concern and dieting (LC group, OR: 20.6, 95% CI 16.9-25.15 and 11.9, CI 8.9-15.8, boys and girls respectively) (see Table 3). Similar association effects were observed in the associations between weight concern /dieting and mental distress in the normal-/ underweight groups (see results in the UC and UD groups compared to the reference group).

On the other hand, overweight/obese participants with weight concern and dieting (HD group, OR for MD: 6.81) had much lower Or for MD compared to overweight/obese participants with no weight

concern or dieting (LC group, OR for MD: 20.61). Interestingly, our analyses revealed similar effects (Table 2) or even higher odds (Table 3) for MD amongst boys compared to girls.

Table 2. Associations between weight concern, dieting and mental distress in boys and girls.

	Boys				Girls			
	OR	CI 95%		P-value	OR	CI 95%		P-value
		Lower	Upper			Lower	Upper	
Unnecessary weight concern, no dieting in normal-/underweight (UC)	**2.133**	1.333	3.412	0.002	**2.595**	2.064	3.264	< 0.001
Unnecessary weight concern and dieting in normal-/underweight (UD)	**2.122**	1.198	3.759	0.010	**3.846**	3.085	4.795	< 0.001
Weight concern and dieting in overweight/obese (HD)	**2.759**	1.941	3.921	< 0.001	**3.358**	2.618	4.308	< 0.001
Lack of weight concern, not dieting in overweight/obese (LC)	**1.397**	1.059	1.844	0.018	**1.566**	1.235	1.986	< 0.001

BSP: Body size perception, HD: Healthy dieting group, LC: Lack of weight concern group, UC: Unnecessary weight concern group, UD: Unnecessary dieting group. Reference group: Non overweight/obese participants with no weight concern or dieting.

Table 3: Associations between weight concern, dieting and mental distress in boys and girls, in the group with BSP overestimation.

	Boys				Girls			
		CI 95%				CI 95%		
	OR	Lower	Upper	P-value	OR	Lower	Upper	P-value
Unnecessary weight concern, no dieting in normal-/underweight (UC)	**16.692**	13.287	20.969	< 0.001	**13.552**	10.184	18.034	< 0.001
Unnecessary weight concern and dieting in normal-/underweight (UD)	**15.374**	12.205	19.366	< 0.001	**12.827**	9.662	17.029	< 0.001
Weight concern and dieting in overweight/obese (HD)	**6.809**	5.275	8.788	< 0.001	**6.073**	4.345	8.490	< 0.001
Lack of weight concern, not dieting in overweight/obese (LC)	**20.607**	16.886	25.148	< 0.001	**11.869**	8.895	15.839	< 0.001

BSP: Body size perception, HD: Healthy dieting group, LC: Lack of weight concern group, UC: Unnecessary weight concern group, UD: Unnecessary dieting group. Reference group: Non overweight/obese participants with no weight concern or dieting, with BSP accurate.

Discussion

Principal findings

We found strong supporting evidence that being overweight/obese, having weight concern or body size overestimation are all associated with higher odds for mental distress. We also found supporting evidence that being overweight/obese, body size over estimation, having weight concern and reporting dieting were associated with relatively lower odds for mental distress in boys and girls. Contrary to our hypothesis that predicted higher risk of mental distress amongst

girls due to more focus on thinness, we found that boys with BSP overestimation consistently showed greater increases risk than girls. These results were significant in our population, but the low number of participants in each group makes our results less generalizable.

Comparison with previous studies

Concern about being overweight in overweight individuals has been shown previously to be associated with poor mental health more strongly than the excess weight by itself [25, 26]. Both body size perception and obesity levels have changed amongst adolescents over the past decades, although in a multinational study of longitudinal trends in the associations between body size misperception and dieting in adolescents, overweight did not change the dieting trends [27]. Our findings supported this observation in both the overweight/obese and normal-/ underweight groups, providing more evidence as to the relative importance of cognitive aspects of overweight/obesity, that seem to by themselves, and independent of individual's BMI, associate with mental distress amongst adolescents.

Whilst weight and height (BMI) are routinely measures and tracked throughout childhood and adolescence, no routine enquiries are made about adolescents' attitude towards their own weight or body size [28]. This may lead to failure in early identification of vulnerable adolescents who harbor unnecessary concern about their own weight or body size. Likewise, unnecessary dieting may in itself lead to adverse physical complications and should be prevented.

In agreement with a previous report [29], we found BSP overestimation to be common in our study population. Since body size misperception does not seem to occur due to cognitive or perceptual failures [30] ,we propose that inaccuracy in body size perception occur due to body-ideals.

As children transit to adolescence, their exposure to body-ideals increases in tandem with the increase in dieting behavior [9]. In the past few decades, divergent definitions of body-ideals have been emerging [14, 31]. Whilst the obesity epidemic has shifted public perception towards normalization of excess weight, the negative health consequences of obesity remain unchanged [32]. On the other hand, desirability of thinness has risen. According to the Cognitive Dissonance Theory, divergent body-ideals may increase psychological discomfort, even amongst normal weight adolescents, and can potentially cause mental distress, as shown in our study population.

Body size overestimation is associated with poorer mental health which can lead to unnecessary dieting that may, in turn, further jeopardize adolescents' physical well-being [33-40]. Due to this relationship, authors suggest that children and adolescents are asked about their attitudes towards their own body in routine follow-up examinations by pediatricians, community nurses or other health workers.

Compared to their female counterparts, adolescent boys who overestimated their body size quite consistently showed higher odds for mental distress. In line with previous findings [6], we found higher male vulnerability to mental distress across all weight concern/dieting groups. Since weight concern/dieting groups were defined based on BMI, the higher male vulnerability cannot be solely related to individuals' BMI. This higher male vulnerability could not be attributed to male societal body-ideals either, because male body-ideals are less focused on being overtly thin, and more on being muscular [41-43].

Being overweight/obese puts adolescents in a less favorable social position compared to their peers, and is in itself associated with poorer mental health amongst adolescents [44]. The observed higher vulnerability to mental distress amongst adolescent boys who overestimate their body size, could be a

simple reflection of a higher number of overweight/obese boys, i.e. an issue of statistical strength. However, the increase in odds for mental distress was observed across all BMI groups in our population. On the other hand, the general increase in the population mean BMI has also normalized being obese amongst obese adolescents, which may in effect, lead to less stigma around being overweight/obese, since it becomes easier for the overweight to fit in with their peers [32, 45].

Like in previous studies [46], the overweight/obese female study participants in our study tended to overestimate their weight and body size.

Dieting was far more prevalent amongst girls compared to boys in our population, and previous studies have also shown that more overweight girls, compared to boys, correctly identify themselves as "too heavy" [32]. Furthermore, dieting was shown to be negatively associated with mental distress in our population. Considering this, we conclude that higher vulnerability to mental distress amongst males who overestimate their body size, may be due to lack of a behavioral change such as dieting.

Strengths and limitations of this study

Our study was performed in a large population-based homogenous population of male and female adolescents, which made our results more generalizable.

Studies combining components of body-image and body dissatisfaction has shown clear methodological advantages in previous association studies between body-image and body dissatisfaction amongst female adults [47]. We believe that grouping our study population into smaller but more units has been useful in making inferences as to which exposure variable seemed to contribute the greatest to mental distress.

The population stratification came however at the cost of having much smaller number of participants in some groups. Although results remained consistent and statistically significant

across all groups in both genders, the smaller participant numbers in some groups made it less possible to draw conclusive remarks.

Because of the cross-sectional design of our study, we were unable to make any conclusions on causality between exposures and outcome.

Application of the CDT framework to our findings has offered some theoretical explanation for why societal body-ideals seem to be of greater importance in body image formation in adolescents. Similarly, CDT has offered some theoretical explanation for higher vulnerability for mental distress amongst boys who overestimate their body size.

Our results suggest that inconsistencies in the existing literature on adolescent obesity and its psychological comorbidities, may stem from biased methodological approaches that give greater importance to adolescents' BMI rather than their weight concern or body size perception [26].

Conclusion

Our study points at a few important factors that were consistently associated with mental distress amongst our participants. Being overweight, having weight concern even if unnecessary increases the odds for mental distress amongst boys and girls. Body size overestimation seems to have a greater impact on mental distress related to weight concern and dieting amongst adolescents. Unexpectedly, we found that male adolescents who overestimate their body size are at a particularly high risk for having mental distress compared to their female counterparts.

Since societal body-ideals seem to play a greater part in formation of body-image, interventions aimed at reducing the psychological burden of a negative body-image should focus on changing the societal body-ideals to a set of attainable body-ideals that are population representative. Such

changes in societal body-ideals may help adolescents to form a more accurate body image, which may prevent unnecessary weight concern or unnecessary dieting.

A more holistic exploratory approach towards adolescents' body-image and body-ideals, make for a more comprehensive assessment of developmental growth, and may help identify vulnerable adolescents. A change of focus from normalization of BMI to normalization of different body size/shapes may improve mental well-being amongst adolescents with body-image dissatisfaction. Replication of our findings in clinical populations of adolescents with body-image dissatisfaction, may pave the way for improvement in the novel treatment techniques for disorders of feeding and eating [48, 49].

Dieting seems to promote better mental well-being in overweight and obese adolescents. Since behavioral changes such as dieting often make fast and short-lived reduction in cognitive dissonance [50], it is imperative to encourage adolescents to reduce weight by offering them motivational support over longer follow-up periods.

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The material described in this paper is original research and has not been previously published or submitted for publication elsewhere.

Author Contributions

FSS has conceived the idea, performed the analyses and drafted the manuscript. FSS and KK have contributed to interpretation of results and critical revision of manuscript. FSS and KK have read and approved the final version of the manuscript before submission. Authors FSS and KK declare no conflict of interest or any competing financial interests.

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Data availability statement

Due to restrictions imposed by the HUNT Research Centre (in accordance with Norwegian Data Inspectorate), data cannot be made publicly available. Data are currently stored in the HUNT Databank, and there are restrictions in place for the handling of HUNT data files. Data used from the HUNT Study in research projects will be made available on request to the HUNT Data Access Committee (hunt@medicine.ntnu.no). The HUNT data access information (available here: http://www.ntnu.edu/hunt/data) describes in detail the policy regarding data availability.

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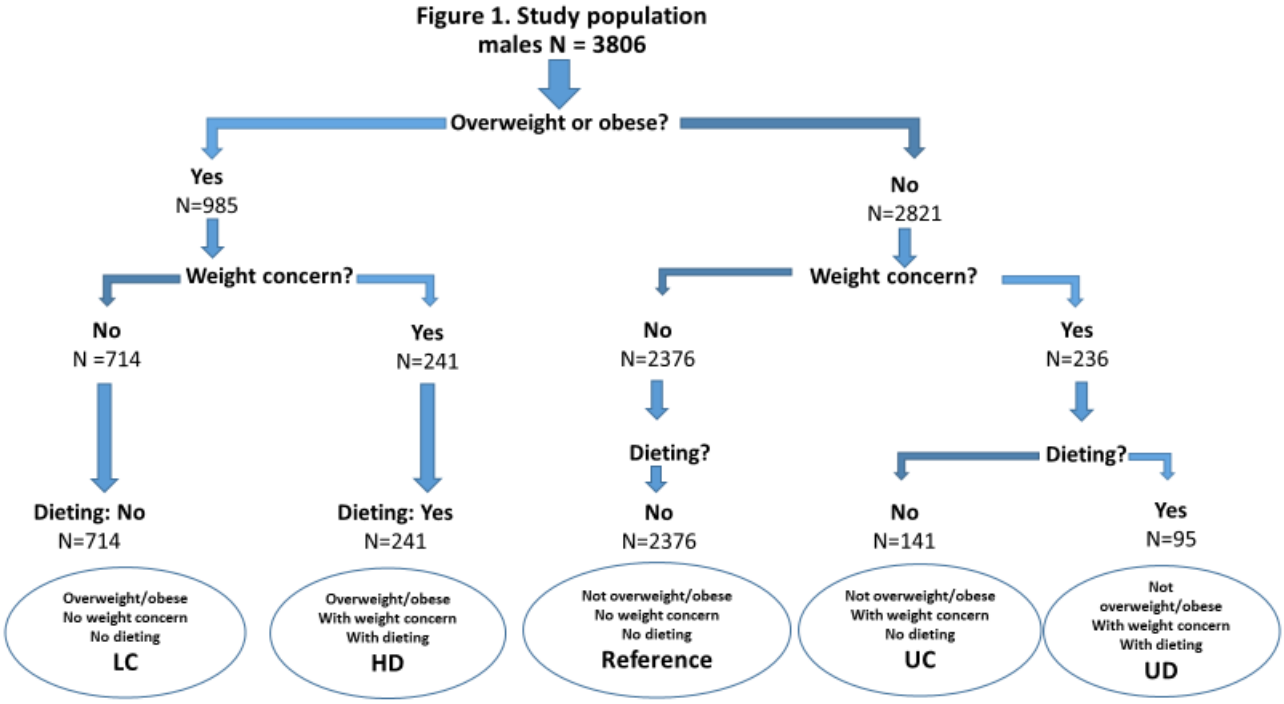
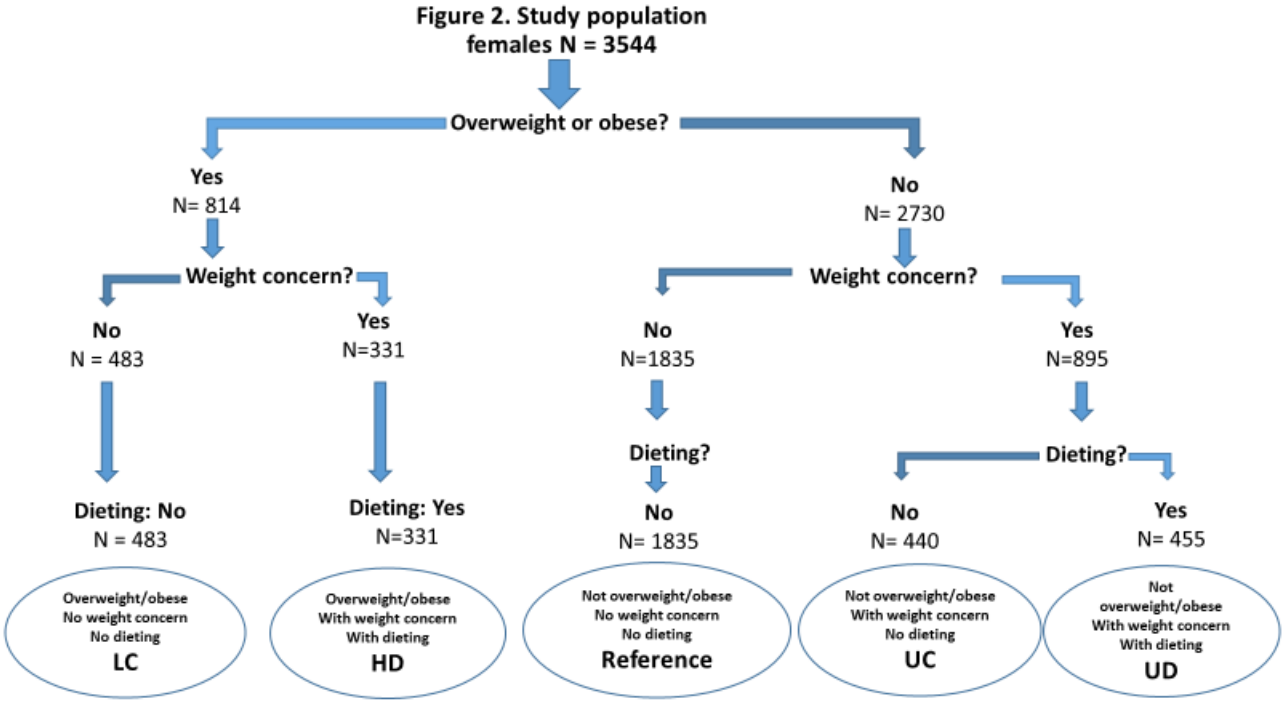
Figure caption:

Figure 1. Study population males N=3 806

Figure 2. Study population females N= 3 544





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A Cross-sectional Study of BMI, weight concern, body size perception, dieting and mental distress in adolescents - The HUNT Study

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Abstract

Objective: We examined the associations between BMI, weight concern, body size perception, dieting and mental distress in a population-based study of 7 350 adolescents. **Design:** Cross-sectional. **Settings:** Data from a Norwegian population-based cohort, The Young-HUNT3 (2006-08) from the county of Nord-Trøndelag, Norway. **Participants:** A total of 7 350 adolescents (13-19 years) who had both self-reported questionnaire data and anthropometric measures. **Primary outcome measures:** Odds for mental distress given sex, BMI, weight concern, body size perception, and dieting. Analyses were performed in binomial logistic regression models. **Results:** Compared to being overweight/obese, having weight concern, irrespective of body mass index (BMI), was associated with higher odds ratio (OR) for mental distress (MD) amongst

boys and girls. Body size overestimation was associated with an increase in the OR for MD, in participants who were overweight/obese, had weight concern or dieted. This effect was more pronounced in boys. **Conclusions:** Weight concern and body-size estimation are strongly associated with mental health in adolescent boys and girls. Routine assessment of adolescents' attitudes towards their weight and body size is advised.

Keywords: Adolescents, body size overestimation, weight concern, dieting, BMI, mental health, Cognitive dissonance theory, HUNT.

Strength and limitations of this study:

- Our findings were based on a study of a large, population-representative dataset of male and female adolescents.
- Stratification of our study population into smaller groups based on their body size perception and weight concern allowed for inferences being made on the interaction terms between the two, which had clear methodological advantage in making inferences as to which component seemed to contribute more to the outcome variable.
- The relationship of weight concern, body-size estimation and mental distress has been discussed within the framework of the Cognitive Dissonance Theory.
- A limitation of this study was the cross-sectional design that is not suitable for studying causality between exposure and outcome variables.

Introduction

Long-term negative effects of pediatric obesity on the physical and mental wellbeing are widely known. Preventing obesity has however, proved difficult [1-3]. To lose weight, many adolescents resort to dieting; whose effectivity and long-term health consequences are debated [4-7]. In order to strive to achieve (or maintain) normal weight, it is necessary for individuals, to have awareness of their own body.

Previous studies in adolescent populations, have collectively pointed at inter-related and multifaceted relationships between body awareness, BMI and dieting [4-7]. High BMI and having concerns about one's weight or body size have been associated with poorer mental health amongst adolescents, but what contributes to this association is not fully understood [6].

Body awareness is a human construct, formed by comparisons made between individuals' perception of their own body (body-image) to that of others (body-ideal)[8]. The definition of body-ideals may vary depending on the context within which it is applied. In medical terms, there is a preference for normal BMI (defined by the World Health Organization as between 18.5–24.9). Societal body-ideals, which seems to be culturally dependent, is what advance individuals towards goals such as being liked or being successful [9]. In a societal context, emphasis is often put on body shape/size [9]. Weight perception and body-ideals may vary in different racial or ethnical groups[10]. For instance, in western societies, there is a preference for overly thin bodies in girls [11] and masculine and lean bodies in boys [12-15]. Individuals may also compare their weight (or BMI) to what they consider most prevalent (hence normal) by looking at their peers [14].

In the past few decades, there has been a significant increase in the obesity rate and mean population BMI amongst both adults and adolescents [16]. This is contrary to the current societal

preference for overly thin body-ideals many adolescents find unattainable [9]. In today's western societies, the perceived distance between BMI in overweight/obese individuals and societal or medical body-ideals has increased compared to previous situations. In contrast, due to the increase in mean population BMI, the perceived distance between BMI in overweight/obese individuals and the population norm has decreased. It is known that holding contradictory elements of cognition causes psychological discomfort (Cognitive Dissonance theory)[17, 18].

Psychological theories have provided a scientific framework for studying body-image [17]. For instance, in the field of eating behavior, Cognitive Dissonance Theory (CDT) has been applied to study body acceptance in female adolescents and adults [19]. CDT suggests that humans have an inert drive to create and maintain harmony between their attitudes and behavior, because disharmony (or cognitive dissonance) causes psychological discomfort. Accordingly, incongruency between the body-ideals themselves, as well as incongruency between individuals' body-image and their body-ideals, could create psychological discomfort, which may then be reduced by making changes in cognition or behavior (such as dieting).

In the current study, we have explored associations between body-image, dieting and mental distress in 7 350 Norwegian adolescents who had taken part in The Young-HUNT3 Survey (2006-08). Body-ideals were defined as, 1- being of normal weight BMI (medical preference), and 2- being closer to societal thinner/leaner body-ideals. Taking advantage of data available on a range of health-related issues, we divided our participants into groups based on their BMI, body-image, and dieting behavior. Body-image consisted of two elements: individuals' perception of their weight (weight concern) and body size (body size under- and overestimation). Odds for mental distress were then estimated across these groups. By cross-comparing the odds

we made inferences as to which body-ideals seem to be playing a greater part in increasing psychological discomfort amongst adolescents.

We hypothesized that adolescents with excess weight, experience higher psychological discomfort due to an increase in the discrepancy between their weight perception and societal preference for thinness and medical preference for lower BMI. We hypothesized that body size overestimation is associated with higher psychological discomfort because overestimation puts adolescents in a less favorable position compared to the societal body-ideal. Due to greater societal preference for thinness in girls, we expected this association to be stronger in the female group. We hypothesized that body size underestimation in adolescents is associated with lower psychological discomfort because the underestimation puts the adolescents in a more favorable position compared to the societal body-ideal. Within the context of CDT, behavioral changes such as dieting are expected to reduce psychological discomfort caused by cognitive dissonance between body-image and body-ideals. We therefore hypothesized that dieting is associated with lower odds for Mental Distress (MD), in both girls and boys.

To our best knowledge, this is the first time CDT is used as a theoretical framework to infer the relative significance of societal definitions of body-ideals for body-awareness at adolescence.

Methods

Participants

Data from The Young-HUNT3 Survey (YH3) (2006-08) was used in the present study. YH3 is the third wave of the adolescent arm of the Trøndelag Health Study (The HUNT Study).

The Young-HUNT surveys were carried out at the Nord-Trøndelag Region County's schools, and comprises three cross-sectional surveys: Young-HUNT1, YH1 (1995–97), Young-HUNT3, YH3 (2006–08) and Young-HUNT4, YH4 (2016-2019). A survey of a limited number of Young-HUNT1 participants was done in a smaller cohort, Young-HUNT2, YH2 (2000-2001).

After completion of YH3 and in total, data on 17 820 adolescent research participants (13-19 years old, response rate 78% - 90%) were collected [20, 21]. Cohort profiles of The HUNT Study are previously described elsewhere [20, 21].

YH3 data included self-administered questionnaires, structured interviews, collection of biological samples and clinical measurements, carried out by trained personnel. For anthropometric measurements of height, weight, hip and waist circumference, standard procedures were followed [21]. In the present study, questionnaire data and anthropometric measurements have been used.

In total, 8 202 individuals in junior and senior high schools participated in YH3 (78% response rate) [21]. Of those, 7 718 individuals had both answered the YH3 questionnaire and had anthropometric measurements data available. Due to missing data on body size perception, dieting or mental distress, 386 participants were excluded from our study. The total study population was 7 350 (3 806 boys and 3 544 girls).

Measurements

Mental distress

The five-item Hopkins Symptom Checklist (SCL-5)[22] was used to evaluate participants' level of mental distress. SCL-5, a valid and reliable measure of mental distress [22, 23] consists of the following question items: "Feeling blue", –"Feeling fearful", –"Feeling hopeless about the future", –" Worrying too much about things" and –" Experiencing nervousness or shakiness inside". Participants recorded their answer on a four-point Likert scale from 1 ('not bothered') to 4 ('very much bothered').

Only participants who had answered four or more questions were included. A negligible number of participants (n = 21) did not have data available for all five questions The mean scores for each question were summed up to a total score that was then divided by the number of questions answered. Based on a previously defined cut-off point [22], participants with "high" mental distress (≥ 2) were identified and compared to those with "low" (< 2) levels of mental distress. In this paper, adolescents with high mental distress are referred to as those with mental distress.

Anthropometric measures

Participants' weight was measured to the nearest half kilo and height to the nearest cm [21]. BMI (body mass index) was calculated as weight (kg)/height^2 (m^2). The adolescent BMI-based weight categories were defined using the age-specified and sex-specified International Obesity Task Force cut-off values [24, 25], participants were grouped into four categories; obese, overweight, normal weight or underweight. In the analyses, overweight and obese in addition to underweight and normal weight were collapsed into groups.

Weight concern and dieting

The Young HUNT research participants were asked a series of questions about their «Meals and eating habits», including a question item on dieting[26]. The dieting item consists of the following question: "Are you trying to lose weight?", with the answer options: : "No, I am comfortable with my weight"(1), "No, but I need to lose weight"(2) or "Yes"(3). The two latter options both indicated weight concern, but only the latter point to actively changing eating behaviors to reduce weight.

By pairing this information with participants' actual BMI-based weight category, we stratified participants into the following five groups (also see Figure 1 and 2) that bore information on participants' BMI-based weight category, weight concern or dieting behavior (or the lack of).

1. Unnecessary weight concern (UC): Normal or underweight adolescents with unnecessary weight concern, but without dieting behavior (answer option 2).
2. Unnecessary weight concern with dieting (UD): Normal or underweight adolescents with weight concern and dieting behavior (answer option 3).
3. Healthy weight concern with dieting (HD): Overweight/obese adolescents with weight concern and dieting behavior (answer option 3).
4. Lack of weight concern (LC): Overweight/obese adolescents who were neither concerned about their weight, nor dieted (answer option 1).
5. Reference: Normal or underweight adolescents with no weight concern or dieting behavior (answer option 1).

Body size perception

Study participants were asked about how they perceived their body size as follows: "Do you consider yourself to be: "very fat", "quite fat", "about the same as others", "quite thin" or "very thin"?

By combining individuals' body size perception (BSP) with their BMI-based weight category, we defined three BSP groups: BSP overestimation (normal- underweight who consider themselves "very fat", "quite fat"), BSP underestimation (overweight/obese who consider themselves "about the same as others", "quite thin" or "very thin"), and accurate BSP estimation (for instance, overweight-obese who thought they were quite fat or very fat).

Statistical analysis

A three-way log-linear analysis was performed to determine which model components (individuals' BMI-based weight category, weight concern, body size perception, dieting and sex) were necessary to retain in order to best account for the data. The log-linear analysis suggested a hierarchical unsaturated model for the associations between sex, weight concern/dieting, and body size perception. An unsaturated model was chosen using SPSS Statistics' hierarchical log-linear model selection procedure with a backwards elimination stepwise procedure. This produced a model that included all main effects and two two-way associations of weight concern/dieting and body size perception. The Log-linear analysis did not recommend including interaction terms between sex and other factors. The model had a likelihood ratio of $\chi 2(14) < 0.001$ $p = 1$.

Binomial logistic regression was employed to study the associations between BMI, weight concern/dieting, body size perception, and mental distress amongst adolescents. Analyses were performed in groups stratified according to weight concern, body size perception (BSP over- and underestimation), and dieting. After stratification on BSP over- and underestimation, groups with BSP underestimation had very few participants; hence excluded from the final analyses. All association analyses were adjusted for age. All association analyses were performed against the group with least cognitive dissonance. i.e. adolescents with normal weight, no weight concern, with accurate BSP, and not dieting.

Results are reported as Odds Ratio (OR) for mental distress (MD), with 95% confidence intervals. Overall missingness (< 5%) was considered as missing at random (MAR). A complete case analyses were performed. IBM SPSS Statistics 26 was used for the analyses.

Application of Cognitive Dissonance Theory (CDT)

According to CDT, discrepancies between adolescents' body-image and their body-ideals should be associated with increased mental distress. Emergence of divergent sets of body-ideals would inevitably lead to discrepancy between how adolescents view their weight and body size in different context within which body-ideals are defined. Accordingly, individuals' sum of cognitive dissonance (CD) due to discrepancy between body-image and body-ideals (See Figure 1 and 2), can be considered as the sum of:

1- CD due to weight concern as a mismatch between person's actual BMI and medical body-ideal (normal weight BMI).
2- CD due to discrepancy between person's body size estimation and their societal body-ideal.

For instance, in a normal weight person who thinks she/he is overweight, CD may be, in part, due to as discrepancy between what the person thinks they weigh and their ideal weight. This ideal weight, however, is defined based on medical and societal expectations. On the other hand, ideal weight may be, in part, relative to the population mean BMI that has been changing upwards in the past few decades. Similarly, changes in CD are expected due to discrepancies between individuals' perception of their body size and an increasingly thin societal body-ideal.

By comparing the odds for mental distress across groups defined according to their BMI-based weight category, weight concern, body size perception (BSP under- and overestimation), and dieting, authors made inferences as to which of these possible discrepancies seem to have higher impact on the total CD.

Ethics

The Young-HUNT Study was approved by the Norwegian Data Inspectorate. The present study was approved by the Regional and National Committees for Medical and Health Research Ethics (2009/740-2) as well as by the HUNT Data Access Committee. All study procedures were in accordance with the Helsinki Declaration, as of 1975, and revised in 2000.

Participants signed written consents before they were enrolled in The Young-HUNT Study. In Norway, legal age for providing informed consent is 16 years. Written consents were obtained from participants aged 16 years or older and from their parents or legal guardians if participants were younger than 16 years.

Patient and Public Involvement

No patient involved.

Results

Population characteristics

Study participant's characteristics of main variables are summarized in Table 1. In total, 7 350 adolescents (3 806 boys and 3 544 girls) were included in the current study (mean age: 15.82 years old).

Most boys (70.9%) and girls (72.9%) were of normal weight BMI. The prevalence of overweight/obesity was slightly higher amongst boys than girls (25.9% vs. 22.3%). Being underweight was slightly more prevalent in girls than boys (4.7% vs. 3.2%).

More girls than boys showed unnecessary weight concern (overestimation of weight in UC & UD groups, 6.6% in boys vs. 25.2% in girls). More boys showed lack of weight concern/dieting despite being overweight/obese (underestimation of weight in LC group, 19.8% of boys vs. 13.6% of girls).

More boys misperceive their body size as thinner (BSP underestimation in 19.8% of boys vs. 13% of girls), and more girls misperceived their body size as fatter (BSP overestimation in 16.8% of boys vs. 22.3% of girls) . In boys, BSP overestimation was more prevalent than weight overestimation (UC and UD groups) (Table 1).

The majority of boys and girls were happy with their weight, hence not dieting. Compared to their female counterparts, fewer overweight/obese boys had weight concern or tried to lose weight by dieting (weight underestimation seen in LC group: 19.8 % of boys vs. 13.6 % of girls). Compared to boys, and irrespective of BMI-based weight category, more girls resorted to dieting in order to lose weight, as expressed by the prevalence of dieting in HD group (9.3% of girls vs. 6.7 % of boys) and UD group (12.8 % of girls vs. 2.6% of boys). The higher prevalence of dieting in girls paralleled their higher tendency of BSP overestimation (Table 1).

Mental distress was prevalent in both genders, more so in girls than boys (27% vs. 10.2%, Table 1). The Relative Risk for mental distress in girls compared to boys was 2.66, CI 95% 2.38 - 2.96, p-value < 0.0001 (data not shown).

Table 1. Population characteristics.

		Boys		Girls	
		N	%	N	%
BMI based weight categories	Obese	244	6.4	179	4.7
	Overweight	741	19.5	668	17.6
	Normal weight	122	3.2	179	4.7
	Underweight	2699	70.9	2765	72.9
Are you trying to lose weight?	No, I am happy with my weight	2998	79.8	2206	58.3
	No, but I need to lose weight	423	11.3	760	20.1
	Yes	338	9	819	21.6
Weight concern/dieting	Unnecessary concern but not dieting in normal- /underweight (UC)	146	4	440	12.4
	Unnecessary concern and dieting in normal- /underweight (UD)	95	2.6	455	12.8
	Weight concern and dieting in overweight/obese (HD)	241	6.7	331	9.3
	Lack of concern, no dieting in overweight/obese (LC)	714	19.8	483	13.6
	Lack of concern, no dieting in normal- /underweight (reference)	2413	66.9	1835	51.8
Body size perception	Very fat	58	1.6	122	3.2
	Quite fat	676	18.1	1008	26.6
	Like others	721	19.3	534	14.1
	Quite thin	66	1.8	41	1.1
	Very thin	2212	59.3	2080	55.0

Body size perception	BSP underestimation	687	19.8	455	13.0
	BSP overestimation	585	16.8	783	22.3
	BSP accurate	2204	63.4	2272	64.7
Mental distress(SCL-5)	Low mental distress (score < 2)	3330	89.8	2780	73.0
	High mental distress (score ≥ 2)	377	10.2	1030	27.0

BMI-based weight categories are age and sex adjusted in accordance with Cole et al. [23, 24]. BSP: Body size perception. HD: Healthy dieting, LC: Lack of weight concern, MD: Mental distress, UC: Unnecessary weight concern, UD: Unnecessary dieting, SCL-5: The five-item Hopkins Symptom Checklist.

Association between participants' BMI, weight concern/dieting, body size perception and mental distress

Confirming findings from the initial log-linear analysis, The discrepant number of participants in each BMI-based weight category compared with the size of groups with presumed correlated weight concern or body size perception (Table 1) showed that weight concern and body size perception do not entirely measure the same thing.

In both boys and girls, being overweight/obese was associated with increased odds for mental distress, independent of the presence of weight concern or dieting (Table 2 and Table 3; OR for mental distress in HD and LC groups). Likewise, comparable size effects were observed in the in normal-/underweight groups with unnecessary weigh concern and dieting (in Table 2 and Table 3; higher odds for mental distress in UC and UD groups).

In both boys and girls, analyses based on BSP overestimation had even larger effects on the associations between all the various weight concern/dieting groups and mental distress. (Table 3).

Interestingly, overweight/obese adolescents with weight concern and dieting had much lower odds for mental distress (HD group, OR: 6.8, 95% CI 5.3-8.8 and 6.1, CI 4.3-8.5, boys and girls

respectively) compared to overweight/obese with lack of weight concern and dieting (LC group, OR: 20.6, 95% CI 16.9-25.15 and 11.9, CI 8.9-15.8, boys and girls respectively) (see Table 3). Similar association effects were observed in the associations between weight concern /dieting and mental distress in the normal-/ underweight groups (see results in the UC and UD groups compared to the reference group).

On the other hand, overweight/obese participants with weight concern and dieting (HD group, OR for MD: 6.81) had much lower OR for MD compared to overweight/obese participants with no weight concern or dieting (LC group, OR for MD: 20.61). Interestingly, our analyses revealed similar effects (Table 2) or even higher odds (Table 3) for MD amongst boys compared to girls.

Table 2. Associations between weight concern, dieting and mental distress in boys and girls.

	Boys				Girls			
	OR	CI 95%		P-value	OR	CI 95%		P-value
		Lower	Upper			Lower	Upper	
Unnecessary weight concern, no dieting in normal-/underweight (UC)	**2.133**	1.333	3.412	0.002	**2.595**	2.064	3.264	< 0.001
Unnecessary weight concern and dieting in normal-/underweight (UD)	**2.122**	1.198	3.759	0.010	**3.846**	3.085	4.795	< 0.001
Weight concern and dieting in overweight/obese (HD)	**2.759**	1.941	3.921	< 0.001	**3.358**	2.618	4.308	< 0.001
Lack of weight concern, not dieting in overweight/obese (LC)	**1.397**	1.059	1.844	0.018	**1.566**	1.235	1.986	< 0.001

BSP: Body size perception, HD: Healthy dieting group, LC: Lack of weight concern group, UC: Unnecessary weight concern group, UD: Unnecessary dieting group. Reference group: Non overweight/obese participants with no weight concern or dieting.

Table 3: Associations between weight concern, dieting and mental distress in boys and girls, in the group with BSP overestimation.

	Boys				Girls			
		CI 95%				CI 95%		
	OR	Lower	Upper	P-value	OR	Lower	Upper	P-value
Unnecessary weight concern, no dieting in normal-/underweight (UC)	**16.692**	13.287	20.969	< 0.001	**13.552**	10.184	18.034	< 0.001
Unnecessary weight concern and dieting in normal-/underweight (UD)	**15.374**	12.205	19.366	< 0.001	**12.827**	9.662	17.029	< 0.001
Weight concern and dieting in overweight/obese (HD)	**6.809**	5.275	8.788	< 0.001	**6.073**	4.345	8.490	< 0.001
Lack of weight concern, not dieting in overweight/obese (LC)	**20.670**	16.886	25.148	< 0.001	**11.869**	8.895	15.839	< 0.001

BSP: Body size perception, HD: Healthy dieting group, LC: Lack of weight concern group, UC: Unnecessary weight concern group, UD: Unnecessary dieting group. Reference group: Non overweight/obese participants with no weight concern or dieting, with BSP accurate.

Discussion

Principal findings

We found strong supporting evidence that being overweight/obese, having weight concern or body size overestimation are all associated with higher odds for mental distress. We also found supporting evidence that being overweight/obese, body size over estimation, having weight concern and reporting dieting were associated with relatively lower odds for mental distress in boys and girls. Contrary to our hypothesis that predicted higher risk of mental distress amongst

girls due to more focus on thinness, we found that boys with BSP overestimation consistently showed greater increases risk than girls. These results were significant in our population, but the low number of participants in each group makes our results less generalizable.

Comparison with previous studies

Concern about being overweight in overweight individuals has been shown previously to be associated with poor mental health more strongly than the excess weight by itself [27, 28]. Both body size perception and obesity levels have changed amongst adolescents over the past decades, although in a multinational study of longitudinal trends in the associations between body size misperception and dieting in adolescents, overweight did not change the dieting trends [29]. Our findings supported this observation in both the overweight/obese and normal-/ underweight groups, providing more evidence as to the relative importance of cognitive aspects of overweight/obesity, that seem to by themselves, and independent of individual's BMI, associate with mental distress amongst adolescents.

Whilst weight and height (BMI) are routinely measures and tracked throughout childhood and adolescence, no routine enquiries are made about adolescents' attitude towards their own weight or body size [30]. This may lead to failure in early identification of vulnerable adolescents who harbor unnecessary concern about their own weight or body size. Likewise, unnecessary dieting may itself lead to adverse physical complications, and should be prevented.

In agreement with a previous report [31], we found BSP overestimation to be common in our study population. Since body size misperception does not seem to occur due to cognitive or perceptual failures [32] ,we propose that inaccuracy in body size perception occur due to body-ideals.

As children transit to adolescence, their exposure to body-ideals increases in tandem with the increase in dieting behavior [9]. In the past few decades, divergent definitions of body-ideals have been emerging [15, 33]. Whilst the obesity epidemic has shifted public perception towards normalization of excess weight, the negative health consequences of obesity remain unchanged [34]. On the other hand, desirability of thinness has risen. According to the Cognitive Dissonance Theory, divergent body-ideals may increase psychological discomfort, even amongst normal weight adolescents, and can potentially cause mental distress, as shown in our study population.

Body size overestimation is associated with poorer mental health which can lead to unnecessary dieting that may, in turn, further jeopardize adolescents' physical well-being [35-42]. Due to this relationship, authors suggest that children and adolescents are asked about their attitudes towards their own body in routine follow-up examinations by pediatricians, community nurses or other health workers.

Compared to their female counterparts, adolescent boys who overestimated their body size quite consistently showed higher odds for mental distress. In line with previous findings [6], we found higher male vulnerability to mental distress across all weight concern/dieting groups. Since weight concern/dieting groups were defined based on BMI, the higher male vulnerability cannot be solely related to individuals' BMI. This higher male vulnerability could not be attributed to male societal body-ideals either, because male body-ideals are less focused on being overtly thin, and more on being muscular [43-45].

Being overweight/obese puts adolescents in a less favorable social position compared to their peers, and is in itself associated with poorer mental health amongst adolescents [46]. The observed higher vulnerability to mental distress amongst adolescent boys who overestimate their body size, could be a

simple reflection of a higher number of overweight/obese boys, i.e. an issue of statistical strength. However, the increase in odds for mental distress was observed across all BMI groups in our population. On the other hand, the general increase in the population mean BMI has also normalized being obese amongst obese adolescents, which may in effect, lead to less stigma around being overweight/obese, since it becomes easier for the overweight to fit in with their peers [34, 47].

Like in previous studies [48], the overweight/obese female study participants in our study tended to overestimate their weight and body size.

Dieting was far more prevalent amongst girls compared to boys in our population, and previous studies have also shown that more overweight girls, compared to boys, correctly identify themselves as "too heavy" [34]. Furthermore, dieting was shown to be negatively associated with mental distress in our population [49]. Considering this, we conclude that higher vulnerability to mental distress amongst males who overestimate their body size, may be due to lack of a behavioral change such as dieting.

Strengths and limitations of this study

Our study was performed in a large population-based homogenous population of male and female adolescents, which made our results more generalizable.

Studies combining components of body-image and body dissatisfaction has shown clear methodological advantages in previous association studies between body-image and body dissatisfaction amongst female adults [50]. We believe that grouping our study population into smaller but more units has been useful in making inferences as to which exposure variable seemed to contribute the greatest to mental distress.

The population stratification came however at the cost of having much smaller number of participants in some groups. Although results remained consistent and statistically significant across all groups in both genders. The smaller participant numbers in some groups came with the disadvantage of introducing bias in a regression model, and hence made it less possible to make conclusive remarks.

It should also be noted that because of the cross-sectional design of our study, we were unable to make any conclusions on causality between exposures and outcome.

Application of the CDT framework to our findings has offered some theoretical explanation for why societal body-ideals seem to be of greater importance in body image formation in adolescents. Similarly, CDT has offered some theoretical explanation for higher vulnerability for mental distress amongst boys who overestimate their body size.

Our results suggest that inconsistencies in the existing literature on adolescent obesity and its psychological comorbidities, may stem from biased methodological approaches that give greater importance to adolescents' BMI rather than their weight concern or body size perception [28].

Conclusion

Our study points at a few important factors that were consistently associated with mental distress amongst our participants. Being overweight, having weight concern even if unnecessary increases the odds for mental distress amongst boys and girls. Body size overestimation seems to have a greater impact on mental distress related to weight concern and dieting amongst adolescents. Unexpectedly, we found that male adolescents who overestimate their body size are at a particularly high risk for having mental distress compared to their female counterparts.

Since societal body-ideals seem to play a greater part in formation of body-image, interventions aimed at reducing the psychological burden of a negative body-image should focus on changing the societal body-ideals to a set of attainable body-ideals that are population representative. Such changes in societal body-ideals may help adolescents to form a more accurate body image, which may prevent unnecessary weight concern or unnecessary dieting.

A more holistic exploratory approach towards adolescents' body-image and body-ideals, make for a more comprehensive assessment of developmental growth, and may help identify vulnerable adolescents. A change of focus from normalization of BMI to normalization of different body size/shapes may improve mental well-being amongst adolescents with body-image dissatisfaction. Replication of our findings in clinical populations of adolescents with body-image dissatisfaction, may pave the way for improvement in the novel treatment techniques for disorders of feeding and eating.

Dieting seems to promote better mental well-being in overweight and obese adolescents. Since behavioral changes such as dieting often make fast and short-lived reduction in cognitive dissonance, it is imperative to encourage adolescents to reduce weight by offering them motivational support over longer follow-up periods.

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Author statement

FSS has conceived the idea, performed the analyses and drafted the manuscript. FSS and KK have contributed to interpretation of results and critical revision of manuscript. FSS and KK have read and approved the final version of the manuscript before submission. Authors FSS and KK declare no conflict of interest or any competing financial interests.

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Data availability statement

Due to restrictions imposed by the HUNT Research Centre (in accordance with Norwegian Data Inspectorate), data cannot be made publicly available. Data are currently stored in the HUNT Databank, and there are restrictions in place for the handling of HUNT data files. Data used from the HUNT Study in research projects will be made available on request to the HUNT Data Access Committee (hunt@medicine.ntnu.no). The HUNT data access information (available here: http://www.ntnu.edu/hunt/data) describes in detail the policy regarding data availability.

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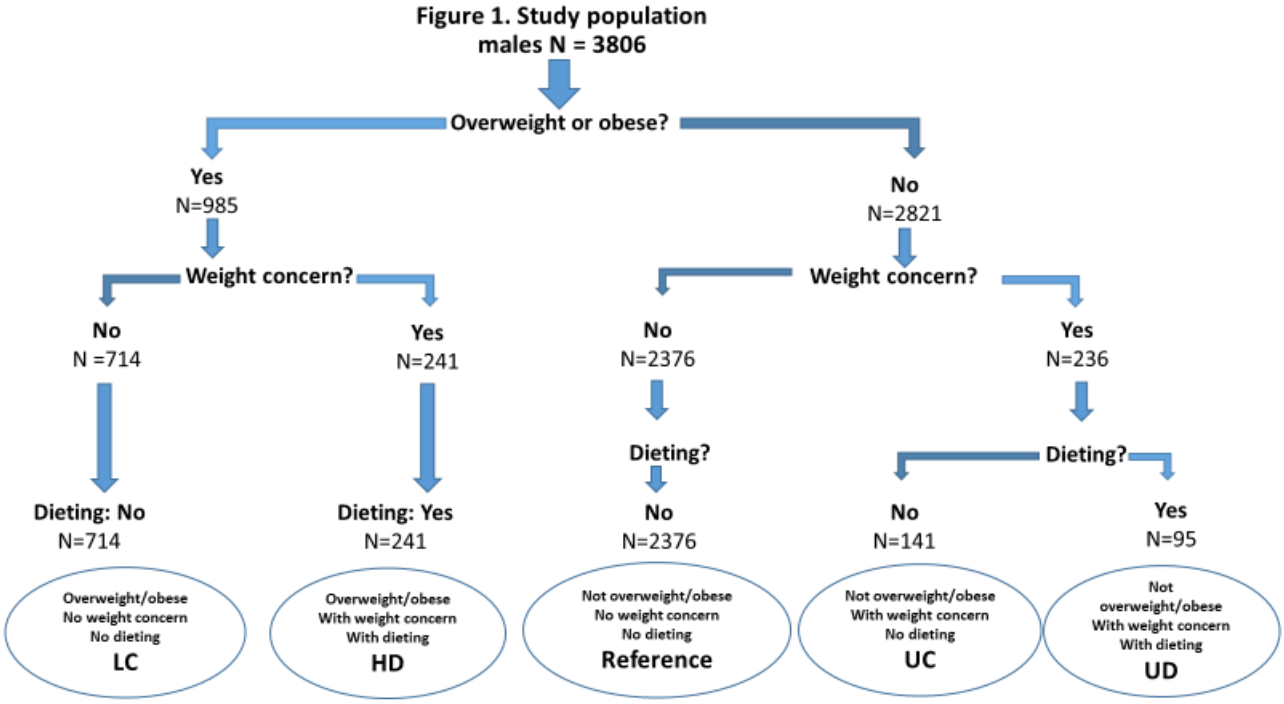
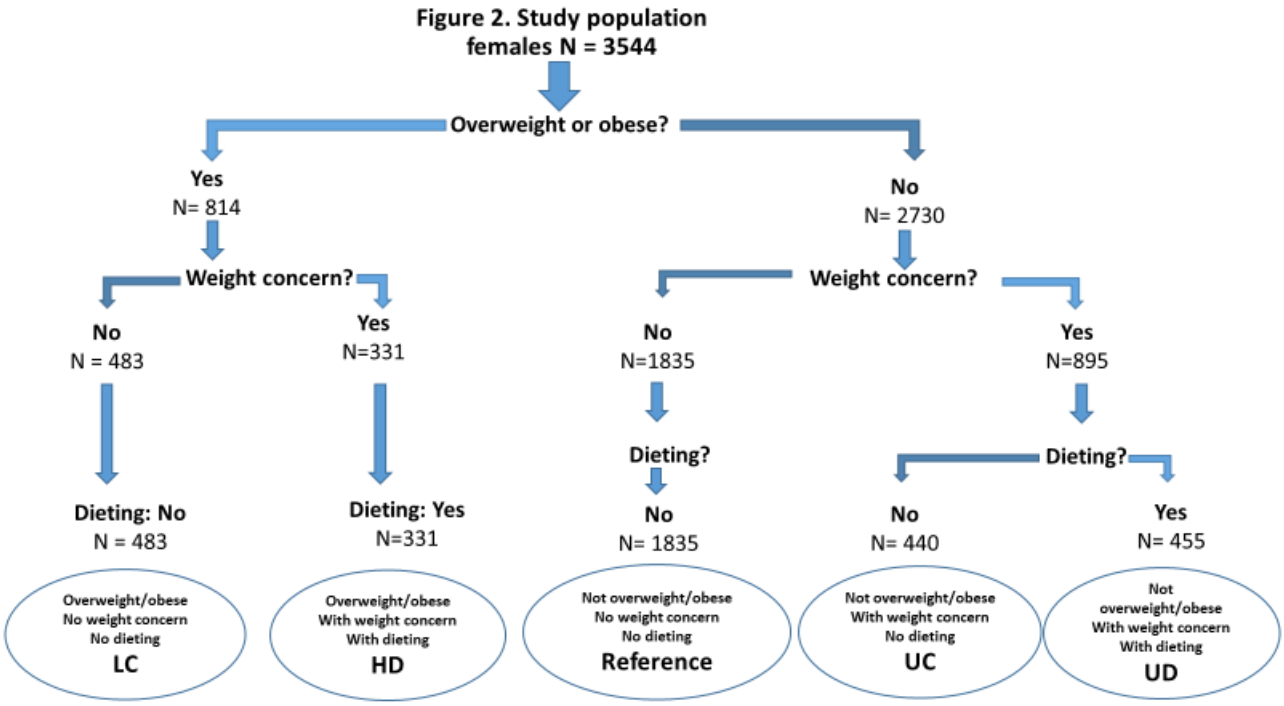
Figure 1. Study population males N = 3806

Figure 2. Study population females N = 3544





STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*6-9*
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9-10
		(*b*) Describe any methods used to examine subgroups and interactions	9-10
		(*c*) Explain how missing data were addressed	9-10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	---
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12
		(b) Indicate number of participants with missing data for each variable of interest	7, 10
Outcome data	15*	Report numbers of outcome events or summary measures	12-17

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-17
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-10
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	18-19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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A Cross-sectional Study of BMI, weight concern, body size perception, dieting and mental distress in adolescents - The HUNT Study

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A Cross-sectional Study of BMI, weight concern, body size perception, dieting and mental distress in adolescents - The HUNT Study

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Abstract

Objective: We examined the associations between BMI, weight concern, body size perception, dieting and mental distress in a population-based study of 7 350 adolescents. **Design:** Cross-sectional. **Settings:** Data from a Norwegian population-based cohort, The Young-HUNT3 (2006-08) from the county of Nord-Trøndelag, Norway. **Participants:** A total of 7 350 adolescents (13-19 years) who had both self-reported questionnaire data and anthropometric measures. **Primary outcome measures:** Odds for mental distress given sex, BMI, weight concern, body size perception, and dieting. Analyses were performed in binomial logistic regression models. **Results:** Compared to being overweight/obese, having weight concern, irrespective of body mass index (BMI), was associated with higher odds ratio (OR) for mental distress (MD) amongst

boys and girls. Body size overestimation was associated with an increase in the OR for MD, in participants who were overweight/obese, had weight concern or dieted. This effect was more pronounced in boys. **Conclusions:** Weight concern and body-size estimation are strongly associated with mental health in adolescent boys and girls. Routine assessment of adolescents' attitudes towards their weight and body size is advised.

Keywords: Adolescents, body size overestimation, weight concern, dieting, BMI, mental health, Cognitive dissonance theory, HUNT.

Strength and limitations of this study:

- Our findings were based on a study of a large, population-representative dataset of male and female adolescents.
- Stratification of our study population into smaller groups based on their body size perception and weight concern allowed for inferences being made on the interaction terms between the two, which had clear methodological advantage in making inferences as to which component seemed to contribute more to the outcome variable.
- The relationship of weight concern, body-size estimation and mental distress has been discussed within the framework of the Cognitive Dissonance Theory.
- A limitation of this study was the cross-sectional design that is not suitable for studying causality between exposure and outcome variables.

Introduction

Long-term negative effects of pediatric obesity on the physical and mental wellbeing are widely known. Preventing obesity has however, proved difficult [1-3]. To lose weight, many adolescents resort to dieting; whose effectivity and long-term health consequences are debated [4-7]. In order to strive to achieve (or maintain) normal weight, it is necessary for individuals, to have awareness of their own body.

Previous studies in adolescent populations, have collectively pointed at inter-related and multifaceted relationships between body awareness, BMI and dieting [4-7]. High BMI and having concerns about one's weight or body size have been associated with poorer mental health amongst adolescents, but what contributes to this association is not fully understood [6].

Body awareness is a human construct, formed by comparisons made between individuals' perception of their own body (body-image) to that of others (body-ideal)[8]. The definition of body-ideals may vary depending on the context within which it is applied. In medical terms, there is a preference for normal BMI (defined by the World Health Organization as between 18.5–24.9). Societal body-ideals, which seems to be culturally dependent, is what advance individuals towards goals such as being liked or being successful [9]. In a societal context, emphasis is often put on body shape/size [9]. Weight perception and body-ideals may vary in different racial or ethnical groups[10]. For instance, in western societies, there is a preference for overly thin bodies in girls [11] and masculine and lean bodies in boys [12-15]. Individuals may also compare their weight (or BMI) to what they consider most prevalent (hence normal) by looking at their peers [14].

In the past few decades, there has been a significant increase in the obesity rate and mean population BMI amongst both adults and adolescents [16]. This is contrary to the current societal

preference for overly thin body-ideals many adolescents find unattainable [9]. In today's western societies, the perceived distance between BMI in overweight/obese individuals and societal or medical body-ideals has increased compared to previous situations. In contrast, due to the increase in mean population BMI, the perceived distance between BMI in overweight/obese individuals and the population norm has decreased. It is known that holding contradictory elements of cognition causes psychological discomfort (Cognitive Dissonance theory)[17, 18].

Psychological theories have provided a scientific framework for studying body-image [17]. For instance, in the field of eating behavior, Cognitive Dissonance Theory (CDT) has been applied to study body acceptance in female adolescents and adults [19]. CDT suggests that humans have an inert drive to create and maintain harmony between their attitudes and behavior, because disharmony (or cognitive dissonance) causes psychological discomfort. Accordingly, incongruency between the body-ideals themselves, as well as incongruency between individuals' body-image and their body-ideals, could create psychological discomfort, which may then be reduced by making changes in cognition or behavior (such as dieting).

In the current study, we have explored associations between body-image, dieting and mental distress in 7 350 Norwegian adolescents who had taken part in The Young-HUNT3 Survey (2006-08). Body-ideals were defined as, 1- being of normal weight BMI (medical preference), and 2- being closer to societal thinner/leaner body-ideals. Taking advantage of data available on a range of health-related issues, we divided our participants into groups based on their BMI, body-image, and dieting behavior. Body-image consisted of two elements: individuals' perception of their weight (weight concern) and body size (body size under- and overestimation). Odds for mental distress were then estimated across these groups. By cross-comparing the odds

we made inferences as to which body-ideals seem to be playing a greater part in increasing psychological discomfort amongst adolescents.

We hypothesized that adolescents with excess weight, experience higher psychological discomfort due to an increase in the discrepancy between their weight perception and societal preference for thinness and medical preference for lower BMI. We hypothesized that body size overestimation is associated with higher psychological discomfort because overestimation puts adolescents in a less favorable position compared to the societal body-ideal. Due to greater societal preference for thinness in girls, we expected this association to be stronger in the female group. We hypothesized that body size underestimation in adolescents is associated with lower psychological discomfort because the underestimation puts the adolescents in a more favorable position compared to the societal body-ideal. Within the context of CDT, behavioral changes such as dieting are expected to reduce psychological discomfort caused by cognitive dissonance between body-image and body-ideals. We therefore hypothesized that dieting is associated with lower odds for Mental Distress (MD), in both girls and boys.

To our best knowledge, this is the first time CDT is used as a theoretical framework to infer the relative significance of societal definitions of body-ideals for body-awareness at adolescence.

Methods

Participants

Data from The Young-HUNT3 Survey (YH3) (2006-08) was used in the present study. YH3 is the third wave of the adolescent arm of the Trøndelag Health Study (The HUNT Study).

The Young-HUNT surveys were carried out at the Nord-Trøndelag Region County's schools, and comprises three cross-sectional surveys: Young-HUNT1, YH1 (1995–97), Young-HUNT3, YH3 (2006–08) and Young-HUNT4, YH4 (2016-2019). A survey of a limited number of Young-HUNT1 participants was done in a smaller cohort, Young-HUNT2, YH2 (2000-2001).

After completion of YH3 and in total, data on 17 820 adolescent research participants (13-19 years old, response rate 78% - 90%) were collected [20, 21]. Cohort profiles of The HUNT Study are previously described elsewhere [20, 21].

YH3 data included self-administered questionnaires, structured interviews, collection of biological samples and clinical measurements, carried out by trained personnel. For anthropometric measurements of height, weight, hip and waist circumference, standard procedures were followed [21]. In the present study, questionnaire data and anthropometric measurements have been used.

In total, 8 202 individuals in junior and senior high schools participated in YH3 (78% response rate) [21]. Of those, 7 718 individuals had both answered the YH3 questionnaire and had anthropometric measurements data available. Due to missing data on body size perception, dieting or mental distress, 386 participants were excluded from our study. The total study population was 7 350 (3 806 boys and 3 544 girls).

Measurements

Mental distress

The five-item Hopkins Symptom Checklist (SCL-5)[22] was used to evaluate participants' level of mental distress. SCL-5, a valid and reliable measure of mental distress [22, 23] consists of the following question items: "Feeling blue", –"Feeling fearful", –"Feeling hopeless about the future", –" Worrying too much about things" and –" Experiencing nervousness or shakiness inside". Participants recorded their answer on a four-point Likert scale from 1 ('not bothered') to 4 ('very much bothered').

Only participants (N=7329) who had answered four or more questions were included. The mean scores for each question were summed up to a total score that was then divided by the number of questions answered. Based on a previously defined cut-off point [22], participants with "high" mental distress (≥ 2) were identified and compared to those with "low" (< 2) levels of mental distress. In this paper, adolescents with high mental distress are referred to as those with mental distress.

Anthropometric measures

Participants' weight was measured to the nearest half kilo and height to the nearest cm [21]. BMI (body mass index) was calculated as weight (kg)/height^2 (m^2). The adolescent BMI-based weight categories were defined using the age-specified and sex-specified International Obesity Task Force cut-off values [24, 25], participants were grouped into four categories; obese, overweight, normal weight or underweight. In the analyses, overweight and obese in addition to underweight and normal weight were collapsed into groups.

Weight concern and dieting

The Young HUNT research participants were asked a series of questions about their «Meals and eating habits», including a question item on dieting[26]. The dieting item consists of the following question: "Are you trying to lose weight?", with the answer options: : "No, I am comfortable with my weight"(1), "No, but I need to lose weight"(2) or "Yes"(3). The two latter options both indicated weight concern, but only the latter point to actively changing eating behaviors to reduce weight.

By pairing this information with participants' actual BMI-based weight category, we stratified participants into the following five groups (also see Figure 1 and 2) that bore information on participants' BMI-based weight category, weight concern or dieting behavior (or the lack of).

1. Unnecessary weight concern (UC): Normal or underweight adolescents with unnecessary weight concern, but without dieting behavior (answer option 2).
2. Unnecessary weight concern with dieting (UD): Normal or underweight adolescents with weight concern and dieting behavior (answer option 3).
3. Healthy weight concern with dieting (HD): Overweight/obese adolescents with weight concern and dieting behavior (answer option 3).
4. Lack of weight concern (LC): Overweight/obese adolescents who were neither concerned about their weight, nor dieted (answer option 1).
5. Reference: Normal or underweight adolescents with no weight concern or dieting behavior (answer option 1).

Body size perception

Study participants were asked about how they perceived their body size as follows: "Do you consider yourself to be: "very fat", "quite fat", "about the same as others", "quite thin" or "very thin"?

By combining individuals' body size perception (BSP) with their BMI-based weight category, we defined three BSP groups: BSP overestimation (normal- underweight who consider themselves "very fat", "quite fat"), BSP underestimation (overweight/obese who consider themselves "about the same as others", "quite thin" or "very thin"), and accurate BSP estimation (for instance, overweight-obese who thought they were quite fat or very fat).

Statistical analysis

A three-way log-linear analysis was performed to determine which model components (individuals' BMI-based weight category, weight concern, body size perception, dieting and sex) were necessary to retain in order to best account for the data. The log-linear analysis suggested a hierarchical unsaturated model for the associations between sex, weight concern/dieting, and body size perception. An unsaturated model was chosen using SPSS Statistics' hierarchical log-linear model selection procedure with a backwards elimination stepwise procedure. This produced a model that included all main effects and two two-way associations of weight concern/dieting and body size perception. The Log-linear analysis did not recommend including interaction terms between sex and other factors. The model had a likelihood ratio of $\chi 2(14) < 0.001$ $p = 1$.

Binomial logistic regression was employed to study the associations between BMI, weight concern/dieting, body size perception, and mental distress amongst adolescents. Analyses were performed in groups stratified according to weight concern, body size perception (BSP over- and underestimation), and dieting. After stratification on BSP over- and underestimation, groups with BSP underestimation had very few participants; hence excluded from the final analyses. All association analyses were adjusted for age. All association analyses were performed against the group with least cognitive dissonance. i.e. adolescents with normal weight, no weight concern, with accurate BSP, and not dieting.

Results are reported as Odds Ratio (OR) for mental distress (MD), with 95% confidence intervals. Overall missingness (< 5%) was considered as missing at random (MAR). A complete case analyses were performed. IBM SPSS Statistics 26 was used for the analyses.

Application of Cognitive Dissonance Theory (CDT)

According to CDT, discrepancies between adolescents' body-image and their body-ideals should be associated with increased mental distress. Emergence of divergent sets of body-ideals would inevitably lead to discrepancy between how adolescents view their weight and body size in different context within which body-ideals are defined. Accordingly, individuals' sum of cognitive dissonance (CD) due to discrepancy between body-image and body-ideals (See Figure 1 and 2), can be considered as the sum of:

1- CD due to weight concern as a mismatch between person's actual BMI and medical body-ideal (normal weight BMI).
2- CD due to discrepancy between person's body size estimation and their societal body-ideal.

For instance, in a normal weight person who thinks she/he is overweight, CD may be, in part, due to as discrepancy between what the person thinks they weigh and their ideal weight. This ideal weight, however, is defined based on medical and societal expectations. On the other hand, ideal weight may be, in part, relative to the population mean BMI that has been changing upwards in the past few decades. Similarly, changes in CD are expected due to discrepancies between individuals' perception of their body size and an increasingly thin societal body-ideal.

By comparing the odds for mental distress across groups defined according to their BMI-based weight category, weight concern, body size perception (BSP under- and overestimation), and dieting, authors made inferences as to which of these possible discrepancies seem to have higher impact on the total CD.

Ethics

The Young-HUNT Study was approved by the Norwegian Data Inspectorate. The present study was approved by the Regional and National Committees for Medical and Health Research Ethics (2009/740-2) as well as by the HUNT Data Access Committee. All study procedures were in accordance with the Helsinki Declaration, as of 1975, and revised in 2000.

Participants signed written consents before they were enrolled in The Young-HUNT Study. In Norway, legal age for providing informed consent is 16 years. Written consents were obtained from participants aged 16 years or older and from their parents or legal guardians if participants were younger than 16 years.

Patient and Public Involvement

No patient involved.

Results

Population characteristics

Study participant's characteristics of main variables are summarized in Table 1. In total, 7 350 adolescents (3 806 boys and 3 544 girls) were included in the current study (mean age: 15.82 years old).

Most boys (70.9%) and girls (72.9%) were of normal weight BMI. The prevalence of overweight/obesity was slightly higher amongst boys than girls (25.9% vs. 22.3%). Being underweight was slightly more prevalent in girls than boys (4.7% vs. 3.2%).

More girls than boys showed unnecessary weight concern (overestimation of weight in UC & UD groups, 6.6% in boys vs. 25.2% in girls). More boys showed lack of weight concern/dieting despite being overweight/obese (underestimation of weight in LC group, 19.8% of boys vs. 13.6% of girls).

More boys misperceive their body size as thinner (BSP underestimation in 19.8% of boys vs. 13% of girls), and more girls misperceived their body size as fatter (BSP overestimation in 16.8% of boys vs. 22.3% of girls) . In boys, BSP overestimation was more prevalent than weight overestimation (UC and UD groups) (Table 1).

The majority of boys and girls were happy with their weight, hence not dieting. Compared to their female counterparts, fewer overweight/obese boys had weight concern or tried to lose weight by dieting (weight underestimation seen in LC group: 19.8 % of boys vs. 13.6 % of girls). Compared to boys, and irrespective of BMI-based weight category, more girls resorted to dieting in order to lose weight, as expressed by the prevalence of dieting in HD group (9.3% of girls vs. 6.7 % of boys) and

UD group (12.8 % of girls vs. 2.6% of boys). The higher prevalence of dieting in girls paralleled their higher tendency of BSP overestimation (Table 1).

Mental distress was prevalent in both genders, more so in girls than boys (27% vs. 10.2%, Table 1). The Relative Risk for mental distress in girls compared to boys was 2.66, CI 95% 2.38 - 2.96, p-value < 0.0001 (data not shown).

Table 1. Population characteristics.

		Boys		Girls	
		N	%	N	%
BMI based weight categories	Obese	244	6.4	179	4.7
	Overweight	741	19.5	668	17.6
	Normal weight	122	3.2	179	4.7
	Underweight	2699	70.9	2765	72.9
Are you trying to lose weight?	No, I am happy with my weight	2998	79.8	2206	58.3
	No, but I need to lose weight	423	11.3	760	20.1
	Yes	338	9	819	21.6
Weight concern/dieting	Unnecessary concern but not dieting in normal- /underweight (UC)	146	4	440	12.4
	Unnecessary concern and dieting in normal- /underweight (UD)	95	2.6	455	12.8
	Weight concern and dieting in overweight/obese (HD)	241	6.7	331	9.3
	Lack of concern, no dieting in overweight/obese (LC)	714	19.8	483	13.6
	Lack of concern, no dieting in normal- /underweight (reference)	2413	66.9	1835	51.8
Body size perception	Very fat	58	1.6	122	3.2
	Quite fat	676	18.1	1008	26.6
	Like others	721	19.3	534	14.1

	Quite thin	66	1.8	41	1.1
	Very thin	2212	59.3	2080	55.0
Body size perception	BSP underestimation	687	19.8	455	13.0
	BSP overestimation	585	16.8	783	22.3
	BSP accurate	2204	63.4	2272	64.7
Mental distress(SCL-5)	Low mental distress (score < 2)	3251	89.8	2715	73.0
	High mental distress (score ≥ 2)	361	10.2	1002	27.0

BMI-based weight categories are age and sex adjusted in accordance with Cole et al. [23, 24]. BSP: Body size perception. HD: Healthy dieting, LC: Lack of weight concern, MD: Mental distress, UC: Unnecessary weight concern, UD: Unnecessary dieting, SCL-5: The five-item Hopkins Symptom Checklist.

Association between participants' BMI, weight concern/dieting, body size perception and mental distress

Confirming findings from the initial log-linear analysis, The discrepant number of participants in each BMI-based weight category compared with the size of groups with presumed correlated weight concern or body size perception (Table 1) showed that weight concern and body size perception do not entirely measure the same thing.

In both boys and girls, being overweight/obese was associated with increased odds for mental distress, independent of the presence of weight concern or dieting (Table 2 and Table 3; OR for mental distress in HD and LC groups). Likewise, comparable size effects were observed in the in normal-/underweight groups with unnecessary weigh concern and dieting (in Table 2 and Table 3; higher odds for mental distress in UC and UD groups).

In both boys and girls, analyses based on BSP overestimation had even larger effects on the associations between all the various weight concern/dieting groups and mental distress. (Table 3).

Interestingly, overweight/obese adolescents with weight concern and dieting had much lower odds for mental distress (HD group, OR: 6.8, 95% CI 5.3-8.8 and 6.1, CI 4.3-8.5, boys and girls respectively) compared to overweight/obese with lack of weight concern and dieting (LC group, OR: 20.6, 95% CI 16.9-25.15 and 11.9, CI 8.9-15.8, boys and girls respectively) (see Table 3). Similar association effects were observed in the associations between weight concern /dieting and mental distress in the normal-/ underweight groups (see results in the UC and UD groups compared to the reference group).

On the other hand, overweight/obese participants with weight concern and dieting (HD group, OR for MD: 6.81) had much lower OR for MD compared to overweight/obese participants with no weight concern or dieting (LC group, OR for MD: 20.61). Interestingly, our analyses revealed similar effects (Table 2) or even higher odds (Table 3) for MD amongst boys compared to girls.

Table 2. Associations between weight concern, dieting and mental distress in boys and girls.

	Boys				Girls			
	OR	CI 95%		P-value	OR	CI 95%		P-value
		Lower	Upper			Lower	Upper	
Unnecessary weight concern, no dieting in normal-/underweight (UC)	**2.133**	1.333	3.412	0.002	**2.595**	2.064	3.264	< 0.001
Unnecessary weight concern and dieting in normal-/underweight (UD)	**2.122**	1.198	3.759	0.010	**3.846**	3.085	4.795	< 0.001
Weight concern and dieting in overweight/obese (HD)	**2.759**	1.941	3.921	< 0.001	**3.358**	2.618	4.308	< 0.001
Lack of weight concern, not dieting in overweight/obese (LC)	**1.397**	1.059	1.844	0.018	**1.566**	1.235	1.986	< 0.001

BSP: Body size perception, HD: Healthy dieting group, LC: Lack of weight concern group, UC: Unnecessary weight concern group, UD: Unnecessary dieting group. Reference group: Non overweight/obese participants with no weight concern or dieting.

Table 3: Associations between weight concern, dieting and mental distress in boys and girls, in the group with BSP overestimation.

	Boys				Girls			
		CI 95%				CI 95%		
	OR	Lower	Upper	P-value	OR	Lower	Upper	P-value
Unnecessary weight concern, no dieting in normal-/underweight (UC)	**16.692**	13.287	20.969	< 0.001	**13.552**	10.184	18.034	< 0.001
Unnecessary weight concern and dieting in normal-/underweight (UD)	**15.374**	12.205	19.366	< 0.001	**12.827**	9.662	17.029	< 0.001
Weight concern and dieting in overweight/obese (HD)	**6.809**	5.275	8.788	< 0.001	**6.073**	4.345	8.490	< 0.001
Lack of weight concern, not dieting in overweight/obese (LC)	**20.670**	16.886	25.148	< 0.001	**11.869**	8.895	15.839	< 0.001

BSP: Body size perception, HD: Healthy dieting group, LC: Lack of weight concern group, UC: Unnecessary weight concern group, UD: Unnecessary dieting group. Reference group: Non overweight/obese participants with no weight concern or dieting, with BSP accurate.

Discussion

Principal findings

We found strong supporting evidence that being overweight/obese, having weight concern or body size overestimation are all associated with higher odds for mental distress. We also found

supporting evidence that being overweight/obese, body size over estimation, having weight concern and reporting dieting were associated with relatively lower odds for mental distress in boys and girls. Contrary to our hypothesis that predicted higher risk of mental distress amongst girls due to more focus on thinness, we found that boys with BSP overestimation consistently showed greater increases risk than girls. These results were significant in our population, but the low number of participants in each group makes our results less generalizable.

Comparison with previous studies

Concern about being overweight in overweight individuals has been shown previously to be associated with poor mental health more strongly than the excess weight by itself [27, 28]. Both body size perception and obesity levels have changed amongst adolescents over the past decades, although in a multinational study of longitudinal trends in the associations between body size misperception and dieting in adolescents, overweight did not change the dieting trends [29]. Our findings supported this observation in both the overweight/obese and normal-/ underweight groups, providing more evidence as to the relative importance of cognitive aspects of overweight/obesity, that seem to by themselves, and independent of individual's BMI, associate with mental distress amongst adolescents.

Whilst weight and height (BMI) are routinely measures and tracked throughout childhood and adolescence, no routine enquiries are made about adolescents' attitude towards their own weight or body size [30]. This may lead to failure in early identification of vulnerable adolescents who harbor unnecessary concern about their own weight or body size. Likewise, unnecessary dieting may itself lead to adverse physical complications, and should be prevented.

In agreement with a previous report [31], we found BSP overestimation to be common in our study population. Since body size misperception does not seem to occur due to cognitive or perceptual failures [32] ,we propose that inaccuracy in body size perception occur due to body-ideals.

As children transit to adolescence, their exposure to body-ideals increases in tandem with the increase in dieting behavior [9]. In the past few decades, divergent definitions of body-ideals have been emerging [15, 33]. Whilst the obesity epidemic has shifted public perception towards normalization of excess weight, the negative health consequences of obesity remain unchanged [34]. On the other hand, desirability of thinness has risen. According to the Cognitive Dissonance Theory, divergent body-ideals may increase psychological discomfort, even amongst normal weight adolescents, and can potentially cause mental distress, as shown in our study population.

Body size overestimation is associated with poorer mental health which can lead to unnecessary dieting that may, in turn, further jeopardize adolescents' physical well-being [35-42]. Due to this relationship, authors suggest that children and adolescents are asked about their attitudes towards their own body in routine follow-up examinations by pediatricians, community nurses or other health workers.

Compared to their female counterparts, adolescent boys who overestimated their body size quite consistently showed higher odds for mental distress. In line with previous findings [6], we found higher male vulnerability to mental distress across all weight concern/dieting groups. Since weight concern/dieting groups were defined based on BMI, the higher male vulnerability cannot be solely related to individuals' BMI. This higher male vulnerability could not be attributed to male societal body-ideals either, because male body-ideals are less focused on being overtly thin, and more on being muscular [43-45].

Being overweight/obese puts adolescents in a less favorable social position compared to their peers, and is in itself associated with poorer mental health amongst adolescents [46]. The observed higher vulnerability to mental distress amongst adolescent boys who overestimate their body size, could be a simple reflection of a higher number of overweight/obese boys, i.e. an issue of statistical strength. However, the increase in odds for mental distress was observed across all BMI groups in our population. On the other hand, the general increase in the population mean BMI has also normalized being obese amongst obese adolescents, which may in effect, lead to less stigma around being overweight/obese, since it becomes easier for the overweight to fit in with their peers [34, 47].

Like in previous studies [48], the overweight/obese female study participants in our study tended to overestimate their weight and body size.

Dieting was far more prevalent amongst girls compared to boys in our population, and previous studies have also shown that more overweight girls, compared to boys, correctly identify themselves as “too heavy” [34]. Furthermore, dieting was shown to be negatively associated with mental distress in our population [49]. Considering this, we conclude that higher vulnerability to mental distress amongst males who overestimate their body size, may be due to lack of a behavioral change such as dieting.

Strengths and limitations of this study

Our study was performed in a large population-based homogenous population of male and female adolescents, which made our results more generalizable.

Studies combining components of body-image and body dissatisfaction has shown clear methodological advantages in previous association studies between body-image and body

dissatisfaction amongst female adults [50]. We believe that grouping our study population into smaller but more units has been useful in making inferences as to which exposure variable seemed to contribute the greatest to mental distress.

The population stratification came however at the cost of having much smaller number of participants in some groups. Although results remained consistent and statistically significant across all groups in both genders. The smaller participant numbers in some groups came with the disadvantage of introducing bias in a regression model, and hence made it less possible to make conclusive remarks.

It should also be noted that because of the cross-sectional design of our study, we were unable to make any conclusions on causality between exposures and outcome.

Application of the CDT framework to our findings has offered some theoretical explanation for why societal body-ideals seem to be of greater importance in body image formation in adolescents. Similarly, CDT has offered some theoretical explanation for higher vulnerability for mental distress amongst boys who overestimate their body size.

Our results suggest that inconsistencies in the existing literature on adolescent obesity and its psychological comorbidities, may stem from biased methodological approaches that give greater importance to adolescents' BMI rather than their weight concern or body size perception [28].

Conclusion

Our study points at a few important factors that were consistently associated with mental distress amongst our participants. Being overweight, having weight concern even if unnecessary

increases the odds for mental distress amongst boys and girls. Body size overestimation seems to have a greater impact on mental distress related to weight concern and dieting amongst adolescents. Unexpectedly, we found that male adolescents who overestimate their body size are at a particularly high risk for having mental distress compared to their female counterparts.

Since societal body-ideals seem to play a greater part in formation of body-image, interventions aimed at reducing the psychological burden of a negative body-image should also focus on changing the societal body-ideals to a set of attainable body-ideals that are population representative. Such changes in societal body-ideals may help adolescents to form a more accurate body image, which may prevent unnecessary weight concern or unnecessary dieting.

A more holistic exploratory approach towards adolescents' body-image and body-ideals, make for a more comprehensive assessment of developmental growth, and may help identify vulnerable adolescents, whom do not necessary meet the clinical thresholds of current diagnostic categories but nevertheless show higher odds for mental distress. A change of focus from normalization of BMI to normalization of different body size/shapes may improve mental well-being amongst adolescents with body-image dissatisfaction. Replication of our findings in clinical populations of adolescents with body-image dissatisfaction, may pave the way for improvement in the novel treatment techniques for disorders of feeding and eating, with more attention paid to sex differences in the descriptive phenomenology of weight and body perception.

Dieting seems to associate with better mental well-being in overweight and obese adolescents in our study, which may be a potential area for interventions aimed at promoting health and well-being. Since behavioral changes such as dieting often make fast and short-lived reduction in cognitive dissonance, it is imperative to encourage adolescents to reduce weight by offering them motivational

support over longer follow-up periods, where end target is not solely a certain BMI, but overall health of individuals.

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The material described in this paper is original research and has not been previously published or submitted for publication elsewhere.

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Author statement

FSS has conceived the idea, performed the analyses and drafted the manuscript. FSS and KK have contributed to interpretation of results and critical revision of manuscript. FSS and KK have read and approved the final version of the manuscript before submission. Authors FSS and KK declare no conflict of interest or any competing financial interests.

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Data availability statement

Data used in the current study are stored in the HUNT databank. In accordance with Norwegian Data Inspectorate, these data cannot be made publicly available. Data used from the HUNT Study in research projects will be made available upon written request to the HUNT Data Access Committee (hunt@medicine.ntnu.no). The HUNT data access information (available here: http://www.ntnu.edu/hunt/data) gives a detailed description of the policy regarding data availability.

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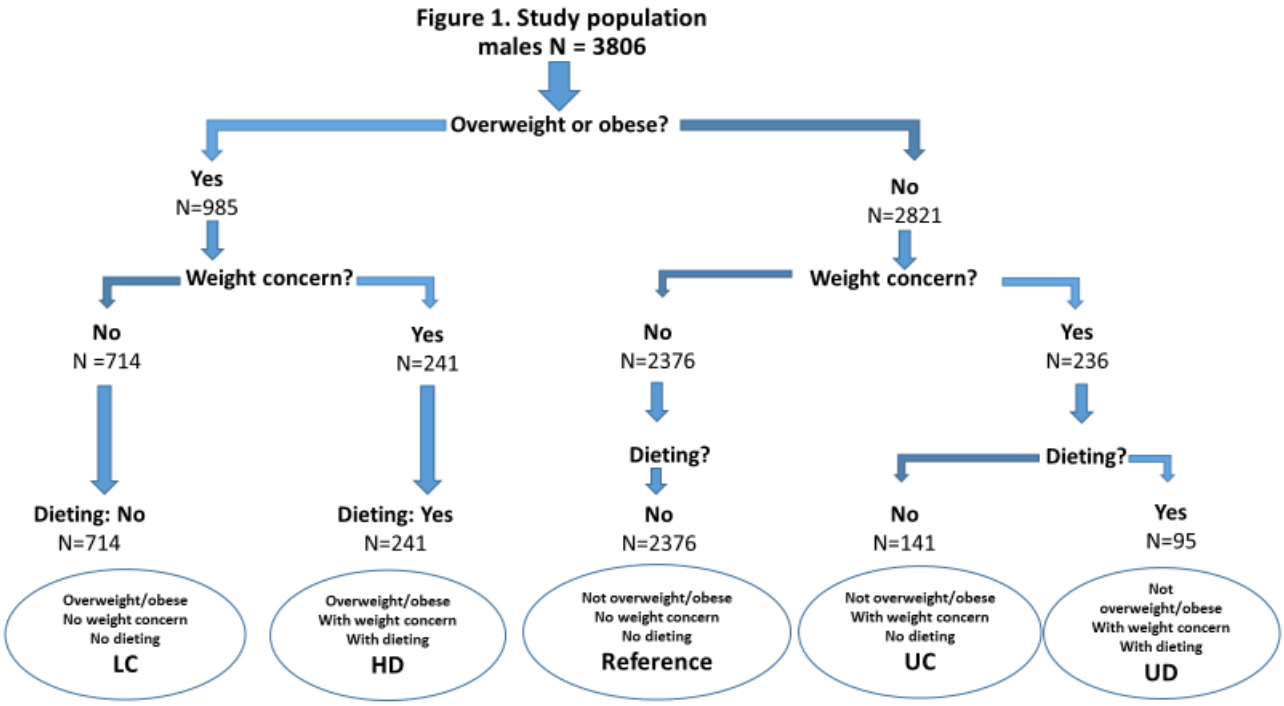
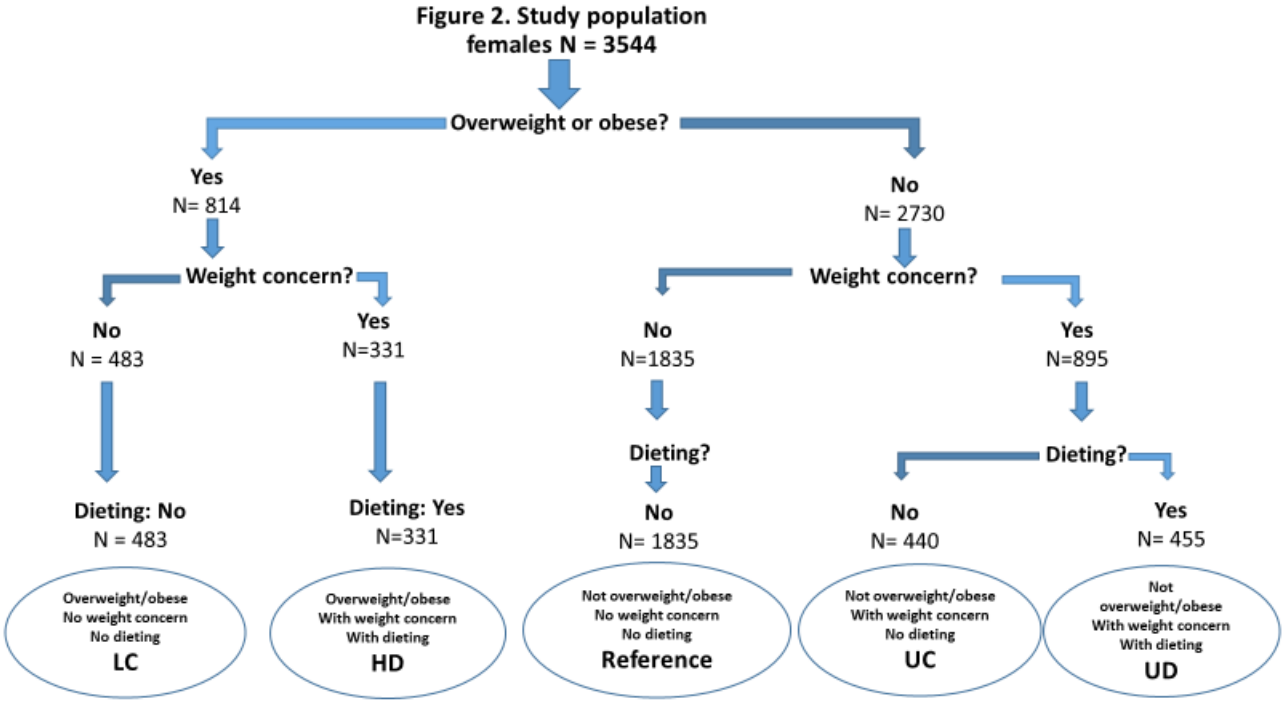
Figure 1. Study population Males N = 3806

Figure 2. Study population females N = 3544





STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*6-9*
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9-10
		(*b*) Describe any methods used to examine subgroups and interactions	9-10
		(*c*) Explain how missing data were addressed	9-10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	---
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12
		(b) Indicate number of participants with missing data for each variable of interest	7, 10
Outcome data	15*	Report numbers of outcome events or summary measures	12-17

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-17
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-10
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	18-19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.