DISSERTATION FROM THE
NORWEGIAN SCHOOL OF
SPORT SCIENCES
2022

Kethe Marie Engen Svantorp-Tveiten

Reducing risk for eating disorder development and muscle-building supplement use in high school students:

A Cluster Randomized Controlled Trial

NIH NORWEGIAN SCHOOL OF SPORT SCIENCES

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If we knew what we were doing,

it would not be called research, would it?

- Albert Einstein

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Acknowledgements

I can hardly believe that I am at the beginning of a new chapter of finalizing my PhD work. The past five years have truly been a roller coaster of emotions, achievements, and obstacles that has raised existential questions about the meaning of life. To be given the opportunity to complete a PhD is a rarity, and I am grateful for everyone who has made it possible. This has truly been a team effort.

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List of papers

Paper I

Svantorp-Tveiten KME, Friborg O, Torstveit MK, Mathisen TF, Sundgot-Borgen C, Rosenvinge JH, Bratland-Sanda S, Pettersen G, Sundgot-Borgen J. Protein, creatine and dieting supplements among adolescents: Use and associations with eating disorder risk factors, exercise- and sports participation, and immigrant status. Front Sports Act Living 2021;3(727372.):1-11.

Paper II

Svantorp-Tveiten KME, Torstveit MK, Rosenvinge JH, Sundgot-Borgen C, Friborg O, Bratland-Sanda S, Pettersen G, Sundgot-Borgen J. Effect of A Healthy Body Image intervention on risk- and protective factors for eating disorders: A cluster randomized controlled trial. Ment Health Prev. 2021:200225.

Paper III (in review after revision)

Svantorp-Tveiten KME, Ivarsson A, Torstveit MK, Sundgot-Borgen C, Mathisen TF, Bratland-Sanda S, Rosenvinge JH, Friborg O, Pettersen G, Sundgot-Borgen J. The Healthy Body Image (HBI) intervention and reduction in eating disorder symptomatology and supplement use in high school students: a study of mediating factors. Front Psychol. 2022; [in review].

Summary

Background: The global burden of eating disorders (EDs) is increasing and is highest in Western countries. Development and implementation of interventions successful in promoting mental health and preventing EDs in adolescents have been requested by researchers, professionals, and stakeholders for several years. However, among the few intervention studies using a randomized and controlled design, most are hampered by having a small sample size, a short follow-up period, and a lack of measures assessing muscular-oriented body image and disordered eating (DE). Inclusion of such measures has been suggested as important, especially for boys. There is limited knowledge about the use of muscle-building supplements and ED risk factors in adolescent boys and girls. Increased knowledge about the association between muscle-building supplement use and ED risk factors is needed to clarify whether prevention of muscle-building supplement use can be included within an ED prevention intervention. Additionally, knowledge about change mechanisms is important to understand which psychological factors are important to target within an intervention to facilitate a risk reduction or preventive effect. Such insight may be beneficial when developing or refining intervention programs in the future. Unfortunately, few studies have investigated mediators in universal ED prevention programs. The Healthy Body Image (HBI) intervention was developed to fill current research gaps and respond to methodological limitations from previous research.

Objectives: In the first paper, we aimed to identify adolescents' use of muscle-building supplements and explore whether such use was independently explained by ED risk factors, exercise, sport participation, and immigrant status in boys and girls. In the second paper, we investigated the immediate and 12-month effects of the HBI intervention on risk and protective factors for ED development and muscle-building supplement use in high school boys and girls. In Paper III, we explored potential mediators for the HBI intervention's effect on ED symptomatology and muscle-building supplement use in girls and boys.

Methods: The HBI intervention is a cluster-randomized controlled trial including 30 high schools in Oslo and Akershus counties. In total, 2,466 12^{th}-grade students (43% boys) were included in the study and randomly allocated to the HBI intervention or control group (classes as usual). The HBI intervention was comprised of three workshops targeting 1) body image, 2) (social) media literacy, and 3) lifestyle. Students were assessed at the baseline, posttest, and 3 and 12 months after the intervention. A Mann-Whitney U test and a chi-squared test were performed to determine whether muscle-building supplement use differed between participants of different genders or immigrant status while multiple hierarchical

regression analyses were performed to examine the baseline muscle-building supplement use and the association with ED risk factors, exercise, sport participation, and immigrant status. Furthermore, a mixed linear model was used to examine the effect of the intervention at all assessment points while conditional growth curve analyses were applied to investigate the indirect effects of the intervention on ED symptomatology and muscle-building supplement use.

Results: Paper I found that the use of muscle-building supplement use is more common among boys than among girls and is more common among immigrants than nonimmigrants. The use of muscle-building supplements was associated with ED risk factors and exercise and sport participation in boys but not in girls. Paper II revealed that the intervention had a lasting effect on all outcomes. Gender was a significant moderator in several outcomes, where girls benefited more in terms of psychological outcomes and only boys reduced their use of muscle-building supplements. Paper III revealed several indirect effects of the intervention in girls with respect to ED symptomatology. No indirect effects were observed in boys.

Conclusion: Prevention of muscle-building supplements is warranted, especially among boys. Moreover, the HBI intervention produced sustained effect in reducing risk and enhancing protective factors for ED development in boys and girls and prevented the use of muscle-building supplements in boys. However, girls tended to benefit more from the intervention than boys did. The study provides several potential mechanisms of change for ED symptomatology in girls. Several adjustments and modifications should be made to enhance the effect in boys such as including a male intervention deliverer, focusing more on creating a safe place for sharing, using digital intervention methods, and possibly expanding the intervention outside the classroom setting.

Sammendrag (summary in Norwegian)

Den globale konsekvensen av spiseforstyrrelser er økende, og konsekvensen er høyest i land i den vestlige verden. Utvikling og implementering av intervensjoner som er effektive i å fremme mental helse og forebygge spiseforstyrrelser har vært etterspurt i en årrekke. Blant de få intervensjonsstudiene som har benyttet et kausalt studiedesign er det dessverre mange som har få deltakere, kort oppfølgingstid og de er ingen som har inkludert utfallsmål som på muskelorientert kroppsbilde eller forstyrret spiseatferd. Å inkludere slike utfallsmål har blitt foreslått som viktig i intervensjoner som inkluderer gutter fordi gutter ofte har en annen måte enn jenter å uttrykke kroppsmisnøye, forstyrret spiseatferd og spiseforstyrrelser. I tillegg ser det ut til at kroppsidealene er i endring, hvor også flere jenter idealiserer atletiske, trente og muskuløse kropper. Kunnskapen om hvordan bruk av muskelbyggende kosttilskudd er assosiert med risikofaktorer for å utvikle spiseforstyrrelser er begrenset, og da spesielt for jenter hvor det ikke foreligger noen tidligere studier. Slik kunnskap er viktig for å kunne få klarhet i om forebygging av bruk av muskelbyggende kosttilskudd kan kombineres med forebygging av spiseforstyrrelser. I tillegg til å utvikle effektive forebyggende intervensjoner er det også et behov for å undersøke endringsmekanismer i intervensjoner. Dette er viktig for å få innsikt i hvilke psykologiske faktorer det er hensiktsmessig å endre for å få en effekt av intervensjonen. Slik kunnskap er også fordelaktig i arbeidet med å utvikle nye, eller forbedre eksisterende intervensjoner. Dessverre er det få studier som har undersøkt medierende faktorer i universelle intervensjoner. Prosjektet Sunn Kroppsopplevelse (HBI) ble utviklet for å fylle nevnte kunnskapshull og metodologiske begrensinger identifisert tidligere studier.

Hensikt: Den første artikkelen hadde til hensikt å identifisere hvor mange ungdommer som brukte muskelbyggende kosttilskudd og slankeprodukter, og å undersøke om bruk var uavhengig forklart av ulike risikofaktorer for spiseforstyrrelser, fysisk aktivitet, trening, idrettsdeltakelse og innvandrerstatus. I artikkel II ble effekten av intervensjonen på beskyttende- og risikofaktorer for spiseforstyrrelser og muskelbyggende kosttilskudd undersøkt. I den siste artikkelen undersøkte vi medierende faktorer for intervensjonens effekt på spiseforstyrrelsessymptomatologi og bruk av muskelbyggende kosttilskudd.

Metode: HBI intervensjonen er en klyngerandomisert kontrollert studie som inkluderte 30 videregående skoler i Oslo og (tidligere) Akershus. Alle skolene ble tilfeldig randomisert til enten HBI intervensjonen eller kontroller (undervisning som vanlig). Totalt ble 2,466 elever (43 % gutter) inkludert i studien. HBI intervensjonen består av tre workshoper som målrettet jobbet med flere ulike teamtikker. Hovedtemaer for de tre workshopene var 1) kroppsbilde, 2) kritisk medieforståelse og 3) livsstil. Elevene svarte på spørreskjemaer før intervensjonen,

rett etter intervensjonen og ved 3- og 12 måneder etter intervensjonen. Mann Whitney U test og Chi kvadrat test ble brukt for å sammenligne bruk av muskelbyggende kosttilskudd mellom kjønn og innvandrerstatus. Multippel hierarkisk regresjon ble brukt for å undersøke om bruk av muskelbyggende kosttilskudd var uavhengig relatert til ulike risiko- og beskyttende faktorer for utvikling av spiseforstyrrelser, fysisk aktivitet, trening, idrettsdeltakelse og innvandrerstatus. Lineære blandingsmodeller ble benyttet for å undersøke effekten av intervensjonen på ulike beskyttende- og risikofaktorer for spiseforstyrrelser og bruk av kosttilskudd ved alle måletidspunktene. Til slutt ble latent vekstkurvemodellering gjennomført for å undersøke ulike medierende faktorer for intervensjonens effekt på spiseforstyrrelsessymptomatologi og bruk av muskelbyggende kosttilskudd.

Resultater: Artikkel I viser at bruk av muskelbyggende kosttilskudd er vanlig, og at bruk er mer fremtredende hos gutter enn hos jenter og bland ungdommer med innvandrerbakgrunn. Videre var bruk av muskelbyggende tilskudd forklart av risikofaktorer for utvikling av spiseforstyrrelser, trening, idrettsdeltakelse og innvandrerstatus. Artikkel II viser at det var varige effekter av HBI intervensjonen på alle psykologiske beskyttende- og risikofaktorer for utvikling av spiseforstyrrelser, men at intervensjonen var mer effektiv blant jenter når det kom til de psykologiske utfallsmålene. Intervensjonen reduserte også bruk av muskelbyggende kosttilskudd blant guttene. Artikkel III viste at det er flere mulige endringsmekanismer for effekt på spiseforstyrrelsessymptomatologi hos jenter, men ingen medierende effekter var til stede hos gutter.

Konklusjon: Forebygging av bruk av muskelbyggende kosttilskudd er nødvendig, spesielt blant gutter. I tillegg viser studiene at HBI intervensjonen reduserte risiko for å utvikle spiseforstyrrelser hos gutter og jenter, og bruk av muskelbyggende tilskudd hos gutter. Dessverre hadde gutter hadde noe mindre effekt av intervensjonen enn jenter på flere utfallsmål. På bakgrunn av dette er det behov for å gjennomføre justeringer og forbedringer av intervensjonen for å øke effekten hos gutter. Dette kan f.eks. være å inkludere en mannlig intervensjonsformidler, ha et sterkere søkelys på å skape en trygg arena for deling av personlige tanker og følelser, inkludere digitale formidlingsmetoder og trekke intervensjonen ut av klasseromsettingen. Avslutningsvis ble det foreslått flere nye endringsmekanismer for spiseforstyrrelsessymptomatologi hos jenter.

Abbreviations

BMI	Body mass index
BIAAQ	Body image acceptance and action questionnaire
DE	Disordered eating
ED	Eating disorder
EDEQ	Eating disorder examination questionnaire
EDEQ-11	Abbreviated version of the EDEQ
HBI	Healthy Body Image

Nomenclature

Appearance ideal internalization: Appearance internalization captures to what degree an individual cognitively accepts appearance ideals promoted by society (i.e., family, peers, media) and uses them as personal standards (1).

Attitudes: Attitudes may be defined as "the general evaluations people hold in regard to themselves, other people, objects, and issues" (2). The general evaluations that create attitudes may be created and influenced by a variety of behavioral, affective, and cognitive processes (2).

Body image: Body image is a psychological construct embracing several dimensions of how the body is being experienced. Despite the fact that different researchers use a wide range of terms for the same psychological concept, there is an agreement that body image is a dynamic and multidimensional construct that unfolds differently influenced by context and time. As such, body image could be defined as "a dynamic and multi-dimensional self-perception of one's body" (3).

Disordered eating: Disordered eating (DE) is the experience of behavioral or psychological pathology related to eating. It captures all dimensions of eating symptomatology such as the use of unhealthy weight control behaviors (e.g., excessive exercise, binge eating, fasting, vomiting, and dieting supplement use) and increased levels of body dissatisfaction and weight and shape concerns. The DE construct is broad and captures individuals who experience a wide range of severe or less severe eating symptomatology (4). An individual may experience DE without having a clinical eating disorder (ED), but not the other way around.

Eating disorders: An ED is a group of mental disorders defined by the Diagnostic and Statistical Manual of Mental Disorders or the International Classification of Diseases. The most common EDs are binge eating, bulimia nervosa, and anorexia nervosa. Common features of EDs are abnormal eating habits, distortion in weight management, and overevaluation of body shape and weight leading to excessive weight and shape concerns (5). In addition to full syndrome EDs, individuals may also suffer from partial or subthreshold EDs. These are situations where some but not all diagnostic criteria are met. Suffering from a subthreshold ED may cause similar psychological distress and medical complications as suffering from a full-syndrome ED. Full-syndrome, partial, or subthreshold EDs are diagnosed with clinical interviews.

Eating disorder symptomatology: It this thesis, ED symptomatology is used as a construct to describe the degree or presence of overall ED symptoms assessed by different versions of the Eating Disorder Examination Questionnaire or similar measures.

Health promotion and illness prevention: Universal prevention initiatives of EDs aim to both influence determinants of mental health and reduce known risk factors for ED development (6). Universal prevention of EDs can therefore be understood as both health promotive and illness preventive. The two perspectives of health promotion and illness prevention are distinct but highly interrelated and overlapping. However, in research, they are often evaluated and treated as similar concepts (7, 8) where mental health promotion may be one pathway to preventing mental disorders (9).

Muscle-building supplement use: Muscle-building supplements are dietary supplements consumed to enhance muscularity by improving muscle definition by promoting leanness, increasing muscle size, or both. Such supplements may include protein supplements, creatine supplements, fat burners, and other sport supplements (10).

Risk reduction: Most universal ED prevention interventions are in reality risk reduction studies because they do not assess the true preventive effect on new ED cases with clinical interviews (11-13). Scholars in the field of EDs have challenged the use of the term "prevention" (12, 13). However, in this thesis, the term "ED prevention" is used as a common term for studies aiming to either prevent or reduce the risk of ED development by enhancing protective factors and reducing risk factors independent of the assessment of clinical EDs.

Universal prevention: Universal prevention refers to prevention initiatives in which all individuals belonging to the population studied are included independent of gender and risk status (14).

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Introduction

Study background

One core feature of a properly functioning society is citizens who are capable of giving more to the community than they consume. As such, one key societal task is to ensure that children and adolescents develop into healthy and happy adults. Up to 30% of the Norwegian young adult population suffers from a mental disorder (15), and previous estimates revealed that as much as half of the population in high- and middle-income countries will suffer from at least one mental disorder during their lifespan (16). Mental disorders are the leading cause of disability-adjusted life years in children and adolescents, and these disorders are predicted to become the dominating public health challenge of the 21st century in Western societies (17). Approximately 70% of all mental health problems (18) and 95% of all eating disorder (ED) cases (19) occur during adolescence or in the transition to adulthood. The adolescent years are a time period involving major physiological, psychological, and social change, making adolescents vulnerable to mental health problems. Therefore, preventing mental health issues during childhood and adolescence may reduce the burden of mental health issues (20). Implementing successful universal prevention programs targeting generic risk factors for several mental disorders are most likely to reduce the global probability of developing mental disorders (21).

The adolescent population is described as higher functioning and better academic achievers, and they use fewer drugs and drink less alcohol than previous generations (22). However, research findings reveal a longitudinal and secular increase in mental health problems in late adolescence (22), which may be related to difficulties in managing stress produced by performance and appearance pressure (23). Previous research reveals that up to 50% of the adolescent population can be characterized as having disordered eating (DE; 24-26), which puts them at risk for developing physiological and mental health problems such as EDs, depression, obesity, and other noncommunicable diseases (24, 27). The high prevalence of mental health issues and DE has raised the alarm and led to policy changes to improve adolescent mental health and reduce societal appearance pressure (28-30).

The eating disorder continuum and eating disorder symptomatology in adolescents

The development of EDs is often explained by a continuum ranging from body acceptance and healthy eating and lifestyle habits through DE and ED symptomatology to clinical EDs. Figure 1illustrates the ED continuum and includes muscularity manifestations of DE.

EDs such as anorexia nervosa, bulimia nervosa, and binge ED constitute a group of mental disorders characterized by abnormal eating habits, dysregulation of body weight, and excessive weight and shape concerns (5). The lifetime prevalence of EDs in the Western adolescent population is estimated to be between 4.5 and 5.7% in girls and 1.2 and 2.2% in boys (31-33). However, the number of adolescents experiencing partial or subthreshold EDs is considerably higher with a combined prevalence as high as 21 to 30% in girls (26, 34) and 5.5% in boys (35). A recent study reported a point prevalence of EDs of 12.8% in boys and 32.9% in girls (36). Studies assessing DE without using clinical interviews found prevalence rates of up to 30 to 50% in adolescents boys and girls (4, 25, 37). Importantly, the real prevalence rates of DE and EDs are most likely higher because there is a large risk of underreporting, especially in boys (38). Male expressions of eating symptomatology have been given more research attention in the past decade, challenging the traditional view of EDs being a rarity among males. Previous studies agree that EDs are more prevalent among females than males. However, more recent studies have revealed that this gap is closing as more males with DE and EDs are being recognized (39).

Unlike most other mental health issues, DE and EDs have a profound effect on physiological health, influencing all bodily systems (40). Additionally, metabolic consequences caused by abnormal eating habits, high energy intake, and inactivity increases the risk of weight gain, obesity, type 2 diabetes, and increased cardiometabolic risk (41), especially for nonrestrictive EDs such as bulimia nervosa and binge ED (42, 43). Moreover, it is estimated that 3.3 million healthy life years are lost worldwide due to EDs, with risk of premature death due to medical complications or suicide increased five to six times for individuals with anorexia nervosa and two times for those with bulimia nervosa or binge ED (44-47). The high impact of DE and EDs on mental and physiological health contributes the substantial global burden caused by EDs (5). The global burden caused by EDs has increased from 1990 to 2017, with the highest burden observed in Western European countries (5), which could be partially explained by an increased prevalence of EDs (33), possibly due to reduced stigma and increased recognition of EDs as treatment needed conditions (5).

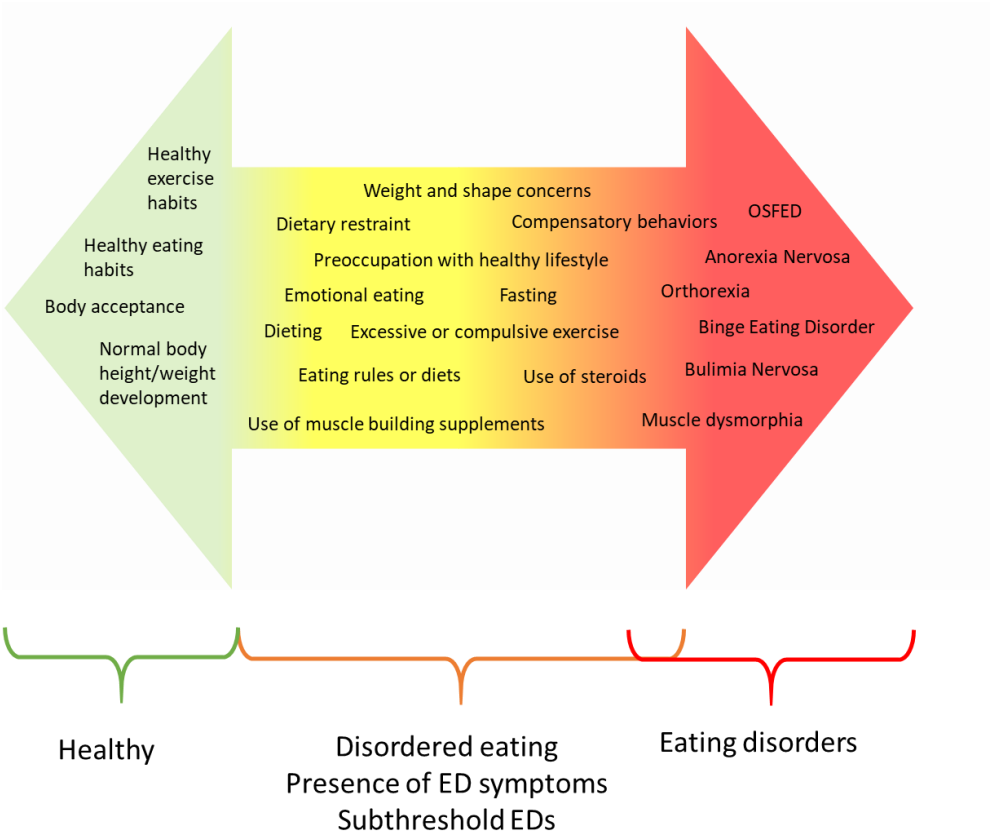

Figure 1. Eating disorder (ED) continuum in adolescents illustrating that eating habits exist on a continuum ranging from healthy through disordered eating and subthreshold EDs to EDs. The continuum also includes muscular-oriented expressions of disordered eating. Red and orange sections overlap to also capture unrecognized eating disorders. Own illustration based on Shisslak, Crago (48), Murray, Griffiths (49), and Lavender, Brown (50). OSFED = other specified feeding and eating disorders.

Risk and protective factors for eating disorder development

Several models have aimed to describe how body mass index (BMI) and social, cultural, and psychological factors relate to the development of body dissatisfaction, EDs, and the use of unhealthy methods to change appearance (51, 52) in adults (53-56), and adolescent girls (57, 58) and boys (57, 59). These models highlight several modifiable risk and protective factors for DE and ED development that could be targeted in intervention programs. Figure 2 presents a modified biopsychosocial model combining sociocultural, biological, psychological, and behavioral factors found to explain development of DE, EDs, and muscle-building behaviors. Specifically, the model includes how perceived appearance pressure, social media usage, and positive and negative affect are associated with appearance

internalization, social comparison, body dissatisfaction, symptoms of DE and EDs, and muscle-building behaviors. Body image flexibility has been incorporated into the model due to evidence suggesting that this construct as an important moderator between sociocultural factors and the development of body dissatisfaction and appearance change strategies (60-62). Finally, a possible influence of age (i.e., adolescence) and lifestyle has been included in this model. The roles of the respective risk factors are explained in more detail below.

Alongside psychological, social, and cultural risk factors, the inclusion of biological markers (e.g. genes, hormone status) and measures of pubertal development represent important paradigms in the area of risk factor research (63-66). The inclusions of biological markers and risk factors adds to the understanding of ED development (63).

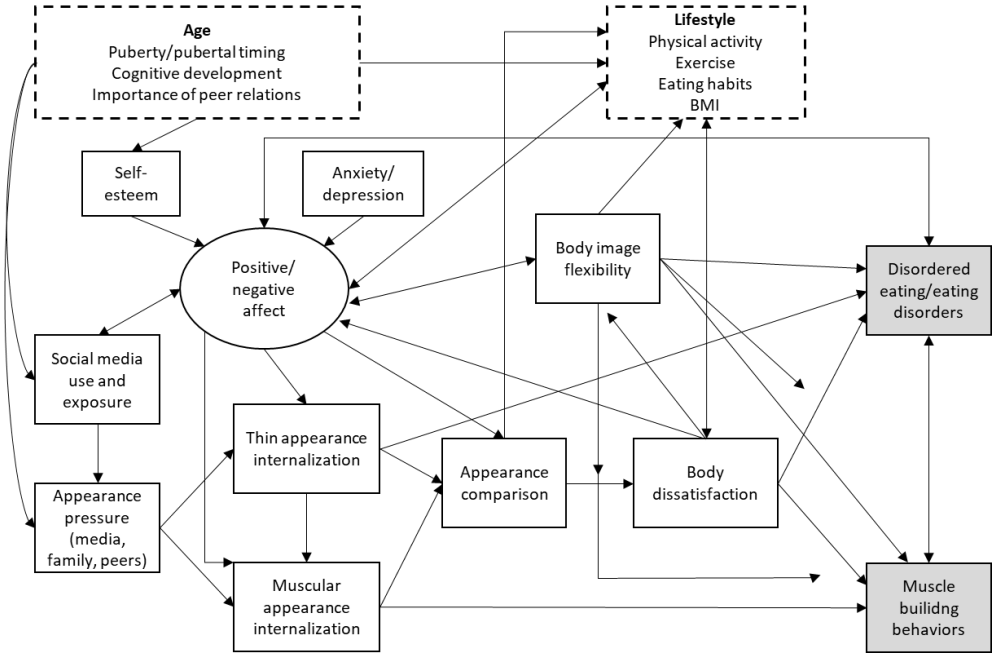

Figure 2. A modified biopsychosocial model of disordered eating, eating disorders, and muscle-building supplement use including the possible roles of age and lifestyle factors. Modified from Rodgers et al. (2012; 2014; 2020) and Girard, Chabrol (54) and including possible roles of body image flexibility, age, and lifestyle.

Adolescent development and body image

The physical and cognitive development during adolescence is greater than changes occurring during any other life stage except for infancy (67, 68). Changes during adolescence include both pubertal development and structural and functional changes in the brain, which cause major cognitive and social changes. The adolescent years are viewed as a vulnerable time period for the onset of mental health problems and ED development (69).

Puberty and pubertal timing

The bodily changes that occur during puberty influence adolescent self-perception and mental health. Bodily changes affecting body image in girls include increased fat mass and body weight, whereas for boys, pubertal change is accompanied by increased fat-free mass (70). These changes remove girls further from and bring boys closer to the idealized body (71). Therefore, it is not surprising that postpubertal boys experience more body satisfaction than their prepubertal or pubertal counterparts while girls develop greater body dissatisfaction (72). In addition, early pubertal timing in girls and late pubertal timing in boys are considered risk factors for body image issues, DE, and EDs in adolescence (65, 66, 72). Higher levels of circulating testosterone could act as a protective factor for DE and ED development in males during or after puberty and may contribute to the explanation of why few males develop a clinical ED (73). In contrast, the increased risk of DE and ED in adolescent girls may be accelerated by puberty due to changes in genetic factors in pubertal girls (74), where genetic influences explain 0% of the variability in DE before puberty and as much as 50% during and after puberty (74-76). Thus, there is agreement that inerrability and biology play a role in ED development; however, the size of this contribution is unclear due to methodological limitations (77). Nevertheless, puberty accompanied by physiological and biological changes together with increased social comparison, a growing social milieu, and the process of finding one's place in society makes the adolescent years a vulnerable period for body image development and the development of DE and EDs, especially in girls (78, 79).

Brain and psychosocial development

The adolescent years are known as a central time period of identity and self-perception development, which processes are facilitated and influenced by social and cultural factors (80). Social and psychological development during adolescence is determined by rapid changes and developments in the brain. During childhood, children develop their self-perception and an awareness of themselves as individuals. As children age and enter adolescence, the part of the brain responsible for social cognition undergoes structural and functional developments, creating major psychosocial changes. During this time period, children develop their self-concept as they increase their understanding of others', they become more self-conscious, and peer relationships become more important and complex (81). However, the different parts of the brain responsible for unique cognitive tasks do not develop simultaneously, which results in a cognitive gap between the desire for social acceptance, maintenance of self-concept, and capacity to evaluate risk. As such, fear of negative evaluation from their peers may dispose adolescents to increased weight and shape

concerns and to engage in DE or muscle-enhancing behaviors to avoid social rejection (81, 82) or because the social context of peers enhances the desire to engage in risk-taking behaviors to gain social acceptance (83).

Body dissatisfaction and weight and shape concerns

The prevalence of body dissatisfaction varies considerably due to different conceptualizations and measurements. Body dissatisfaction is highly prevalent in the adolescent population. Studies from the past decade reveal that 15 to 21% of boys and 31 to 50% of girls in Norway are dissatisfied with their appearance or body weight (25, 84). In other Western countries, body dissatisfaction is found to affect 12.7 to 55% and 37 to 80.8% of adolescent boys and girls, respectively (85-87).

The prevalence of body dissatisfaction increases throughout adolescence, which is mostly explained by increase in body weight. However, different development trajectories have different predictors, where self-esteem, depressive symptoms, parental and peer influences, and teasing predict different development patterns (87). Body dissatisfaction, especially weight and shape concerns, are considered the most proximal and strongest prospective risk factors for ED development (76). Moreover, weight and shape concerns are central features across ED diagnoses (76, 88, 89). In addition, body dissatisfaction, weight and shape concerns, or low body satisfaction in adolescence predicts several other negative health consequences and developmental trajectories from adolescent to adulthood, including weight gain (28, 90, 91), obesity and low physical activity level (92-94), lower perceived health (28), reduced self-esteem (28, 95), depression (95), and suicidal thoughts (96). Furthermore, poor body image predicts smoking in girls and boys and drug use, high-risk alcohol consumption, and self-harm in girls (97). Therefore, adolescents' experience of body dissatisfaction and weight and shape concerns may be considered a generic risk factor crucial to target when aiming to promote adolescent health and prevent mental illness and problematic behaviors later in life (28).

Appearance ideals and social influence

It is well known that while girls generally experience the idealization of a thin and slender appearance and a drive for thinness, boys are more prone to internalize a muscular and athletic ideal (98) and have a higher drive for muscularity (99). Internalizing a thin appearance ideal is an established sociocultural risk factor for ED development (88). Recent knowledge also suggest that thin internalization is one of the early risk factors experienced by almost half of the girls who later developed threshold or subthreshold bulimia nervosa or binge ED. The experience of thin appearance ideal internalization also emerges early and

before high levels of negative affect and body dissatisfaction (100). The relationship between appearance internalization and health outcomes is not fully understood. Some studies investigating muscular and athletic appearance internalization and drive for leanness conclude that these outcomes are less associated with measures of DE or EDs in females compared to males because the muscular and athletic ideal is less relevant for females (98, 101) and that striving for a lean body appearance is less maladaptive than experiencing a high drive for a thin or muscular appearance alone (102). However, there are reasons to believe that appearance ideals have shifted during the past decade, with a muscular body with low body fat to achieve muscle definition and leanness being idealized for both boys and girls (103, 104) with potential negative mental health and ED outcomes (104, 105).

Body image and social media

Several models describing body image and EDs have been developed using a sociocultural theory. These models highlight three domains of social influence acting as precursors for appearance internalization and social comparison: peers, family, and media (53-56, 59). Social media networking sites (social media) have grown drastically in the past decade, enabling a constant flow of idealized images and messages communicating what appearance is the most desirable. Almost 90% of adolescents report being online almost constantly (106). This growth makes social media an important arena for social influence and comparison that transmit societal messages of appearance. This recognition has resulted in a growing interest in how use relates to and affect adolescents' mental health, body image, and risk of DE and ED development (57). Type, duration, and frequency of social media exposure have been linked to negative health outcomes. First, social media have been identified as an important source of unhealthy lifestyle and fitness inspiration since "influencers" often promote physical fitness through extreme diet and exercise regimes (103, 107-109) where the use of muscle-building supplements is often portrayed as a necessity to achieve leanness and muscularity (110). These fit and lean appearance ideals are falsely portrayed as being healthier than the more traditional thin and slender ideals (104, 105, 111-113). Second, studies have concluded that more time spent on and more frequent use of social media negatively affect different mental health outcomes such as anxiety (114), depression (115), appearance internalization (116), body image (116, 117), and ED symptoms (117, 118). Other aspects of social media usage potentially influencing and affecting body image and mental health are the occurrence of bullying (119, 120) and social comparison related to aspects other than appearance (121) including striving for more likes, positive social feedback, and feelings of loneliness (122-125). However, the findings on the association

between social media and mental health are conflicting since one should consider types of social media usage (problematic versus nonproblematic, time versus type of exposure, etc.), several developmental trajectories, and individual differences in personality when evaluating how social media affects mental health (126-128). For example, a study by Steinsbekk, Wichstrøm (129) found that following, liking, and commenting on others' activity rather than self-oriented use on social media negatively predicted self-esteem in girls but not in boys. Furthermore, being a passive observer on social media without the social interaction may have a more negative impact on appearance self-esteem than social media usage focusing on social interaction (130). Importantly, it seems that social media usage has a stronger negative impact on girls than on boys (129, 130).

Self-esteem

One definition of global self-esteem is "the positivity of the person's self-evaluation" (131). Global self-esteem comprises several self-concept domains (132) and is considered both a state and a trait characteristic (133). Trait characteristics of global self-esteem are more stable and less affected by stressful life events than state self-esteem (134). It is estimated that approximately 70 to 85% of the variance in global self-esteem is accounted for by trait factors, and up to 30% of the variance is explained by state characteristics (133, 135).

Self-esteem gradually increases up to late childhood before it decreases among girls during adolescence (134, 136). During the transition to adulthood, self-esteem increases and reaches a long peak during late adulthood before it decreases substantially during older age (136). Self-esteem is found to be a predictor of central life outcomes such as quality of life, life satisfaction, education, and occupational success (132, 137) as well as both mental and physical health. More specifically, low self-esteem is a universal risk factor for ED development (138) and together with negative affect (symptoms of anxiety and depression) is a mediator between body dissatisfaction and DE in adolescent girls (139).

Some domains of self-esteem may be especially important for global self-esteem in different developmental stages from childhood to adulthood. A study by von Soest, Wichstrøm (132) examined domain-specific self-esteem and its relationship with global self-esteem in children, adolescents, and young adults using a longitudinal design. The researchers found that appearance-self-esteem became more important for maintaining global self-esteem in adolescence. Moreover, social self-esteem had an increased influence on global self-esteem with age. This suggests that interventions successful in improving body image and peer relationships could potentially have an impact on global self-esteem in adolescents.

Body image flexibility

Body image flexibility has branched out from the broader concept of psychological flexibility and is a psychological construct within the field of positive psychology (140, 141). Body image flexibility is considered an important part of positive body image (142). Body image flexibility is the ability to openly experience and accept negative and stressful events challenging body image without compromising chosen values (141). Furthermore, body image flexibility reflects an individual's ability to constructively cope with stressful life events and not engage in DE behaviors (140).

Body image flexibility is not widely studied in adolescents in general. Body image flexibility is found to protect adolescent girls from developing body dissatisfaction after internalizing societal appearance ideals (143). Additionally, experiencing higher body image flexibility may act as a protective factor against mental distress caused by body dissatisfaction in young adult men and women (144). Moreover, body image flexibility acts as an mediator between negative and positive affect (61) and appearance comparison (145) and ED symptomatology. Furthermore, body image flexibility may act as a mediator (62) and moderator (146) between ED cognitions and ED behaviors, indicating that individuals with high body image flexibility may experience ED cognitions without engaging in ED behaviors. Importantly, there is evidence that body image flexibility could be an important component in the ability to maintain a positive body image while experiencing body dissatisfaction (147). A large body of evidence suggests that body image flexibility is susceptible to change through psychological interventions (140). Previous scholars have advised that body image flexibility should be targeted as a mechanism of change in ED prevention interventions (62). However, only one universal school-based intervention study has included body image flexibility as an outcome measure (148). Moreover, it has been recommended that the relationship between body image flexibility and other psychological contracts should be examined using a causal design (140).

Negative affect

Negative affect is an umbrella term used to summarize the feeling of emotional distress and incorporates a broad spectrum of unpleasant emotions such as depression, anxiety, fear, irritability, shame, and guilt (149, 150), or more broadly, the experience of sadness (151). Scholars disagree about the direction of the relationship between different measures of negative affect and (risk of) ED development or body dissatisfaction. Some have argued that emotional distress predicts future ED onset (152) or acts as a mediator between body

dissatisfaction and ED symptoms (139, 153). Moreover, depressive symptoms may also predict lasting high body dissatisfaction (87). However, research suggests that the relationship between negative affect and EDs or ED symptomatology are bidirectional (100). Nevertheless, negative affect, either defined as mental distress, anxiety, depression, or symptoms of such, is related, tends to co-occur in individuals with EDs (154), and predicts ED severity over time (155).

Lifestyle, body image, and eating disorder development

Weight status

Several factors may cause or contribute to abnormal weight development during childhood and adolescence. Genetic inheritance may put children in different body weight and adiposity developmental trajectories (156, 157). Moreover, parental eating and feeding habits and children's maternal attachment act as important influences that may predict weight status and eating behaviors later in life (158-160). Independent of initial cause, studies suggest that it is likely that the relationship between weight status and mental health is bidirectional (161, 162). Thus, higher BMI has a negative impact on mental health over time. Furthermore, mental health problems may contribute to continued weight gain due to unfavorable eating habits, physical inactivity, and medications. Additionally, individuals may also be influenced by genetic factors disposing them to both weight gain and mental disorders (163). In relation to EDs, premorbid BMI during childhood is found to predict later development of both restrictive and nonrestrictive EDs (164, 165). Moreover, DE behaviors tend to track over time and increase the risk of more rapid weight gain in girls (41). Independent of the causal direction, having a very low BMI in adolescent boys and a higher BMI in boys and girls is associated with an increase in ED symptomatology (166). This may have several explanations. Being overweight is associated with negative social sanctions and often described in relationship with less desirable personal characteristics such as being lazy and lacking willpower and discipline (167, 168). Such stigma may inflict feelings of shame and guilt and negatively impact mental health (168, 169). In addition, the experience of being far from the culturally idealized appearance standard may result in more negative appearance comparisons, higher body dissatisfaction, and a higher risk of engaging in muscle-building behaviors and ED development (54, 170, 171).

Physical activity and exercise

Physical activity and exercise are positively related to body image through the mechanisms of enhanced self-esteem, mastery, and self-efficacy (172-174). In addition, exercise may influence several mechanisms that may act as risk or protective factors for EDs such as

influencing body weight and body composition, reduced symptoms of anxiety, depression, and stress, and enhanced self-esteem, positive affect, social support, and overall quality of life (175). There are several potential mechanisms explaining how exercise influences brain physiology and how such influence may improve mental health. For example, exercise increases the excretion of endorphins and important neurotransmitters (i.e., serotonin, noradrenalin, and dopamine), which may reduce symptoms of anxiety and depression (174). Moreover, aerobic exercise may improve neuroplasticity due to increased mitochondrial genesis increasing mitochondrial number, and improved oxygen utilization capacity may enhance mood (174, 176, 177). Exercise is also likely to enhance learning and memory and reduce stress-related disorders such as anxiety and depression by increasing the protein kinase mammalian target of rapamycin in several parts of the brain (178-180). Disturbances in the hypothalamic–pituitary–adrenal (HPA) axis function may cause increased or reduced production of cortisol and other hormones influencing stress and energy metabolism. Exercise is found to improve the function of the HPA-axis and reduce the HPA response to stress. Dysfunction and hyperreactivity of the HPA-axis are especially present among individuals with anxiety and depression (174).

However, several aspects of physical activity and exercise are important in relation to body image and EDs, such as type, context, and motives for exercise. While there is strong evidence of the effect of physical activity and exercise on mental health, important psychological mediators and moderators may exist. Research suggests that the positive effect of physical activity and exercise on body image and ED risk is only or more present among individuals with less appearance-based motives for exercise and lower exercise dependence and among individuals who experience intrinsic motives for exercise (175, 181, 182).

Moreover, exercise context and competitive sport participation may influence the positive relationship between exercise and mental health and body image. Participating in exercise contexts that emphasize appearance or body weight may increase appearance internalization and appearance comparison and result in increased body dissatisfaction, which may increase the risk of ED development. The fitness center context has been identified as a potential arena acting as a source of appearance pressure (183). Moreover, engaging in weight-sensitive sports is known to act as a major risk factor for ED development (184). Weight-sensitive sports may be classified into three categories: 1) weight class sports where participants compete in predefined weight categories and being at the highest possible weight within the weight category represents a competitive advantage (e.g., wrestling, rowing, sailing, boxing),

2) aesthetic sports where performance is determined by appearance and aesthetic presentation (e.g., diving, gymnastics, equestrian dressage), and 3) gravitational sports where performance is heavily reliant on forward locomotion or air time and thus favors low body weight (e.g., long-distance running, cross-country skiing, horse racing and jumping, ski jumping). In addition, early sport specialization, injuries, and sexual harassment or inappropriate interpersonal behavior can be additional risk factors for ED development that are highly relevant among athletes (185-188).

Muscle-building supplement use in the context of body image and eating disorders

Adolescents use a wide range of methods to change or enhance their appearance. Several are recognized as DE behaviors, such as fasting, excessive exercise, using dieting pills, and vomiting (4). Another group of products often used by adolescents are muscle-building supplements. Adolescents' use of muscle-building supplements is often motivated by a belief that it may improve muscle growth, appearance, and sport or exercise performance (189, 190). Supplements, which are often consumed to increase muscle size or tone, are protein and creatine supplements, sport bars and drinks, energy drinks, and various types of vitamins (191, 192), while supplements to aid weight and fat loss to achieve muscle definition include dieting pills, dieting supplements, fat burners, and herbal products (192). Some adolescents also start using drugs and medication to change their weight or shape, such as diuretics, laxatives, stimulants, and different types of androgenic steroids (10, 193, 194).

For many, the use of muscle-building supplements may seem like a shortcut in the mission of acquiring the ideal appearance. Therefore, it is not surprising that the use of muscle-building supplements is associated with higher muscle-oriented body dissatisfaction in boys (191) and weight reduction and muscle-building behaviors in both girls and boys (195). In addition, young male and female users of ergogenic supplements (i.e., creatine supplements) experience higher dietary restraint, eating concerns, and body weight and shape concerns (196), putting them at increased risk for EDs. Adolescent use of sport supplements is not recommended (197). Properly administered use of noncontaminated protein or creatine supplements in experimental studies has not been linked to health risks in adults (198). Nevertheless, research findings suggest that the use of such supplements in a nonexperimental setting is related to several negative health outcomes in adolescents (199, 200) that may be partially related to a high proportion of contaminated products (201) leading to severe and unintended health consequences (202, 203). In addition, use may also act as a

gateway to future steroid use (204, 205). Thus, adolescents should not use supplements to enhance performance or appearance (197).

Prevalence of muscle-building supplement use

Various conceptualizations of supplement use across studies complicate the determination of prevalence of use. Studies report that adolescent girls consume considerably less muscle-building supplements than adolescent boys do. However, the scientific evidence regarding girls' use is scarce. Previous studies on muscle-building supplement use involving adolescents in the general population found a lifetime or 12-month prevalence of protein supplement use of between 29 and 50% in boys (191, 206-208) while 6.3% and 16 to 25% of boys may be frequent or current users, respectively (189, 191, 208). In comparison, previous studies report a lifetime or 12-month prevalence of protein supplement use of 2 to 20% among adolescents (203, 208). Thus, 2% and 9% of the users could be considered more frequent or current users, respectively (189, 208). Meanwhile, the estimated overall proportion of general adolescents currently or previously using creatine supplements varies from 0.6 to 22.2% in boys and 0.6 to 3% in girls (198, 203, 206, 209).

Universal and school-based prevention of eating disorders in adolescents

The field of ED prevention has grown in the past 30 years, expanding the available knowledge about successive prevention strategies. Most often, universal prevention of EDs does not yield large effect sizes in reducing risk factors or enhancing protective factors (6). This issue is mainly related to the nature of universal prevention where the target population is mainly healthy participants with less room for improvement than in targeted or indicated prevention programs. Nevertheless, the results from a wide range of universal prevention programs are promising (6, 210).

Furthermore, universal prevention of EDs includes features from both universal health promotion and disease prevention because individuals are included regardless of their baseline risk status. Most participants have a low level of baseline ED risk and would probably never develop an ED independent of participation in the intervention. However, enhancing protective factors and reducing risk factors could be health promotive. Furthermore, for individuals with elevated baseline risk, the same positive development in risk and protective factors could act as both preventive and health promotive.

Table 1 summarizes studies from the past two decades that aimed to prevent EDs or promote body image in a universal, school-based, and coeducational setting by applying a randomized and controlled design.

Table 1. Summary of universal, school-based, and co-educational eating disorder prevention studies applying a randomized controlled design between 2000 and 2021

Author	Sample (boys/girls)	Intervention and delivery		Theory	Follow-up	Body image	ED symptomatology	Internalization/ pressure	Self-esteem	Mental distress
O'Dea and Abraham (211)	Age 13.0 (11-14) y N:470 (173/297) Australia	Self-esteem (everybody's different). 9 x 50-80 min sessions Classroom based, teacher led, psychoeducational + interactive elements homework		Educational theory (cooperative, interactive, and student-centered learning	3	↔ BD	↓ Drive for thinness girls (LFU) ↔Dieting		↑ Athletic competence	↔ Anxiety ↔Depression
Dalle Grave, De Luca (212)	Age: 11.6 (11.12) y N: 106 (45/61) Italy	ML + nutrition 6 sessions + 2 booster sessions Classroom based, Psychoeducational + interactive elements. Homework		Cognitive behavioral theory	12	↔ WSC	↓ Eating concern ↓ EAT (LFU) ↔ EDEQ			
Wade, Davidson (213)	Age: 13.4y N: 86 (53/33) Australia	ML (go girls)	5 x 50 min sessions. Classroom based teacher led (male) Psychoeducational + interactive elements		3	↓ WSC ↔ BD	↔ Dietary restraint		↑ Close friendships ↓ Behavioral conduct	
		Self-esteem (everybody's different)				↔ WSC ↔ BD	↔ Dietary restraint		↓ Scholastic competence	
Ghaderi, Mårtensson (214)	Age: 11-13y N: 164 (77/87) Sweden	Self-esteem (everybody's different) 9 x 50-80 min sessions Classroom based, teacher led. Psychoeducational + interactive, homework			post	↔ WSC ↔ BD	↔ EAT			↔ Anxiety ↔Depression
Mccabe, Ricciardelli (215)	Age:10.2 (8-13) y N: 368 (195/173) Australia	Self-esteem and physical activity (ACE-Kids) 8 sessions, class/school based, teacher led. Psychoeducational + physical activity + interactive elements			post	↔ BD				↓ Negative affect boys ↑ Positive affect boys
Wilksch and Wade (216)	Age: 13.6y N: 540 (267/273) Australia	ML (media smart) 8 x 50 min Classroom based, researcher led (male). Psychoeducational + interactive elements		DPBB Inoculation theory	30	↓ WSC (LFU boys) ↓ BD (LFU boys)		↔ Internalization ↔ Pressure	↑ Boys (LFU)	↔Depression
Gonzalez, Penelo (217)	Age: 13.5y N: 443 (189/254) Spain	ML 2 x 90 min + 2 x 60 min.	Classroom based, professional led. Psychoeducational, interactive and practical activism	Social-cognitive theory	30		↓ EAT	↓ Impact of idealized appearances		
		ML + nutrition 3 x 90 min + 2 x 60 min					↓ EAT	↓ Impact of idealized appearances		

Table 1 continued

Author	Sample (boys/girls)	Intervention and delivery		Theories	Follow-up	Body image	ED symptomatology	Internalization/ pressure	Self-esteem	Mental distress
Wilksch (218)	Age: 12.4y N: 51 (24/21) Australia	ML (media smart) 8 x 50 min Classroom based, teacher led. Psychoeducational and interactive		DPBB Inoculation theory	6	↔ WSC ↔ BD	↔ Dietary restraint	↔ Internalization	↔	↔ Depression
Bird, Halliwell (219)	Age: 10.4 (10-11) y N: 88 (46/42) UK	ML (happy being me) 3 x 60 min Classroom based, research led, psychoeducational and interactive		Etiologic theory	3	↑ BS girls	↓ Dietary restraint ↓ Emotional eating girls (LFU)	↓ Internalization boys (LFU	↔	
Wilksch and Wade (220)	Age: 12.7y N: 114 (63/51) Australia	Lifestyle (life smart) 8 x 50 min. Classroom based; researcher led (male). Psychoeducational + interactive elements		DPBB Inoculation theory	Post	↓ WSC girls ↓ BD girls	↔ Dieting	↔ Internalization		↔ Depression
Wilksch, Paxton (221)	Age: 13.2y N: 1316 (476/840) Australia	ML (Media smart)	8 x 50 min. Classroom based, Student led. Psychoeducational and interactive	DPBB Inoculation theory	12	↔ WSC ↓ BD boys (LFU)	↔ Dieting ↔ Eating concern	↔ Internalization ↔ Pressure		↔ Depression
		Lifestyle (Life smart)				↑ WSC girls ↓ BD boys (LFU)	↑ Eating concern girls ↔ Dieting	↑ Pressure girls (LFU)		↓ Depression boys
		ML (HELPP)				↔ WSC ↔ BD	↔ Dieting ↔ Eating concern	↓ Internalization boys (LFU) ↔ Pressure		↔ Depression
Mora, Penelo (222)	Age: 13.4 (12-15) y N: 200 (100/100) Spain	ML + nutrition (Model Female Aesthetic)	10 x 120 min. Classroom based, researcher led. Active education and psychoeducational	Social-cognitive theory	13	↔ BD	↔ EAT ↔ SCOFF	↓ internalization ↔ Pressure	↑	
		Theatre alive				↔ BD	↔ EAT ↔ SCOFF	↓ Internalization (LFU)		
Johnson, Burke (223)	Age 13.6y N: 308 (161/147) Australia	Mindfulness (.be “dot be”) 8 x 35-60 min. Classroom based, professional led. Activities/exercises + homework		Mindfulness-based cognitive therapy.	3	↔ WSC				↑ Anxiety boys ↔ Depression
Gumz, Weigel (224)	Age: 14.5y N: 1452 (808/644) Germany	ML + body image + nutrition + ED educational. 3 x 90 min professional led Stationary, couple delivery. Psychoeducational and interactive		Theory of cognitive dissonance	6		↔ EDEQ	↔Internalization ↑ Pressure (LFU)	↔	↓ Anxiety (LFU) ↔ Depression

Table 1 continued

Author	Sample (boys/girls)	Intervention and delivery	Theory	Follow-up*	Body image	ED symptomatology	Internalization/ pressure	Self-esteem	Mental distress
Agam-Bitton, Abu Ahmad (225)	Age:13.8 (13-15) y N: 171. Assessed only girls. Israel	Self-esteem and ML ("In favor of myself") 9 x 90 min Classroom based, undergraduates/graduate students led. Psychoeducational + interactive elements		3	↔ BD ↑ BS	↔ Drive for thinness	↓ Pressure ↑ Literacy	↓ (LFU)	
Eickman, Betts (148)	Age: grade 11-13 (~ 16-19y) N: 57 (8/41) USA	Body image + ML + nutrition + self-esteem + activism (ReBel) 6 modules delivered over 7 months Classroom/school environment based, peer led Psychoeducational + interactive + practical activism	Bolder model, Positive youth development framework, Theory of cognitive dissonance	post	↓ WSC ↓ BD	↓ EDEQ ↑ Mindful eating	↓ internalization and pressure	↑	↓Negative affect ↑ Positive affect
Warschburger and Zitzmann (226)	Age: 13.0 (10-16) y N: 1113 (514/599 Germany	Body image + ML + nutrition + self-esteem (POPS program) 9 x 45 min Classroom based, teacher led. Psychoeducational + interactive elements. Homebased activities.	Life skills approach, Biopsychosocial model of disordered eating	12	↓ BD (LFU)	↓ EAT girls ↓ Drive for thinness girls	↓ Internalization girls ↓ Pressure		
Jordana Ovejero, Espinoza Guzmán (227)	Age: 14.6y N: 224 (114/110) Spain	ML + lifestyle emotional intelligence + beauty activism. 8 x 50 min Classroom based, and research led. Psychoeducational + interactive elements	Social cognitive and feministic theory	12	↑ BS	↔ EAT	↔ Thin internalization ↔ Muscular internalization ↔ Pressure ↔ Media literacy		
Diedrichs, Atkinson (228)	Age: 11.7 (11-13) y N: 1495 (768/727) UK	ML and self-esteem, Dove confident me (based on Happy being me) 5 x 45 min Classroom based, teacher led. Psychoeducational + interactive elements	Etiologic theory.	36	↑ BS (LFU)	↔ Dietary restraint	↔ Internalization ↔ Pressure and impact	↑ (LFU)	
Garbett, Lewis-Smith (229)	Age 11.9 (11-12) y N: 166 (100/66) India	ML and self-esteem, Dove confident me (based on Happy being me) 5 x 45 min Classroom based, teacher led. Psychoeducational + interactive elements	Etiologic theory.	2	BS ↑	↔ EDEQ	↔ Internalization	↔	↑ Positive affect

y = years, N = sample size, ML = media literacy, ED = eating disorder, DPBB = Dual Pathway of Bulimic Behavior, BD = body dissatisfaction, WSC = Weight and Shape Concerns, BS = body satisfaction, EDEQ = Eating Disorder Examination Questionnaire, EAT = Eating Attitudes Test, SCOFF = Sick, Control, One, Fat, Food questionnaire, LFU = lost to follow-up, ↓ = reduced score relative to control group, ↑ = increased score relative to control group, ↔ no change in score relative to control group *months

Study characteristics

Australia was the country with the most published studies with eight studies published between 2000 and 2016 (211, 215, 216, 218, 220, 221, 223). Other studies were conducted in Spain (217, 222, 227), the United Kingdom (219, 228), Germany (226), Italy (212), Sweden (214), India (229), and Israel (225). The number of participants varied considerably from 51 to 100 (148, 213, 218, 219) up to 1,300 to 1,500 (221, 224, 228). The ages of included participants ranged from 8 to 16 years where none of the studies had a mean age below 10 years. Most intervention programs were conducted in secondary schools and included participants with a mean age between 11 and 14 years (211-214, 216-218, 220-223, 225, 226, 228, 229), while only one study was performed with high school students (148).

Types of interventions

All studies aimed to prevent EDs or body dissatisfaction and targeted psychological, cultural, or social risk factors such as appearance internalization, perceived media pressure, peer influence, teasing, perfectionism, negative or positive affect, and BMI and lifestyle. Most studies used a media literacy approach either alone or in combination with either a self-esteem and/or nutrition and lifestyle approach. In total, eight "pure" media literacy interventions were performed in six studies, such as the Media-Smart program (216, 218, 221), Happy Being Me or a similar program (219, 221), the Go Girls! program (213), or the "Eating, feminine, aesthetic beauty model and the mass media: How to train critical students in secondary schools" (Model Female Aesthetic) program (217). The Everybody's Different program was the only pure self-esteem program tested in three interventions (211, 213, 214); however, six other multicomponent interventions included self-esteem as an approach (148, 215, 225, 226, 228, 229). The Life-Smart program was the only program that uses a lifestyle approach alone (220, 221); however, a lifestyle or nutritional approach was implemented in six other multicomponent interventions (148, 217, 222, 224, 226, 227). Three programs included active education and included a physical activity (215), mindfulness (223), or drama approach (222) while only one used a cognitive behavioral approach (212). The majority of programs were multicomponent, meaning they used several approaches within an intervention. These included the Dove Confident Me (228, 229), POtsdam Prevention at Schools (226), In Favor of Myself (225), ReBel (148), and Model Female Aesthetic (217, 222) programs. Three studies tested the effect of two types of interventions (213, 217, 222), while Wilksch, Paxton (221) compared the effects of three different interventions to a control group.

Intervention framework

All of the studies described their interventions in detail and argued for the development of the interventions with reference to scientific knowledge. Most of the studies used one or several theoretical frameworks or models as a foundation for their interventions, while only six studies report applying a specific theory for intervention delivery (148, 211, 216, 218, 220, 221, 224).

Delivery

All studies were school based and delivered within a school or classroom setting. Three interventions were delivered using active education (215, 222, 223). Most of the interventions were delivered by trained teachers (211, 213-215, 218, 226, 228, 229), researchers within the field (216, 219, 220, 222, 227), or graduate or postgraduate students in relevant fields of study (221, 225). Only one study was peer led (148), and one did not report the type of facilitator (212).

Follow-up

Only four studies did not include follow-up assessments (148, 214, 215, 220), while eight studies included a 12-month or longer follow-up (212, 216, 217, 221, 222, 226-228).

Outcome measures

Eating disorder symptomatology

The majority of studies also included measures of ED symptomatology or behaviors using validated measures such as different versions of the ED Examination Questionnaire (EDEQ; 230-232); ED Inventory (EDI; 233); Three-Factor Eating Questionnaire (234); Eating Attitudes Test ((235-237); Sick, Control, One, Fat, Food questionnaire (238); or Dutch Eating Behavior Questionnaire (239).

Weight and shape concerns and body image

Most of the studies used several outcome measures to conceptualize ED risk and protective factors. All studies but two (217, 224) included measures of body image such as weight and shape concerns, body dissatisfaction, or body satisfaction. Instruments used for assessing body image were weight and shape concerns measured by the EDEQ or Killen's scale (232, 240), EDI body dissatisfaction subscale (233), figural rating instruments (241, 242), or the Body Image Body Checking Questionnaire (243). Only one study (215) used single items to assess body dissatisfaction (244), while measures of body satisfaction were the Body Esteem Scale for Adolescents and Adults (245) or the Body Satisfaction Visual Analog Scale (246).

Other risk and protective factors

Sociocultural attitudes and impact on body image were measured in 14 studies by different versions of the Sociocultural Attitudes Towards Appearance Questionnaire (98, 247, 248) and the Questionnaire on Influences of Aesthetic Body Ideal (249, 250). These instruments measure the degree of appearance ideal internalization and sources of appearance pressure and how these influence body image.

Dimensions of self-esteem or global self-esteem were measured in 11 studies using four different instruments: the BECK Self-Concept Inventory (251), the Self-Perception Profile for Adolescents (252), the Rosenberg Self-Esteem Scale (253), or the Single-Item Self-Esteem Scale (254). Depression and anxiety, often conceptualized as positive and negative affect, were measured with a wide range of validated instruments: the Depression Inventory (255), Depression Patient Health Questionnaire-9 (256), Generalized Anxiety Disorder Scale-7 (257), the Children's Depression Inventory (258), the Positive and Negative Affect Schedule for Children (259), the Depression Anxiety Stress Scale Short Form (260), the State-Trait Anxiety Inventory (261), the Multidimensional Anxiety Scale for Children (262), and the Trait Scale of Emotional-States Meta-Knowledge (263).

Main findings from eating disorder prevention interventions

Most interventions except those from five programs (213, 214, 216, 218, 223) improved at least one of the outcomes measured, while some programs had unfavorable outcomes such as the increased weight and shape concerns, eating concerns, and thin internalization observed among girls in the Life-Smart program (221); the poor Everybody's Different program outcomes with regard to self-esteem (213); and increased anxiety among boys who participated in the mindfulness program (223).

Among the eight studies, when examining the effect of 10 interventions with a long follow-up period (≥ 12 months), only three interventions showed improvements in ED symptomatology (212, 217, 226). However, the two interventions in the study by Gonzalez, Penelo (217) were the only ones with similar improvements in ED symptomatology in boys and girls. No study improved body dissatisfaction, but the study by Jordana Ovejero, Espinoza Guzmán (227) found a 12-month effect on body satisfaction. In addition, four interventions from three studies with longer follow-up periods reported reduced internalization of appearance ideals or societal influence on body image (217, 221, 222, 226), but with no effect observed in boys in one study (226). Only one intervention enhanced

(global) self-esteem (222), and one intervention reduced symptoms of depression in boys (221). Unfortunately, no studies reduced perceived appearance pressure or symptoms of anxiety.

Previous research is promising, and several intervention programs have features that may be beneficial to include in future intervention programs such as the media literacy approach and a multicomponent and interactive intervention format. However, many studies have a small sample size, have a short follow-up period, do not create effects on multiple outcomes, and have not included outcomes adapted for boys and girls within the muscular-oriented dimension of body image. Moreover, only three studies (224, 225, 264) have examined mediators accounting for the intervention effect in these studies. None of these studies have investigated change mechanisms in boys and girls separately or included mediators that could be especially relevant for boys and girls internalizing an athletic or muscular appearance ideal. These limitations makes it difficult to draw conclusions regarding lasting effects, effects in boys, and which psychological factors to target within an intervention to improve the effects in girls and boys.

Prevention of muscle-building supplement use in adolescents

Initiatives to prevent supplement use have mainly been performed among males and athletes with less attention paid to general adolescents. However, one study has replicated the Athletes Training and Learning to Avoid Steroids (ATLAS) program with regular adolescent boys (265). The program was school based and teacher led and comprised nutritional, supplement, and steroid education and practical strength training. The pilot study by Yager, McLean (265) showed that the ATLAS participants had small improvements in body image; unfortunately, the researchers did not observe any effects with regard to supplement use. Another steroid prevention program conducted in Norway that included regular adolescent boys and girls found a positive effect in overall nutritional behaviors that included less use of supplements among the intervention group receiving the theory-based educational program (266). However, whether the program reduced or prevented the actual use of supplements is unknown. The Athletes Targeting Healthy Exercise and Nutrition Alternatives program for adolescent female athletes has faced long-term evaluation, but unfortunately, the immediate reduction in DE behaviors and supplement use (267) did not last to the three year follow-up (268). Nevertheless, the results still contribute with important knowledge about mechanisms of change in the prevention of muscle-building supplement use and DE behaviors in female adolescent athletes. The study reported that increased knowledge was a primary mediator for the change in several attitudes, finally explaining the effect on supplement use and DE behaviors nine months after

the intervention (269). However, the study reported unstandardized results, making it difficult to draw conclusions related to the strength of the relationship.

Research gaps

Previous universal and school-based prevention programs have yielded promising findings since most programs succeed in improving at least one known risk or protective factor. Despite promising findings, most of the effects are lost over time and are generally weaker among boys compared to girls.

Increased attention toward boys' body image and expression of body dissatisfaction and DE may improve intervention effect. More specifically, aiming to reduce the internalization of a broader spectrum of appearances such as muscular and athletic internalization could make the preventive program more appealing and relevant to a broader spectrum of adolescents, especially boys. In addition, interventions aiming to prevent EDs or body dissatisfaction should include measures of supplement use and dissatisfaction with muscularity (270).

Nevertheless, awareness when developing and implementing the intervention is important to avoid creating potentially harmful effects. The only program reporting a long-term undesired effect was a lifestyle approach (221) that created an increase in weight and shape concerns and eating concerns among girls. This may highlight that special precautions should be taken when targeting lifestyle in girls. The individual performing the intervention needs to be educated and competent in the areas of exercise, nutrition, psychology, and adolescent development to ensure that topics are presented to and interpreted by the adolescents in a health-promotive manner, where the emphasis should be on body functionality and how a healthy lifestyle may promote a positive body experience (182, 271). All previous interventions targeting lifestyle or nutrition were led by teachers or by professionals, researchers, or students within the area of psychology. Special competence in nutrition and lifestyle seems to have been lacking. Moreover, no universal and mixed gender intervention has aimed to prevent the use of muscle-building supplements, such as protein or creatine supplements, in regular high school adolescents. Aiming to reduce the risk of ED development by targeting several psychological factors influencing body image may also create an intervention effect in supplement use. In addition, targeting supplement use may be especially relevant for adolescents who fall within the muscular and athletic-oriented spectrum of body idealization and dissatisfaction.

Finally, there is a need for increased knowledge about mediators in universal prevention interventions to bring the field forward and notably, to examine whether change mechanisms differ

between boys and girls. This may seem relevant since boys tend to benefit less from ED prevention interventions than girls.

Taken together, future research may benefit from developing and performing interventions that capture a wider range of risk and protective factors for ED development and aim to capture muscular-oriented dimensions of body image in both the intervention and assessments. In addition, the arenas for social influence are rapidly developing, with social media representing one of the most comprehensive social arenas for adolescents. This means that interventions may be more effective if they are developed further to also target social media and aim to make adolescents literate in unhealthy social media messages and strengthen adolescents' skills and ability to take action related to their own social media use. Of the studies presented, few created effects in multiple outcomes. It may be debated whether finding intervention effect in only one outcome is enough to create a sustained effect of reducing the risk of ED development. In addition, many interventions lose their effect during the follow-up period, which indicates that further refinements and testing are necessary to justify implementation in a universal setting. Moreover, few studies with a large sample size have included a follow-up equal to or longer than 12 months, hampering the generalizability and limiting the possibility of evaluating whether implementation of the intervention in schools is justified. There is a need for intervention studies including a large sample size that are successful in creating lasting effects in multiple risk and protective factors for ED development in both boys and girls.

Aims of the thesis

In the following three papers, we aimed to

1) Investigate the proportion of boys and girls using muscle-building and dieting supplements.
2) Investigate if such use was associated with risk and protective factors for ED development, sport and exercise participation, and immigrant status.
3) Investigate the immediate and long-term effect of the HBI intervention on risk and protective factors for ED development and muscle-building and dieting supplement use among boys and girls.
4) Explore potential mediators for the effect of intervention on ED symptomatology and muscle-building supplement use in boys and girls.

Methods

Study design

The Healthy Body Image (HBI) intervention (272) is a cluster-randomized controlled trial. A cluster-randomized design with 1:1 ratio was applied to minimize contamination biases within schools. Each school represented an individual cluster to reduce the risk of diffusion of effects due to information crossover between intervention and control students. The schools were randomly allocated to either the intervention (s = 14) or control (s = 16) group to equalize school size and capture the urban-rural dimension, ensuring that all regions in the catchment area were included. The randomization was performed by a professional not affiliated with the research team.

Power calculation

The power calculation was based on two comparison groups and used an α level of .05 and an average within-cluster sample size of 70 students. The expected effect size was 0.28 and based on one previous meta-analysis investigating the intervention effect on body image-related outcomes (273). We assumed that the within-cluster dependency accounted for 3% of the variation in mental health and body image outcomes. For each group, 10 clusters were needed to achieve a statistical power of 81%. The total required sample size was calculated to be 10 × 2 groups × 70 students in each cluster, resulting in a requirement of 1,400 students.

Recruitment of schools and participants

The school and participant flow at all measurement points is presented in Figure 3.

Schools

The recruitment process considered all public and private high schools from all districts in the Oslo and Akershus counties for inclusion. The study included all 12^{th}-grade classes following a general study program. Students in vocational study programs were excluded. In the fall of 2016, 50 schools were identified to be eligible for inclusion. An invitation letter including a short description of the study was sent by email to the school principals and administrators. Schools that accepted the invitation were given a thorough description of the study, and information meetings were scheduled to provide oral study information to school leaders, teachers, and students.

Participants

A total of 3,947 students aged 16 to 18 years from the 30 consenting schools were eligible for inclusion. We arranged a meeting at each school, and all students were thoroughly informed about the study aims and the implications of participation. They were also asked to provide their email address to be reachable. The students subsequently received an information letter, an invitation to participate in the study, and an informed consent letter together with the questionnaires. After the baseline, all students who completed the posttest questionnaire were offered a movie ticket (a value of $15). Due to limited funding, we were only able to invite participants to the posttest who had consented and partially answered the baseline questionnaire. Additional funding made it possible to reinvite all those who had consented at the baseline to the 3-month follow-up, thereby increasing the number of participants from the posttest to the 3-month follow-up. All students who consented at the baseline were reinvited to the 12-month follow-up.

Study flow

The study was conducted from March 2016 until January 2018. After ethical approval, the intervention was piloted, and adjustments were made prior to the main study. Study flow and measurement points are shown in Figure 4.

Data collection

All questionnaires were completed electronically outside school hours using the web-based survey tool Survey XACT by Ramboll, Norway. The survey tool enabled the survey to be paused during completion, and all questions had to be answered to proceed with the questionnaire. The survey tool automatically adjusted its layout to different devices, making it possible to use a mobile phone, tablet, or laptop. All respondents were included in a draw to win gift cards with a value of 500 to 2,000 NOK ($50 to 200 USD).

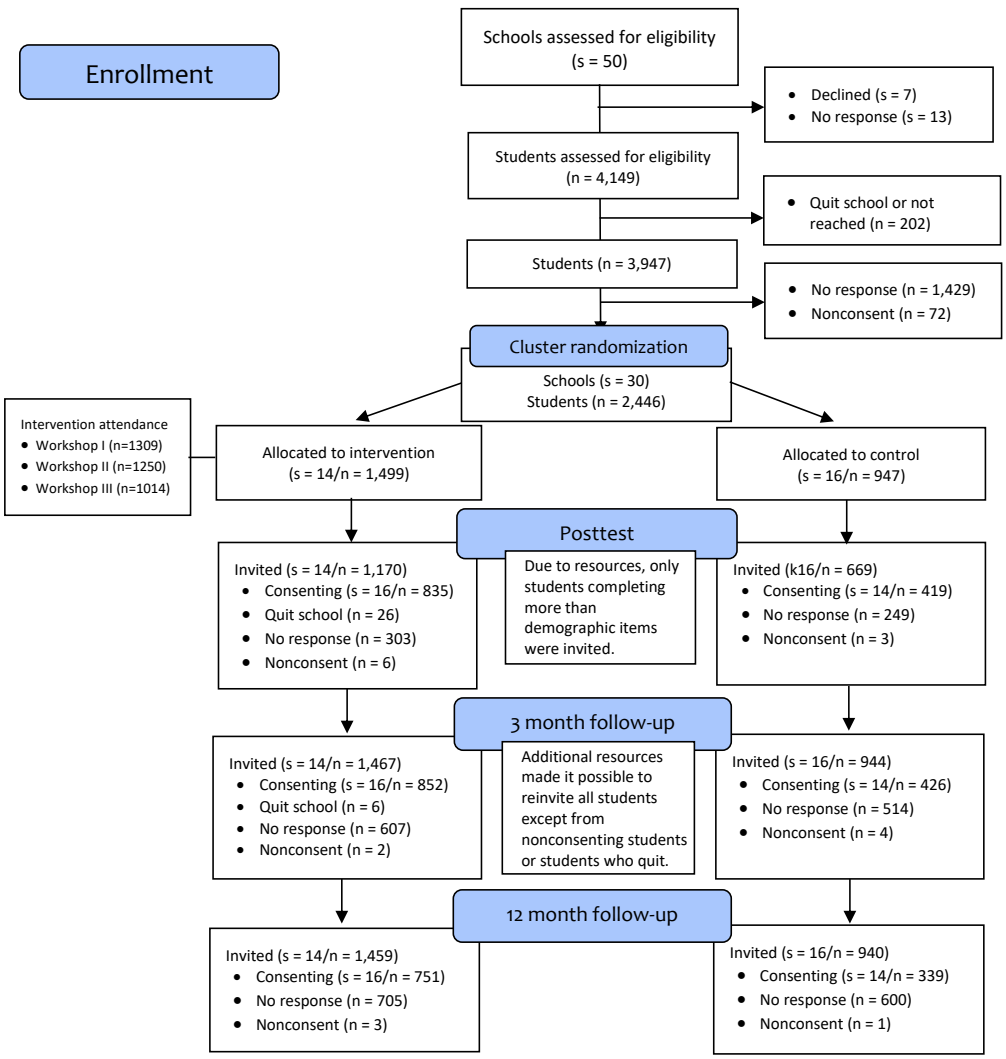

Figure 3. Recruitment, randomization and participant flow. s = number of schools (clusters), n = number of students. The figure presents number of consenting students. The number of students for the outcome measures varies between the different instruments.

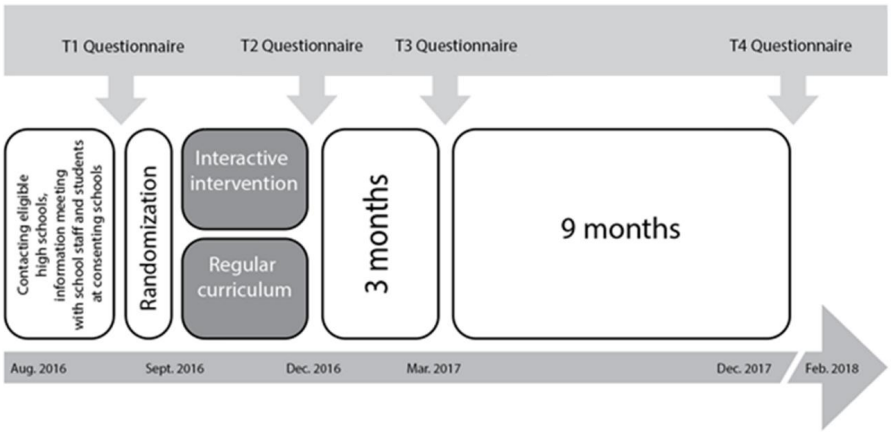

Figure 4. Study flow and measurement timepoints. T1 = baseline, T2 = posttest, T3 = 3-month follow-up, T4 = 12-month follow-up.

Ethics

The study met the intent and requirements of the Health Research Act and the Declaration of Helsinki and was approved by the Regional Committee for Medical and Health Research Ethics (2016/142). The study was further enrolled in the international database of controlled trials at www.clinicaltrials.gov (ID: PRSNCT02901457). This work was supported by the DAM Foundation (2016/FO76521) through the Norwegian Woman's Public Health Association (H1/2016). A commercial sponsor (TINE AS) supported the study after the study protocol was published but was not involved in data collection, data analysis, or the writing of the present paper.

Students at consenting schools who did not want to participate in the study (i.e., answer the questionnaires) also followed the HBI intervention. However, they were not included in the analyses because they did not complete the questionnaires. After the final 12-month follow-up, control schools were offered one lecture wherein the intervention highlights were compressed. Personal backup or stop procedures were not considered relevant due to the nature and focus of the intervention.

The Healthy Body Image intervention

Theoretical framework

The HBI intervention uses important aspects and considerations from the sociocultural theory. The theory highlights that social and cultural influences are dominant in individual development and that

learning is mainly a social process (274, 275). This framework is widely used in understanding the role of social and cultural influences in ED development (52) and is often used in body image and ED prevention interventions (see Table 1). More specifically, sociocultural theories explain how cultural and societal ideals of appearance are transmitted in social interactions with family, peers, and social and mass media and further internalized at an individual level.

The developmental theory of embodiment (276) was also applied when developing and performing the intervention to enhance the health-promotive and salutogenic features of the intervention (277). The developmental theory of embodiment builds on a philosophical mindset that the body and mind are unified and that the lived experience happens through the body shaped by cultural forces (278). The application of the theory of embodiment may provide an important dimension to ED prevention interventions that may facilitate more positive intervention outcomes (279).

Intervention method

The elaboration likelihood method of persuasion model was used when developing the intervention method to facilitate change in attitudes. This theory states that repeated exposure to written, verbal, or nonverbal messages facilitates cognitive elaboration of the content of the messages (2). Persuasion by cognitive elaboration increases the likelihood that the messages delivered in the intervention are processed through a central cognitive route as opposed to a peripheral cognitive route. Processing the intervention messages through a central cognitive route facilitates favorable cognitive structure change and central attitude changes, which means that new cognitions are adopted and stored in the memory. The end point of a successful cognitive elaboration process is sustained change in attitudes that in turn could predict behaviors (2).

To create cognitive elaboration, the intervention messages were repeated and implemented in several student active tasks and discussions of topics of common interest (e.g., social media use and exposure, how to promote self-esteem, and lifestyle). Moreover, the multiple-session format where intervention messages were repeated across the three workshops was chosen to facilitate cognitive elaboration.

Pilot study

In spring 2016, the intervention was piloted in one high school consisting of 120 12^{th}-grade boys and girls. The pilot study had the same features as the HBI intervention with three workshops including the main topics (body image, social media, and lifestyle). Each workshop lasted 90 minutes and was

divided into two 45-minute sessions. The students gave feedback on intervention content, delivery style, and intervention structure (i.e., duration and time between workshops). The students also completed the questionnaire package and provided thorough feedback on the length of the questionnaire as well as the content. The workshops were also recorded to allow the researcher and presenter to actively work on their communication and dissemination skills. The student feedback resulted in reduced time spent on the workshop assignment, allowing more time for peer discussion. The students and school staff were also concerned about the overall workload resulting in the exclusion of homework between workshops. Additionally, the feedback resulted in shortening the questionnaire by excluding somewhat repetitive instruments related to body image and nutrition to reduce the risk of agreement bias (280).

Intervention content and procedure

The intervention was led by two female doctoral students educated and experienced in the field of physical activity and health, exercise, nutrition, body image, and DE. The intervention content was adapted to fit into the schools' learning objectives provided by the Ministry of Education without compromising the theoretical framework.

The intervention involved three classroom-based and interactive 90-minute workshops (two school hours including a 10-minute break) focusing on the three topics of body image and self-esteem, social media, and lifestyle. The intervention content was developed to suit adolescents' cognitive development, ability to process and evaluate messages, and abstract thinking. Teachers could be present during the intervention. However, most teachers chose to be absent during the interventions. On average, 60 students (two school classes) participated in each workshop. The intervention facilitators recorded workshop attendance for every workshop. The intervention period was approximately three months with a three- to four-week interval between each workshop. A comprehensive outline of the HBI intervention rationale, procedure, and content is provided in a protocol paper (272), and a brief summary of the content is presented in Table 2.

Table 2. Overview of the content and aims of the three workshops in the HBI intervention

#1 Body image	
Main content:	Aim:
Project introduction	Experience of meaningfulness and motivation
Influencing factors on body perception. What promotes and reduces positive body image, and how can we enforce the health promoting factors?	Body image and body acceptance
Where does body idealization come from? Why does it conflict with positive body image, and potential health consequences from striving for the idealized body?	Reduce idealization and internalization of body ideals
Fat talk and focus on lifestyle only related to appearance in everyday communication. To what degree do we participate, how does it make us feel, and can we reduce it?	Reduce fat talk and negative body talk Improve peer environment
Introduction to self-talk and self-esteem in WS#2	Stimulate motivation for next workshop
#2 Social media	
Main content:	Aim:
Social media perception and use. Empower yourself to choose mood enhancing over mood destructive content	Enhance media literacy
Extreme exposure without filter equals need to be critical to sources of information and awareness of retouching	Enhance media literacy
The nature of comparison, how to recognize destructive comparison and reduce its presence in everyday life	Reduce amount of comparison
Strengthen acceptance and love for individual differences, defining characteristics of ones' own and among friends. Students tell and write down compliments to a friend and him/herself unrelated to appearance.	Improve positive self-talk Improve self-compassion Improve peer environment
Experiences and benefits of positive self-talk	Improve skills to strengthen self-esteem
#3 Lifestyle	
Main content:	Aim:
Benefits on body experience from listening to bodily needs such as physical activity and healthy eating	Improve experience of embodiment
Truths and myth about lifestyle products and literature	Improve ability to reject exercise and nutritional myths - health information literacy
From aesthetic to functional focus; how can change in focus improve body experience and healthy lifestyle that again benefit well-being?	Change from potential unhealthy focus to healthy focus on the body
How may regular exercise and smart nutrition promote positive body image and what are the basic recommendations?	Body experience enhancing attitudes and behaviors

Retrieved and adapted from Sundgot-Borgen C, Bratland-Sanda S, Engen KME, Pettersen G, Friborg O, Torstveit MK, et al. The Norwegian healthy body image programme: study protocol for a randomized controlled school-based intervention to promote positive body image and prevent disordered eating among Norwegian high school students. BMC Psychology. 2018;6(1):8.

Measures

All instruments and standalone questions are listed in the appendices.

Demographic variables

Students answered questions related to annual family income, parental education level, and immigration status.

Main outcome variable

Eating disorder symptomatology (Papers II and III, independent variable in Paper I)

The main outcome variable, ED symptomatology, was measured with an empirically derived (281) brief version of the EDEQ (232) consisting of 11 items (EDEQ-11) from the weight concern and shape concern subscales. The EDEQ-11 has been found to act as an acceptable abbreviated measure of overall eating pathology and corresponds well with the global EDEQ score (281). The complete 22-item instrument discriminates well between ED patients and healthy individuals with a sensitivity and specificity value of 0.86 (282). The internal consistency (α) of the EDEQ-11 was 0.94 and 0.91 for the girls and boys in our sample, respectively.

Muscle-building and dieting supplement use (dependent variable in Paper I, secondary outcome variable in Paper II, and main outcome variable in Paper III)

Muscle-building supplements included protein and creatine supplements. Use of protein, creatine, and dieting supplements was measured with self-developed questions about the weekly frequency of supplement use. Protein and creatine supplements included powders usually mixed with fluid. Dieting supplements included products consumed to aid weight or fat loss (i.e., fat burners, pills, and powders). Questions were scored on a five-point Likert scale from 1 (never) to 5 (daily). All students who reported using supplements at least once per week were defined as weekly users.

Secondary outcome variables and independent variables

Self-esteem (independent variable in Paper I, secondary outcome in Paper II, and mediator in Paper III)

The Rosenberg self-esteem scale (253) is a 10-item instrument measuring global self-worth using both negatively and positively worded items scored on a four-point Likert scale ranging from strongly agree to strongly disagree. The total score ranges from 0 to 30 where a higher score represents a higher level of global self-worth. Negatively worded items were reversed. In the present study, internal consistency (α) was 0.90 and 0.92 for boys and girls, respectively.

Mental distress (independent variable in Paper I and secondary outcome Paper II)

The symptom checklist-10 is a 10-item instrument assessing symptoms of anxiety and depression on a four-point Likert scale. Higher scores indicate a higher degree of mental distress. Internal consistency for the present study was measured as similar to that of previous findings drawn from a similar Norwegian sample (283) with Cronbach's α values of 0.89 and 0.90 for boys and girls, respectively.

Body image flexibility (secondary outcome for Paper II and mediator in Paper III)

The Body Image Acceptance and Action Questionnaire ((141) is a measure of body image flexibility and of the ability to maintain behaviors that are consistent with chosen values when negative feelings, thoughts, body sensations, or memories related to one's own appearance are experienced. The scale includes 12 items scored on a seven-point Likert scale ranging from "never true" to "always true" and a score scale of 12 to 84. Negatively worded items were reversed for a higher score to reflect more body image flexibility.

Sociocultural attitudes toward appearance (independent variable in Paper I, secondary outcome in Paper II, and mediator in Paper III)

The Sociocultural Attitudes Towards Appearance Questionnaire-4 (98) was developed to assess societal and interpersonal aspects of appearance ideals. The questionnaire consists of five individual subscales scored on a five-point Likert scale ranging from "strongly disagree" to "strongly agree"; The three subscales thinness/low body fat internalization (thin appearance internalization), athletic/muscular internalization (muscular appearance internalization), and perceived pressure from media (media pressure) were included in the questionnaire package. The subscale scores range from 1 to 5 where a higher score indicates a higher degree of internalization or perceived pressure. Cronbach's alpha in the present sample ranged between 0.85 and 0.94 for the boys and between 0.91 and 0.95 for the girls.

Drive for leanness (independent variable in Paper I and secondary outcome in Paper II)

The Drive for Leanness Scale is a measure of the desire to have relatively low body fat and toned muscles (284). Importantly, experiencing a high drive for leanness is not equivalent to wanting to be thin. The scale consists of six items scored on a six-point Likert scale ranging from 1 (never) to 6 (always). The Cronbach's alpha value for the present study was measured as 0.86 for both boys and girls.

Exercise and sport participation (independent variable in Paper I)

Physical activity level was assessed by asking the participants how many hours and minutes they spend being physically active during a normal week, where physical activity was defined within the questionnaire as "any activity making you warm and slightly breathless (i.e., physical education, activities with your family, active transportation [i.e., walking and biking to school], exercise, sports, and self-organized activities)".

Table 3. Principal component analysis of sport activities with loadings and eigenvalues for girls and boys combined (n = 1,703)

	Weight class- and gravitational sports	Aesthetic sports	General sport and exercise
Eigenvalue	2.43	1.59	1.04
Explained variance (%)	24.33	15.88	10.36
Strength/power sports	0.71		
Fitness	0.69		
Martial arts	0.60		
CrossFit	0.53		
Dance		0.78	
Yoga		0.70	
Aesthetic sports		0.62	
General endurance exercise			0.79
General resistance exercise			0.74
Ball sports			0.58

Exercise context was assessed by participants using response categories to report whether they are active members exercising at a fitness center or playing organized sports. The questions were recoded into two dichotomous variables: fitness center exercise (0 = no, 1 = yes) and organized sport participation (0 = no, 1 = yes).

The type and weekly frequency of sport participation was assessed using a self-developed questionnaire listing several different types of exercise and sports and asking how many times per week the participants engaged in different exercise or sport activities. Participants scored each activity on a four-point Likert scale ranging from never to several times per week. To reduce the number of correlated sport and exercise variables and to create meaningful groups of exercise and sport activities, a principal component analysis with varimax rotation was performed. The analysis yielded three components with eigenvalues > 1.0. The three factors were in line with previously suggested groupings of weight-sensitive sports (285): 1) weight class and gravitational sports (i.e., martial arts, CrossFit, fitness, powerlifting, and power sports), 2) aesthetic sports (i.e., gymnastics, diving, figure skating, dance, and yoga), and 3) general exercise and sport activities (i.e., endurance exercise, resistance exercise, and ball sports). Factor structure, loadings, and explained variance are shown in Table 3.

Statistical analyses

Paper I

All analyses were performed using IBM Statistical Package for the Social Sciences (SPSS) version 24. Continuous variables are presented as the mean and standard deviation (SD) and as the number of observations (n) and proportions (%) for categorical data. Between-group differences in demographic psychometric and exercise variables were tested using an independent sample t-test and Fisher's exact test. The Mann-Whitney U test was performed to investigate overall differences between boys and girls in relation to protein, creatine, and dieting supplement use. Cohen's d (d) and odds ratios were used as effect sizes for parametric and nonparametric comparisons, respectively. The alpha level was set to $p = 0.05$.

Comparing users and nonusers of muscle-building supplements (unpublished)

Additional analyses are included to present a broader picture of the difference between users and nonusers of muscle-building and dieting supplements. These results were originally intended to be part of Paper I. However, these results made Paper I too comprehensive and were excluded.

The variables representing the use of muscle-building and dieting supplements were recoded as follows: 1) protein supplements (0 = nonusers, 1 = users), 2) creatine supplements (0 = nonusers, 1 = users), and 3) dieting supplements (0 = nonusers, 1 = users), where nonusers did not consume any of the three supplements. Between-group differences in demographic psychometric and exercise variables were tested using an independent sample t-test and a Fisher's exact test. Cohen's d (d) and odds ratios were used as effect sizes for parametric and nonparametric comparisons, respectively. The alpha level was lowered to 0.010 for analyses investigating differences between supplement users and nonusers to reduce the risk of a type 1 error.

Explanatory factors for muscle-building supplement use

Hierarchical multiple linear regression analysis was performed to investigate potential explanatory variables for the weekly frequency of protein supplement use, creatine supplement use, and dieting supplement use. Bootstrapping was performed to handle nonnormal residual score distributions and was performed using a wild sampling method with unstandardized residuals as value variables. The number of bootstrapping samples was set to 2,000 with bias correlation and accelerated 95% confidence intervals (CIs). The variance inflation factor (≤ 5.0), tolerance (> 0.2) and condition number (<1 0), and variance decomposition proportion (> 80%) were investigated, and no violations of cut points were present (286). All variables were standardized to Z scores to ease interpretation and obtain standardized beta weights from the bootstrapped analysis.

The dependent variables were the weekly frequency of protein supplement use, creatine supplement use, and dieting supplement use. The independent variables were included in three steps as follows: Step 1) ED symptomatology (labeled "weight and shape concerns" in the published Paper I), thin appearance internalization, muscular appearance internalization, media pressure, self-esteem, and mental distress; Step 2) physical activity and sport and exercise variables: physical activity hours per week, organized sport participation (no/yes), fitness center exercise (no/yes), weight class and gravitational sports, aesthetic sports, and general sports and exercise; and Step 3) BMI and immigrant status.

The results are presented as the beta weight and 95% and CIs. Analyses were stratified by gender. The alpha level was set to $p = 0.05$.

Paper II

All analyses were performed using IBM SPSS version 24. The adequacy of the randomization procedure was tested with independent sample t-tests or chi-square tests examining whether group differences in the outcome variables at the baseline were nonsignificant.

Cases without any posttest data were defined as dropouts and otherwise retained. All baseline demographic measures correlating significantly with dropout status or study group (Spearman's rho = > .19) were included as a covariate if significant in the final regression model.

Due to several layers of dependency in the different outcome data, a linear mixed regression model (West, 2009) was specified. Dependency within the school clusters was accounted for by adding the school as a random factor, whereas dependency between the repeated measures was accounted for by fitting a compound symmetry matrix to the residual matrices. The analysis is also robust against missing data because it analyzes all available data owing to the maximum likelihood function (restricted type used). To account for an imperfect randomization and increase the statistical power, the baseline score of the outcome variable was added as a covariate. Fixed factors included group (mean difference between the intervention and control groups), time (mean change across the three measurement times), gender (mean difference between girls and boys), group × time (mean difference at certain measurement occasions only), group × gender (mean intervention difference dependent on gender), gender × time (mean gender difference at certain measurement occasions), and group × time × gender (mean intervention difference at specific measurement occasions depending on gender). Type III F-tests were performed, and alpha values of < .05 were required. Hypothesized group differences observed at specific measurement times were examined as planned comparison tests (Least Significant Difference). The weekly frequency of supplement use was recoded as follows: 1 (never) = 0, 2 (1–2 times per week) = 1.5, 3 (3–4 times per week) = 3.5, 4 (5–6 times per week) = 5.5, and 5 (every day) = 7.

The results are expressed as absolute numbers (n) and percentages (%) for categorical data and model estimated means including standard errors (SEs) and SDs for continuous data. Effect sizes were calculated as standardized mean differences (or Cohen's d = estimated mean difference / observed pooled SD) and interpreted as negligible, small, moderate, or large when d = < .20, .20–.49, .50–.79, or > .79, respectively (Cohen, 1988).

Reliable and relevant change in eating disorder symptomatology and new cases of muscle-building and dieting supplement use (unpublished)

We performed additional analyses investigating reliable and relevant change in ED symptomatology to provide an additional perspective on the intervention effect and to further investigate if there were any harmful effects undetected by the main analyses. Reliable and relevant change in ED

symptomatology at the 12-month follow-up was calculated using the Leeds Reliable Change Indicator (RCI; 287). The RCI was calculated for boys and girls separately as follows:

$$1.96 \times \sqrt{2 \times SE_{measure} \times SE_{measure}}$$

Where the standard error of the measure ($SE_{measure}$) was

$$Baseline\ SD \times \sqrt{1 - \alpha_{reliability\ of\ measure}}$$

The criterion value for relevant significant change was calculated as follows:

$$\frac{Mean\ clinical\ population \times SD\ in\ normative\ sample + Mean\ normative\ sample \times SD\ in\ clinical\ sample}{SD\ in\ clinical\ smple + SD\ in\ normative\ sample}$$

The norms used for ED symptomatology (for items used in EDEQ-11) for the clinical sample was 3.80 (SD 1.45) in males (288) and 4.40 (SD 1.49) in females (289). The mean and SD for the normative samples were 0.69 (SD 1.16) in males and 2.13 (SD 1.94) for females (290). This resulted in criterion values of 2.07 and 3.41 for boys and girls, respectively. A clinically relevant change occurred in students who reduced their score from above the criterion value to below the criterion value 12 months after the intervention. Moreover, they had to demonstrate a change greater than the RCI.

The difference between intervention and control students in proportion with reliable and relevant change was investigated by using a chi-squared test and an odds ratio.

New cases of muscle-building and dieting supplement use were added into the thesis to examine whether the intervention was able to prevent use rather that "only" reduce the frequency of use among existing users. These analyses also provide another nuance to the intervention effect since "new cases" of use excluded participants who were already users of muscle-building or dieting supplements at the baseline. This seemed relevant since muscle-building and dieting supplement use was associated with dropout among control boys and girls.

A chi-squared test was performed on boys and girls separately to investigate whether the proportion of new cases of protein, creatine, and dieting supplement use at the posttest, 3-month, and 12-month follow-ups differed between the intervention and control groups.

Paper III

An independent sample t-test or Mann-Whitney U test was performed to test whether baseline characteristics differed between responders (responded at baseline and in one follow-up measure) and dropouts (responded at baseline only).

To test if there were indirect effects of the intervention on the outcomes measured at the 12-month follow-up through change in the proposed mediators (baseline–12 months), conditional latent growth curve analyses were performed in Mplus 8.4 (291). All models were performed with the robust maximum likelihood estimator. Separate models were estimated for each of the proposed mediators and for both males and females. In the conditional models, group belonging (intervention, control) was included as an independent variable, and ED symptomatology, weekly frequency of protein supplement use, and creatine supplement use were included as dependent variables together with the four waves of the proposed mediators. In all models, the intervention group was coded as 0 and the control group as 1. Within all analyses, we controlled for the baseline scores of all dependent variables (292). To evaluate model fit, we used a combination of the following fit indices (293): the comparative fit index (> .90), the standardized root mean residual (< .08), and the root mean square error of approximation (< .08). Full information maximum likelihood (FIML) was used to address missing data. More specifically, FIML is considered as the state-of-the-art missing data technique when data are considered to be missing at random (294). For each parameter within the model, standardized regression coefficients were calculated together with a *p*-value. For all parameters, a *p*-value < .05 was considered to indicate a statistically significant effect within the model. In line with suggestions within the literature, we inspected nonsymmetric bootstrap CIs to assess mediation (295). These intervals were based on 10,000 bootstrap samples and together provide an empirical representation of the sampling distribution of the indirect effect (*ab*). The indirect effect was considered statistically significant if the 95% *CI* did not include 0 (296).

Because the participants were from different schools, we performed sensitivity analyses to investigate whether the inclusion of school belonging as a covariate would improve the model fit. The Akaike information criterion and the Bayesian information criterion were inspected to determine if the inclusion of the covariate improved the model fit. The results from all the path analyses showed that the inclusion of school as a covariate did not improve the model fit. We therefore decided to present the results for the models without the covariate included.

Results

Demographic characteristics

The response rate at the baseline was 60% of potential students with a higher number of girls than boys (girls 58%, boys 42%, $p = \leq 0.010$). Demographic characteristics and baseline outcome measures for the whole study sample are presented in Tables 4 and 5. Several differences between boys and girls in demographic; psychological; and physical activity, exercise, and sport variables were present (see Tables 4 and 5).

Table 4. Baseline characteristics in boys and girls presented as means for continuous variables and percentages (number of participants) for categorical variables. Effect sizes (ES) are Cohen's d for continuous data and odds ratio for categorical data.

	N	Boys	n	Girls	p	ES (d/OR)
Age	1050	16.78 (0.47)	1441	16.78 (0.49)	0.868	
Body mas5s index	1019	21.73 (2.78)	1420	21.40 (2.91)	0.005	**2.86**[d]
Immigrant background, % (n)	1062	14.2 (151)	1454	15.0 (218)	0.608	
Maternal university education, % (n)	1041	72 (750)	1438	71.7 (1031)	0.857	
Paternal university education, % (n)	1040	71.9 (748)	1438	67.6 (972)	0.022	**1.09**[OR]
Family income > 1 million NOK, % (n)	1042	48.5 (505)	1436	32.9 (473)	<0.001	**1.33**[OR]
Study program, % (n)						
General	1046	80.9 (846)	1439	82.8 (1191)	0.245	
Sports	1046	15.2 (159)	1439	7.2 (104)	<0.001	**1.52**[OR]
Music, dance and drama	1046	2.4 (25)	1439	6.1 (88)	<0.001	**1.95**[OR]
Arts and design	1046	0.3 (3)	1439	1.5 (21)	0.003	**3.39**[OR]
Media and communication	1046	0.8 (8)	1439	0.8 (11)	1.000	
Eating disorder symptomatology	639	1.01 (1.18)	1082	2.50 (1.65)	<0.001	**1.49**[d]
Self-esteem	629	32.81 (5.97)	1073	29.11 (6.13)	<0.001	**6.07**[d]
Mental distress	696	1.65 (0.61)	1140	2.18 (0.74)	<0.001	**0.70**[d]
Body image flexibility	986	69.88 (10.11)	1385	58.01 (15.90)	<0.001	**13.79**[d]
Media pressure	640	2.15 (1.16)	1088	3.20 (1.24)	<0.001	**1.21**[d]
Thin appearance internalization	640	2.53 (0.95)	1088	3.34 (1.09)	<0.001	**1.04**[d]
Muscular appearance internalization	640	3.23 (1.09)	1088	3.02 (1.08)	<0.001	**1.08**[d]
Drive for leanness	969	3.69 (1.10)	1375	3.50 (1.03)	<0.001	**1.06**[d]
Weekly protein supplement use, % (n)	636	29.0 (185)	1078	9.36 (101)	<0.001	**1.93**[OR]
Weekly creatine supplement use, % (n)	636	16.5 (105)	1078	3.0 (32)	<0.001	**2.82**[OR]
Weekly dieting supplement, % (n)	636	7.86 (50)	1078	6.86 (45)	0.500	
Weekly frequency of protein supplement use (0-7)	636	1.03 (1.94)	1078	0.28 (1.03)	<0.001	**1.43**[d]
Weekly frequency of creatine supplement use (0-7)	636	0.74 (1.84)	1078	0.09 (0.58)	<0.001	**1.21**[d]
Weekly frequency of dieting supplement use (0-7)	636	0.32 (1.28)	1078	0.15 (0.70)	<0.001	**0.95**[d]

Immigrants = two foreign born parents, [d] = Cohen's d, [OR] = odds ratio, n = number of participants.

Table 5. Physical activity, exercise context, and sport participation among boys and girls presented as means for continuous variables and percentages (number of participants) for categorical variables. Effect sizes (ES) are Cohen's d for continuous data and odds ratio for categorical data.

	N	Boys	n	Girls	p	ES (d/OR)
Physical activity hours/week	627	8.44 (6.16)	1071	6.84 (5.18)	<0.001	**5.56**[d]
< 7 hours per week, % (n)	627	46.4 (291)	1071	62.3 (667)	<0.001	**1.28**[OR]
Organized sport, % (n)	631	52.9 (334)	1076	38.3 (412)	<0.001	**1.25**[OR]
Fitness center, % (n)	631	54.8 (346)	1076	41.8 (450)	<0.001	**1.22**[OR]
Both organized sport and fitness center, % (n)	631	17.6 (187)	1076	10.4 (152)	<0.001	**1.34**[OR]
Neither organized sport nor fitness center, % (n)	631	21.9 (138)	1076	34.0 (366)	<0.001	**1.50**[OR]
Sport and exercise participation ≥ 1 time per week						
Weight class and gravitational sports, % (n)	632	38.6 (243)	1076	25.6 (271)	<0.001	**1.83**[OR]
Aesthetic sports, % (n)	632	9.7 (61)	1076	32.8 (348)	<0.001	**0.22**[OR]
General sports and exercise, % (n)	632	89.0 (560)	1076	80.7 (855)	<0.001	**1.95**[OR]

BMI = BMI, [d] = Cohen's d, [OR] = odds ratio, n = number of participants.

The baseline and 12-month follow-up scores for participants with repeated measurements qualifying for inclusion in the effect analyses are presented in Table 6. Dropout analyses revealed some differences between dropouts and responders in both boys (p = < 0.010) and girls (p = < 0.010). Control boys who dropped out consumed protein (1.71 vs. 0.97), creatine (1.50 vs. 0.69), and dieting supplements (0.86 vs. 0.19) more times per week than control boys who responded at follow-up. Additionally, control girls who dropped out consumed protein (0.55 vs. 0.20) and creatine supplements (0.20 vs. 0.04) more often than control girls who responded at follow-up. No differences in psychometric variables were observed between dropouts and responders.

Table 6. Sample characteristics and 12-month follow-up score shown as the mean and standard deviation (SD) or percentage and number of observations (n) for students included in the effect analyses.

	Boys				Girls			
	n	Intervention	n	Control	n	Intervention	n	Control
Age (yrs.)	332	16.77 (0.46)	175	16.73 (0.49)	664	16.76 (0.49)	324	16.78 (0.48)
BMI (kg/m^2)	332	21.58 (2.64)	175	21.84 (3.16)	664	21.41 (2.79)	324	21.48 (3.11)
Parental income > 1 mill NOK, % (n)	332	48.8 (162)	175	44.0 (77)	664	34.9 (232)	324	25.5 (83)
Immigrant status % (n)	332	13.3 (44)	175	17.1 (30)	664	13.9 (92)	324	17.8 (58)
Paternal university education % (n)	332	76.8 (255)	175	64.0 (112)	664	72.9 (484)	324	63.4 (206)
Maternal university education % (n)	332	79.8 (265)	175	64,6 (113)	664	74.8 (497)	324	70.8 (230)
Eating disorder pathology								
Baseline	276	0.97 (1.08)	131	1.14 (1.16)	590	2.38 (1.58)	276	2.68 (1.70)
12-month	155	0.69 (0.90)	67	0.68 (0.75)	436	1.59 (1.51)	177	2.44 (1.83)
Self-esteem								
Baseline	263	33.00 (5.63)	123	32.72 (6.37)	574	29.50 (5.97)	259	28.41 (6.50)
12-month	142	33.86 (6.00)	61	32.72 (6.95)	399	31.03 (6.11)	163	28.11 (7.41)
Mental distress								
Baseline	279	1.64 (0.58)	134	1.77 (0.62)	595	2.12 (0.73)	261	2.25 (0.78)
12-month	150	1.49 (0.62)	65	1.72 (0.75)	407	1.93 (0.68)	166	2.23 (0.78)
Body image flexibility								
Baseline	320	70.16 (9.35)	169	68.84 (11.05)	649	58.34 (15.32)	311	57.41 (16.53)
12-month	173	70.65 (11.31)	83	67.72 (12.66)	449	63.03 (16.00)	195	56.51 (19.43)
Media pressure								
Baseline	281	2.08 (1.13)	135	2.15 (1.17)	596	3.15 (1.25)	283	3.28 (1.27)
12-month	151	1.89 (1.03)	64	2.06 (1.09)	420	2.90 (1.27)	170	3.37 (1.23)
Thin internalization								
Baseline	281	2.48 (0.93)	135	2.63 (0.92)	596	3.27 (1.07)	283	3.41 (1.14)
12-month	151	2.06 (0.88)	64	2.26 (0.79)	420	2.79 (1.13)	170	3.28 (1.19)
Muscular internalization								
Baseline	281	3.23 (1.11)	135	3.37 (1.03)	596	3.01 (1.09)	283	2.98 (1.05)
12-month	151	2.77 (1.06)	64	3.08 (1.09)	420	2.68 (1.03)	170	2.73 (1.09)
Drive for leanness scale								
Baseline	332	3.58 (1.02)	175	3.70 (1.09)	664	3.49 (1.00)	324	3.42 (1.06)
12-month	180	3.63 (1.01)	86	3.86 (0.99)	467	3.37 (1.00)	202	3.56 (1.03)
Weekly protein supplement use % (n)								
Baseline	294	22.8 (67)	137	30.7 (42)	613	6.9 (42)	286	7.3 (21)
12-month	158	8.9 (14)	68	29.4 (20)	440	5.0 (22)	185	5.4 (10)
Weekly creatine supplement use % (n)								
Baseline	294	10.5 (31)	137	17.5 (24)	613	2.3 (14)	286	2.4 (7)
12-month	158	3.1 (9)	68	9.7 (9)	440	1.3 (8)	185	1.6 (3)
Weekly dieting supplement use % (n)								
Baseline	294	5.4 (16)	137	8.0 (11)	613	3.9 (24)	286	4.5 (13)
12-month	158	1.0 (3)	68	1.4 (1)	440	2.4 (15)	185	1.6 (3)
Weekly frequency of protein supplement use (0-7)								
Baseline	294	0.86 (1.83)	137	1.01 (1.80)	613	0.21 (0.93)	286	0.23 (0.98)
12-month	158	0.56 (1.50)	68	0.96 (1.77)	440	0.26 (1.13)	185	0.14 (0.76)
Weekly frequency of creatine supplement use (0-7)								
Baseline	294	0.46 (1.48)	137	0.74 (1.82)	613	0.07 (0.56)	286	0.04 (0.30)
12-month	158	0.25 (1.14)	68	0.52 (1.46)	440	0.05 (0.47)	185	0.02 (0.19)
Weekly frequency of dieting supplement use (0-7)								
Baseline	294	0.25 (1.16)	137	0.24 (0.95)	613	0.10 (0.60)	286	0.10 (0.60)
12-month	158	0.06 (0.59)	68	0.02 (0.18)	440	0.08 (0.60)	185	0.05 (0.19)

BMI = BMI, immigrants = two foreign born parents.

Paper I

Paper I investigated the proportion of girls and boys who consumed muscle-building and dieting supplements on a weekly basis and explored whether use was explained by risk or protective factors for ED development, physical activity, exercise and sport participation, and immigrant status.

Use of muscle-building and dieting supplements

More boys than girls consumed muscle-building supplements on a weekly basis (Paper I, Table 2). Furthermore, as shown in Paper I (Table 2), boys were more likely than girls to consume multiple supplements. In addition, among users of muscle-building and dieting supplements, boys were more frequent users of all three supplements than girls were (Paper I, Table 2). Immigrant boys used muscle-building and dieting supplements more often than nonimmigrant boys did, and immigrant girls used creatine supplements more often than nonimmigrant girls did.

Users versus nonusers (not published)

Differences in demographic, psychometric, and exercise and sport participation variables between boy nonusers (not consuming any supplements) and users of muscle-building and dieting supplements are presented in Table 7. Among boys, users of muscle-building and dieting supplements scored more unfavorably than nonusers on all psychometric instruments except for self-esteem among muscle building supplement users. In addition, users of muscle-building and dieting supplements were more likely to report exercising in a fitness center and participating in weight-sensitive sports than nonusers were. Boys consuming muscle-building supplements were also more physically active and more likely to participate in general sports and exercise activities (i.e., endurance and resistance exercise) than nonusers were.

Among girls, protein supplement users had higher muscular internalization and lower self-esteem than nonusers did (Table 8). In addition, girl protein supplement users were more physically active, more likely to exercise in a gym, and more likely to participate in weight class and gravitational sports compared to nonusers. Girl creatine supplement users did not differ from nonusers except that a higher proportion of creatine supplement users compared to nonusers had an immigrant background. On average, girl users of dieting supplements had lower BMI and more unfavorable scores on all psychological outcomes and were more likely to exercise in a fitness center than nonusers were.

Explanatory factors for use

The hierarchical multiple regression analyses showed that more frequent use of muscle-building and dieting supplements were significantly explained by immigrant status, ED symptomatology, appearance internalization, and sport and exercise participation in boys but not in girls (Paper I, Tables 3 and 4). The final model explained 23%, 25%, and 40% of the variance in creatine, protein, and dieting supplement usage among boys, respectively. In total, among girls, 5 to 6% of the variance in the use of protein, creatine, and dieting supplements was explained by the independent variables.

Table 7. Differences between male muscle building- and dieting supplement users and nonuser in demographic and psychometric variables and exercise and sport participation presented as mean and standard deviation and numbers of observations and percentage. Effect size (ES), Cohens d (d) or odds ratio (OR) is shown for significant between group differences.

	Nonusers [a]	Protein [b]	P* [a-b]	ES (d/OR)	Creatine [c]	P* [a-c]	ES (d/OR)	Dieting [d]	P* [a-d]	ES (d/OR)
BOYS (n)	**428**	**185**			**105**			**50**		
Age	16.75 (0.49)	16.78 (0.48)	0.505		16.75 (0.48)	0.982		16.76 (0.51)	0.903	
Body mass index	21.59 (2.72)	22.05 (2.76)	0.058		22.12 (3.02)	0.08		22.47 (2.59)	0.038	
Immigrant status	43 (10.0)	37 (20.0)	**0.002**	**2.24^{OR}**	24 (22.9)	**0.001**	**2.65^{OR}**	11 (22.0)	**0.017**	**2.53^{OR}**
Income > 1 million NOK	208 (48.6)	85 (45.9)	0.597		53 (50.5)	0.745		18 (36.0)	0.101	
ED symptomatology	0.84 (1.02)	1.35 (1.33)	**<0.001**	**0.43^{d}**	1.50 (1.41)	**<0.001**	**0.54^{d}**	2.46 (1.59)	**<0.001**	**1.22^{d}**
Thin internalization	2.42 (0.93)	2.77 (0.96)	**<0.001**	**0.37^{d}**	2.72 (0.98)	**0.006**	**0.31^{d}**	3.22 (0.97)	**<0.001**	**0.84^{d}**
Muscular internalization	2.98 (1.06)	3.78 (0.94)	**0.001**	**0.80^{d}**	3.70 (1.00)	**<0.001**	**0.70^{d}**	3.38 (1.01)	**0.010**	**0.39^{d}**
Media pressure	2.03 (1.13)	2.42 (1.19)	**<0.001**	**0.34^{d}**	2.54 (1.20)	**<0.001**	**0.44^{d}**	3.08 (1.04)	**<0.001**	**0.97^{d}**
Self-esteem	32.98 (5.94)	32.14 (6.27)	0.120		31.56 (6.51)	0.031		26.94 (4.64)	**<0.001**	**1.13^{d}**
Mental distress	1.59 (0.57)	1.73 (0.65)	**0.010**	**0.21^{d}**	1.77 (0.71)	**0.006**	**0.27^{d}**	2.04 (0.81)	**<0.001**	**0.64^{d}**
PA hours/week	7.79 (5.54)	9.52 (7.00)	**0.005**	**0.27^{d}**	10.06 (8.52)	**0.001**	**0.32^{d}**	9.47 (12.29)	0.141	
Fitness center exercise	184 (43.0)	148 (80.0)	**<0.001**	**5.30^{OR}**	84 (80.0)	**<0.001**	**5.30^{OR}**	32 (64.0)	**0.006**	**2.36^{OR}**
Organized sport	231 (54.0)	97 (52.4)	0.725		49 (46.7)	0.192		27 (54.0)	1.000	
Weight class and gravitational sports	116 (27.1)	118 (63.8)	**<0.001**	**4.74^{OR}**	78 (74.3)	**<0.001**	**7.77^{OR}**	42 (84.0)	**<0.001**	**14.12^{OR}**
Aesthetical sports	29 (6.8)	31 (16.8)	**<0.001**	**2.77^{OR}**	24 (22.9)	**<0.001**	**4.08^{OR}**	23 (46.0)	**<0.001**	**11.72^{OR}**
General sport and exercise	370 (86.4)	176 (95.1)	**0.001**	**3.07^{OR}**	99 (94.3)	**0.029**	**2.57^{OR}**	45 (90.0)	0.659	

*significance level is lowered to 0.010. ED = eating disorder, PA = physical activity, Protein = protein supplement use, Creatine = Creatine supplement use, Dieting = dieting supplement use.

Table 8. Differences between female muscle building- and dieting supplement users and nonuser in demographic and psychometric variables and exercise and sport participation presented as mean and standard deviation, and numbers of observations and percentage. Effect size (ES), Cohens d (d) or odds ratio (OR) is shown for significant between group differences.

	Nonusers [a]	Protein [b]	P* [a-b]	ES (d/OR)	Creatine [c]	P* [a-c]	ES (d/OR)	Dieting [d]	P* [a-d]	ES (d/OR)
GIRLS (n)	**897**	**101**			**32**			**74**		
Age	16.78 (0.47)	16.83 (0.49)	0.255		16.84 (0.51)	0.420		16.78 (0.56)	0.880	
Body mass index	21.36 (2.84)	20.79 (2.46)	0.032		21.11 (3.32)	0.636		22.34 (2.58)	**0.004**	**0.36[d]**
Immigrant status	118 (13.2)	17 (16.8)	0.386		9 (28.1)	**0.003**	**2.58[OR]**	5 (6.8)	0.144	
Income > 1 million NOK	300 (33.4)	29 (28.7)	0.373		7 (21.9)	0.187		25 (33.8)	1.000	
ED symptomatology	2.38 (1.62)	2.58 (1.62)	0.231		2.72 (1.63)	0.241		4.13 (1.30)	**<0.001**	**1.19[d]**
Thin internalization	3.31 (1.09)	3.30 (1.05)	0.952		2.93 (1.20)	0.053		3.97 (0.95)	**<0.001**	**0.65[d]**
Muscular internalization	2.94 (1.08)	3.40 (1.02)	**<0.001**	**0.43[d]**	2.79 (1.01)	0.429		3.48 (0.97)	**<0.001**	**0.52[d]**
Media pressure	3.19 (1.25)	3.00 (1.25)	0.157		2.95 (1.25)	0.276		3.72 (1.11)	**<0.001**	**0.46[d]**
Self-esteem	29.42 (6.17)	27.87 (6.05)	**0.010**	**0.25[d]**	27.28 (5.11)	0.027		24.92 (5.58)	**<0.001**	**0.77[d]**
Mental distress	2.15 (0.74)	2.23 (0.73)	0.329		2.20 (0.87)	0.686		2.50 (0.76)	**<0.001**	**0.48[d]**
PA hours/week	6.62 (4.79)	8.50 (7.60)	**<0.001**	**0.26[d]**	7.03 (6.82)	0.612		8.59 (7.20)	0.029	
Fitness center exercise	350 (39.0)	54 (53.5)	**0.007**	**1.80**	15 (49.6)	0.365		44 (59.5)	**0.001**	**2.29[OR]**
Organized sport	341 (38.0)	39 (38.6)	0.914		12 (37.5)	1.000		29 (39.2)	0.901	
Weight class and gravitational sports	217 (24.2)	39 (38.6)	**0.003**	**1.97**	13 (40.6)	0.058		24 (32.4)	0.124	
Aesthetical sports	294 (32.8)	31 (30.7)	0.737		15 (46.9)	0.125		27 (36.5)	0.522	
General sport and exercise	719 (80.2)	85 (84.2)	0.426		21 (65.6)	0.070		61 (82.4)	0.761	

*significance level is lowered to 0.010. ED = eating disorder, PA = physical activity, Protein = protein supplement use, Creatine = Creatine supplement use, Dieting = dieting supplement use.

Paper II

Paper II presents the effect of the HBI intervention on supplement use and risk and protective factors for ED development in boys and girls. The results from the linear mixed model showing the main and interaction effects of and between group, time, and gender are presented in Paper II, Table 4. The results from the planned comparison between the intervention and control groups in the main and secondary outcomes are presented as estimated marginal mean scores at all measurement timepoints for the whole sample (Paper II, Table 5) and for boys and girls separately (Paper II, Table 6).

Intervention effect on eating disorder symptomatology

Only girls had a 12-month effect with respect to ED symptomatology since gender acted as a significant moderator for the intervention effect. In girls, a small intervention effect emerged at the posttest and gradually increased to moderate at the 12-month follow-up.

Protective factors

The intervention had a favorable effect on self-esteem that was observed 12 months after the intervention in both boys and girls. Gender moderated the intervention effect for body image flexibility where only a 3-month effect was present in boys and an immediate and 12-month effect was present in girls.

Risk factors

The intervention created an effect on mental distress that emerged at the 12-month follow-up in boys and girls. Gender moderated the intervention effect on thin appearance internalization and media pressure since a sustained effect was only observed among intervention girls. Boys experienced only an immediate effect on thin internalization that was lost by the 3-month follow-up. Gender did not act as a significant moderator for the intervention effect on muscular internalization or drive for leanness; however, planned post-hoc comparisons revealed that the effect on muscular internalization faded by the 12-month follow-up and that significant differences between the intervention and control groups in the drive for leanness were only present in girls.

Muscle-building and dieting supplement use

A significant interaction between group and time was observed for the weekly frequency of protein and creatine supplement use. The planned comparison revealed that the intervention effect was only present in boys at the 3- and 12- month follow-ups. No intervention effect was observed for dieting supplement use in boys or girls.

Table 9 presents new cases of supplement use in the intervention and control groups (unpublished). Fewer new cases of protein supplement use at the 3- and 12-month follow-ups and creatine supplement use at the 12-month follow-up were observed among intervention boys compared to control boys. Fewer new cases of protein supplement use were observed among intervention girls compared to control girls at the posttest.

Table 9. New cases* of supplement use at the posttest and follow-ups.

	Boys						Girls					
	Intervention		Control				Intervention		Control			
	N	% (n)	n	% (n)	p	OR	n	% (n)	n	% (n)	p	OR
Protein supplements												
posttest	193	6.2 (12)	87	11.5 (10)	0.151		499	2.8 (14)	243	6.2 (15)	**0.041**	**1.41**
3-month	155	7.1 (11)	65	21.5 (14)	**0.004**	**1.68**	432	6.3 (27)	203	3.9 (8)	0.268	
12-month	130	5.4 (7)	50	26.0 (13)	**< 0.001**	**2.2**	427	4.4 (19)	175	4.7 (8)	1.000	
Creatine supplements												
posttest	222	3.6 (8)	103	4.9 (5)	0.559		521	1.2 (6)	252	1.2 (3)	1.000	
3-month	180	4.4 (8)	78	6.4 (5)	0.541		450	2.0 (9)	211	1.9 (4)	1.000	
12-month	144	2.1 (3)	59	8.5 (5)	**0.048**	**1.93**	445	1.6 (7)	182	1.1 (2)	1.000	
Dieting supplements												
posttest	235	0.9 (2)	111	0.0 (0)	1.000		513	1.8 (9)	247	2.0 (5)	0.779	
3-month	189	0.5 (1)	88	3.4 (3)	0.096		442	1.6 (7)	205	1.5 (3)	1.000	
12-month	154	0.0 (0)	65	1.5 (1)	0.297		437	2.1 (9)	179	1.8 (3)	1.000	

*Only including participants who did not use supplements at the baseline.

Reliable and relevant changes in eating disorder symptomatology (unpublished)

Reliable and relevant changes in ED symptomatology are illustrated in Figure 5. In boys, the mean change in the ED symptomatology score was 0.21 (SD 0.72) in the intervention group and 0.32 (SD 0.90) in the control group. Reliable change in boys constituted a change greater than 0.81. No difference between intervention or control boys in reliable unfavorable change (4.5% vs. 4.5, p = 0.99, OR = 1.00) or reliable favorable change (15.5 vs. 22.0, p = 0.217, OR = 1.57) was observed. Moreover, the proportion of boys experiencing a clinically relevant change and clinically relevant deterioration was the same among intervention and control boys, respectively (7.1% vs. 13.4%, p = 0.136, OR = 0.492 and 1.9% vs. 1.5%, p = 0.820, OR = 1.30).

In girls (Figure 5), the mean change in the ED symptomatology score was 0.47 (SD1.17) in the intervention group and 0.19 (SD 1.26) in the control group. In girls, a reliable change was equal to a change in score greater than 1.07. More girls in the intervention group compared to the control group experienced a reliable favorable change (27.5% vs. 20.4%, p = 0.045, OR = 1.54). Moreover, fewer girls in the intervention group compared to the control group had a reliable unfavorable change (6.8% vs. 13.6%, p = 0.009, OR = 2.12).

An equal proportion of intervention girls and control girls experienced a clinically relevant change in ED symptomatology score from the baseline to the 12-month follow-up (9.0% vs. 9.0%, p = 1.000, OR = 1.00). However, more control girls compared to intervention girls had a clinically relevant deterioration of their ED symptomatology (2.9% vs. 6.8%, p = 0.034, OR = 2.38).

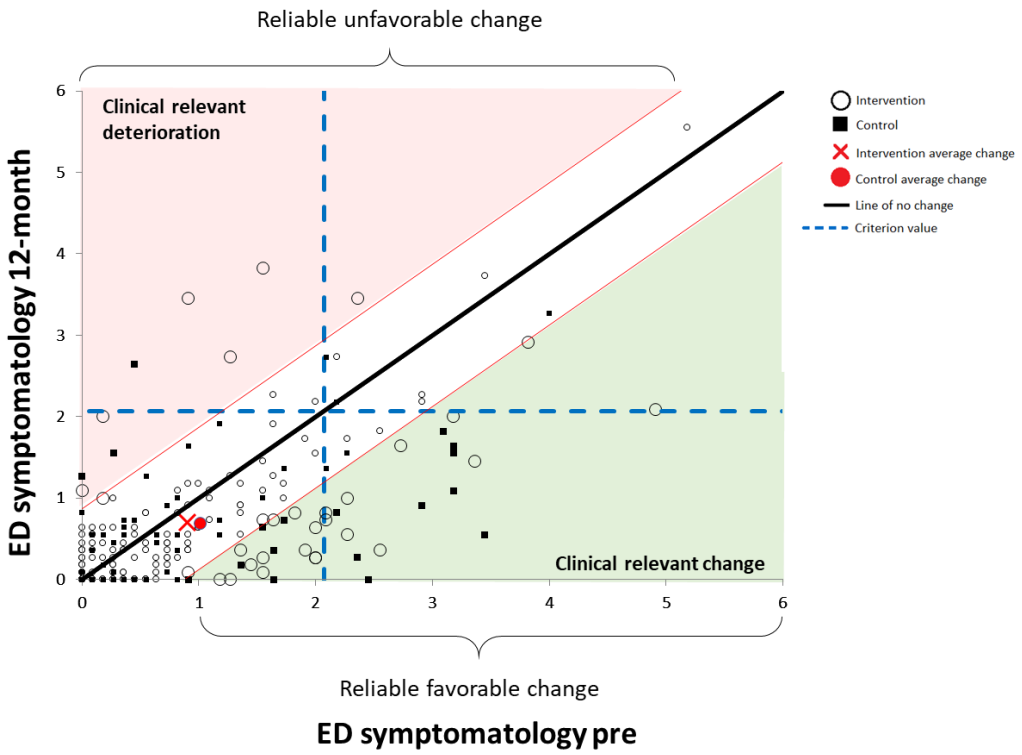

Figure 5. Leeds relevant change indicator illustrating the proportion of boys from the intervention and control groups who had a reliable and relevant change 12 months after the intervention.

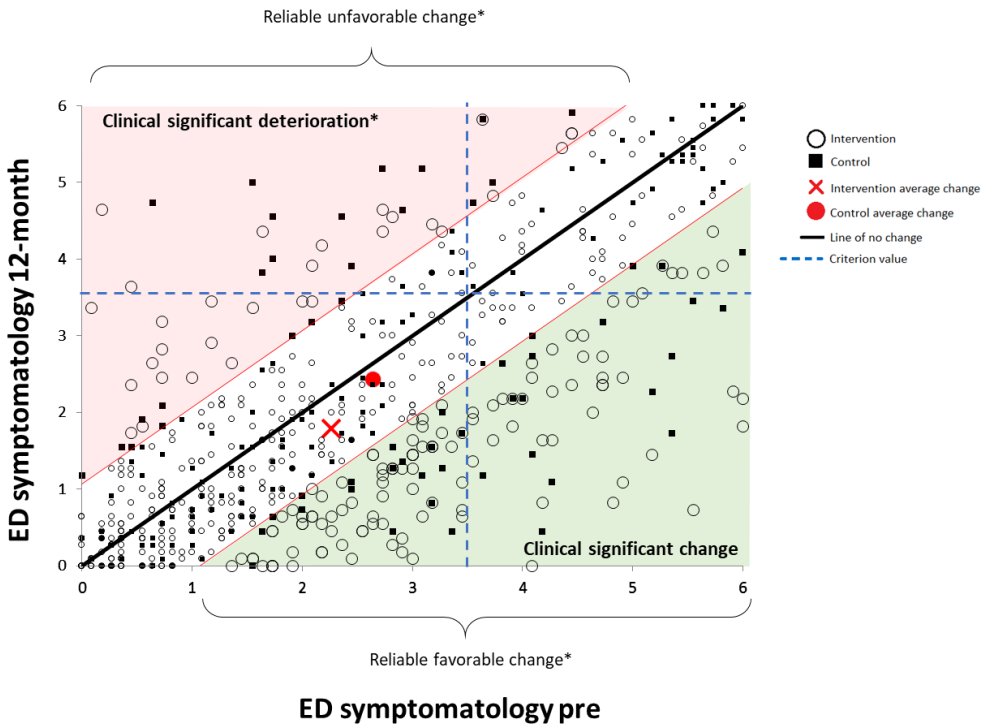

Figure 6. Leeds relevant change indicator illustrating the proportion of girls from the intervention and control groups who had a reliable and relevant change 12 months after the intervention. * = p = < 0.05 in favor of the intervention group.

Paper III

Paper III investigated whether the intervention effect on ED symptomatology and muscle-building supplement use was facilitated by the change in the suggested mediators, namely self-esteem, body image flexibility, appearance pressure from media, thin appearance internalization, and muscular appearance internalization.

Path analyses and change mechanisms

The change from the baseline to the 12-month follow-up in self-esteem, body image flexibility, thin appearance internalization, and appearance pressure from media explained the intervention effect on ED symptomatology in girls (Paper III, Figure 2a–e). Furthermore, a significant indirect effect of the intervention on creatine supplement use 12 months after the intervention through reduced thin appearance internalization was observed in girls (Paper III, Figure 2c). Change in the suggested mediators did not explain ED symptomatology in boys or muscle-building supplement use in boys or girls at the 12-month follow-up.

There was a significant relationship between the increase in body image flexibility and ED pathology 12 months after the intervention in boys (Paper III, Figure 2b). This means that a larger increase in body image flexibility observed in boys was associated with lower ED symptomatology at the 12-month follow-up in boys independent of group. Additionally, a greater decrease in thin appearance internalization between the baseline and the 12-month follow-up was associated with more frequent creatine supplement use 12 months after the intervention in boys and girls independent of group (Paper III, Figure 2c). Moreover, a significant indirect effect between change in perceived media pressure and protein supplement use at the 12-month follow-up was observed. This means that a greater increase in perceived media pressure explained less frequent protein supplement use at the 12-month follow-up in boys independent of group.

Discussion

We aimed to 1) investigate the proportion of boys and girls using muscle-building and dieting supplements.; 2) investigate if such use was associated with risk and protective factors for ED development, sport and exercise participation, and immigrant status.; 3) investigate the immediate and long-term effect of the HBI intervention on risk and protective factors for ED development and muscle-building and dieting supplement use among boys and girls; and 4) explore potential mediators for the effect of intervention on ED symptomatology and muscle-building supplement use in boys and girls.

Use of muscle-building and dieting supplements (Paper I)

As many as one of five adolescents consumed muscle-building supplements one to two times per week or more often, notably among boys and immigrants. A previous study estimated that the use of muscle-building behaviors and supplements peaked at ages 20 to 22 years in boys but remained relatively stable during adolescence and young adulthood in girls (297). Comparison of our results to studies including younger adolescent boys should therefore be conducted with caution. The proportion of users in our study seems comparable to that in previous studies (Introduction, p. 13) reporting muscle-building supplement use in adolescents (189, 191, 203, 206, 208). Still, the numbers of muscle-building supplement users are at the higher end of the spectrum since we reported frequent use as opposed to lifetime or 12-month prevalence. The high number of users of muscle-building supplements in our study may relate to the fact that a large proportion of the adolescents participated in some form of organized sport (Table 5) where supplement use may be a means of enhancing sport performance. Nevertheless, the high number of supplement users in our study raises concerns due to the potential health risk that may come with consuming a large volume of such supplements (199-201, 298) and may lower the barrier for future anabolic steroid use (192, 203-205).

The use of dieting supplements is considered a DE behavior often used to lose weight (299). Previous studies have highlighted that girls are more prone to try to lose weight than boys and that the use of methods traditionally associated with weight reduction was more prevalent among girls (24, 299, 300). A previous longitudinal study including US adolescents and young adults found that the weekly prevalence of dieting pills use increased in both girls (from 2% to almost 5.5%) and boys (from below 1% to almost 2%) between late adolescence and early adulthood (299). Our finding that 7 to 8% of both girls and boys consumed dieting supplements contrasts with previous studies and

suggests that the use of dieting supplements is highly prevalent among both genders in this age group.

Most studies of DE behaviors in adolescents have assessed the use of diet pills. However, diet pills only represent one group of dieting supplements. Including a broader range of dieting products such as products advertised as "fat burners" (and sold by companies with a clear muscle-building profile) may have captured adolescents who fall within the muscular-oriented dimension of body idealization and body image. This could be important since some individuals may use dieting supplements to increase muscle definition by losing fat mass without aiming to reduce their body weight. As such, consuming dieting supplements may be perceived as equally relevant for boys and girls. Many studies include reasons for use when they phrase questions assessing DE behaviors such as "Have you ever used diet pills to aid weight loss?" (41, 94, 301-304). Some also only deliver questions to participants who provide an affirmative answer to a question about whether they are "trying to lose weight" (299). Individuals who have consumed diet pills (or used other DE behaviors) to aid fat loss to increase muscle definition rather than reduce their body weight may not have been identified as "users" in some previous studies. The consequence may have been an underestimation of the prevalence of use and may have influenced the conclusion regarding how use was associated with other factors (e.g., ethnicity, socioeconomic status, exercise and sport participation, and mental health outcomes).

Muscle-building supplement use and immigrant status

In our study, use of all muscle-building and dieting supplements was more common among boys with an immigrant background. In addition, immigrant girls were more frequent users of creatine supplements compared to nonimmigrant girls. Most studies investigating muscle-building supplement use do not include a measure of immigrant status, but one study reported that boys and girls of Asian ethnicities consumed more protein supplements than non-Asians did (208). Moreover, drive for muscularity, body dissatisfaction, and body-altering methods vary between cultures and could be higher among non-White males than males of White ethnicities (305, 306). Because we assessed immigrant status rather than ethnicity, making comparisons with other studies is difficult. Immigrant status is different from ethnicity because it does not divide individuals into groups based on the background of inheritance but based on whether their parents were born inside or outside Norway. Immigrant status may therefore be a broader concept reflecting the experience of integration into the society and possibly the experience of being part of a minority or majority societal group. Some

immigrant boys may be part of a culture where masculinity is strongly defined by muscularity (307), which may result in more muscle-building behaviors. Furthermore, immigrant boys in such cultures may have more friends who engage in muscle-building behaviors, which in turn could make them more likely to use muscle-building supplements due to the increased importance of peer influence during adolescence (207).

Immigrant girls were more frequent users of creatine supplements than nonimmigrant girls were. This finding is surprising and novel and not reported elsewhere. It has been reported that females with a non-Western background may experience lower muscularity drives and less appearance internalization (308). However, acculturation caused by integration may have made the immigrant girls adopt a Western appearance standard resulting in a higher idealization of an athletic body ideal (309). However, it is also likely that some of the immigrant girls in our sample originate from a Western country and thus perceived themselves as being of the ethnic majority. Another hypothesis is that immigrant girls could have been influenced by males within their culture who are also heavier users of muscle-building supplements. The origin for the last hypothesis is from previous research on female steroid users, which found that almost all female steroid users were introduced to steroids by a male they trusted (e.g., boyfriend, friend, close male relative; 310, 311). Regardless, immigrant status did not remain an independent explanatory factor for creatine supplement use when the role of ED risk and protective factors and sport and exercise participation were accounted for. This suggests that more creatine supplement use was not related to the fact that the participants were immigrants but rather to the engagement in sports where creatine supplement use is more common. However, the association between sport participation and creatine supplement use were very small, which makes this reasoning another hypothesis. Future studies could include both ethnicity and immigrant status to investigate whether creatine supplement use is more strongly related to one of these factors. Moreover, performing qualitative interviews with both immigrant and nonimmigrants girls from different ethnicities may improve the understanding of the context and nature of creatine supplement use (and other muscle-building behaviors) among this group of girls.

Association with risk and protective factors for eating disorder development and exercise and sport participation

Enhancing muscularity, burning fat, compensating for suboptimal eating, and enhancing performance have been reported to be central motives for muscle-building supplement use in high school adolescents (312), and this use has been explained by more unfavorable body image and ED

outcomes (191, 196). Furthermore, muscle-building supplement use is more prevalent among adolescents participating in sports and weight training (206, 312). Therefore, it is unsurprising that we found that the use of muscle-building supplements in boys was associated with reporting more unfavorable scores on almost all outcomes acting as risk factors for EDs and engaging in exercise and sports emphasizing appearance, strength, and body weight.

Results from the multiple regression analyses reveal that ED symptomatology was a universal significant explanatory factor for more frequent use of all muscle-building and dieting supplements. Furthermore, more frequent use of muscle-building and dieting supplements had similar explanatory factors except for appearance internalization, which did not explain dieting supplement use. Our results also support the development and implementation of universal interventions aiming to prevent both EDs and muscle-building and dieting supplement use in adolescent boys since more frequent use could be considered a symptom of DE. Our results may suggest that interventions that are successful in reducing ED symptomatology and muscular appearance internalization may be able to prevent the use of muscle-building and dieting supplements.

As somewhat similar to the study by Yager and McLean (206), engaging in fitness center exercise and sport participation stood out as explanatory factors for more frequent use of muscle-building supplements in our study. This was not surprising because muscle-building supplements may be considered common among adult fitness center attendees (313) and adolescent athletes (314, 315). Additionally, the fitness center context may also be considered a source of appearance pressure, which may increase appearance idealization (183).

There was a significant correlation between the three different muscle-building and dieting supplements in boys where half of the boys consumed multiple muscle-building and dieting supplements. This increased the homogeneity between the three groups of supplements, especially in boys. The consequence is that the three groups of supplement use (i.e., protein, creatine, and dieting supplements) became less distinct with similar in explanatory factors for use. Moreover, explanatory factors for protein and creatine supplement use accounted for only 25% and 23% of the variance in use, respectively. This means that approximately 75% of the variance in use was explained by other factors not assessed or by measurement error. In contrast, 40% of the variation in the use of dieting supplements was explained by ED symptomatology, fitness center exercise, and participation in weight-sensitive sports.

Our results indicate that girls who consumed protein supplements were more physically active, more likely to exercise in a fitness center, and more likely to engage in weigh class and gravitational sports than nonusers were. Moreover, girls who consumed protein supplements reported higher muscular appearance internalization and lower self-esteem. Girls who consumed creatine supplements were more likely to be immigrants. Furthermore, compared to nonusers, users of dieting supplements had higher BMI, scored more unfavorably on all psychometric measures, and were more likely to exercise in a fitness center. Surprisingly, ED risk and protective factors and sport and exercise variables accounted for only 5 to 6% of the variance in the use of muscle-building and dieting supplements, indicating that almost 95% of the use is better explained by other factors or measurement errors. However, our findings are novel and indicate that the use of muscle-building and dieting supplements is almost unrelated to sport and exercise. Our results also weaken the hypothesis that muscle-building supplements are used to enhance performance in sports. Moreover, our results do not support previous findings among young females (196) that muscle-building supplements are associated with DE attitudes or behaviors. However, the absolute number of female supplement users was low, and our analyses may be hampered by a low statistical power that may have limited the ability to identify significant differences between users and nonusers and detect significant explanatory factors for use.

Our results from Paper I were that use of muscle-building and dieting supplements was common in boys and girls and related to both ED risk factors and exercise and sport participation in boys. Therefore, a suggestion is that prevention intervention should aim to reduce ED symptomatology and muscular appearance internalization and increase resilience and literacy against supplement advertising and marketing. Increased knowledge about muscle-building supplement use among adolescents, fitness center staff, and sport coaches may be beneficial when aiming to prevent use among boys who also use supplements for performance reasons. Another suggestion is that prevention efforts are especially aimed at adolescents exercising at fitness centers and those participating in weight-sensitive sports. Furthermore, there is a need for policy change and legislation to better regulate the industry and include statutory third-party testing of supplements to reduce the risk of large proportions of contaminated supplements reaching adolescent consumers (316).

Effect of the Healthy Body Image intervention (Papers II and III)

The HBI intervention is the first universal intervention reporting on the effect of both risk and protective factors for ED development and muscle-building supplement use in adolescent boys and

girls. The HBI intervention was successful in reducing risk factors for and enhancing protective factors against ED development in boys and girls and preventing supplement use among boys. However, some gender differences were present, indicating that the girls benefited more from the HBI intervention with respect to psychological outcomes than the boys did.

Effect of the intervention on eating disorder symptomatology (Paper II)

The HBI intervention created an immediate small effect on ED symptomatology in girls that became moderate by the 12-month follow-up. Large variations between intervention studies in sample size, follow-up time, outcome measures, intervention method, and participant age challenge meaningful direct comparison between ED prevention studies. All of the programs except for the study by Eickman, Betts (148) had a younger age group than in our study, which may result in weaker or smaller effects (317). As summarized in the introduction (Table 1), two studies have reported favorable intervention outcomes on measures roughly comparable to the ED symptomatology (i.e., weight and shape concern subscales or the global score from the EDEQ; 148, 220). In contrast to our findings, these two interventions created moderate and large effect sizes for the difference between intervention and control girls. Unfortunately, both interventions had only posttest assessments, which limited the ability to evaluate whether the intervention effect was sustained over time. Including follow-up assessments is crucial when evaluating the effect for several reasons. First, it may not be reasonable or ethically sound to spend resources to implement an intervention creating only temporary effects (318). Second, successful programs with no immediate effect may be cut off as ineffective when they may have a maturation or sleeper effect, and third, potential harmful effects in either boys or girls may develop over time and go undetected in interventions with short follow-up time, such as in Wilksch, Paxton (221). The strengthened effect by the 12-month follow-up observed for several outcomes in our study indicates that some of the intervention content required time to mature before it was manifested in reduced ED symptomatology in girls. A maturation effect on ED symptomatology was also observed in the study by Gonzalez, Penelo (217) in boys and girls and by Warschburger and Zitzmann (226) in girls.

All of the studies reporting favorable outcomes for ED symptomatology or similar outcomes had an intervention strategy targeting media literacy alone (216) or in combination with nutrition (148, 217, 226). The only intervention that did not target media literacy was the “Life-Smart” lifestyle intervention by Wilksch and Wade (220). Unfortunately, the promising finding from the pilot study was not replicated in the main study (221). In contrast, the intervention created lasting undesired

effects in weight and shape concerns and eating concerns in girls. Our results correspond well with current systematic reviews concluding that targeting media literacy is advised for universal ED prevention (210, 319).

In contrast to girls, boys did not benefit from the HBI intervention with respect to ED symptomatology. Gender differences are discussed more thoroughly below (p. 61). However, some considerations may shed light on the findings regarding ED symptomatology in particular. Fortunately, but not in favor of the HBI intervention, all boys reduced their ED symptomatology score over the follow-up period, suggesting a decreased ED risk. The reduction in ED symptomatology observed in boys may be explained by pubertal changes such as weight gain and increased muscle mass, which brings boys closer to the male appearance ideal (320). Moreover, increased circulating testosterone in postpubertal boys is found to decrease their ED risk (75). One may argue that it could be difficult to reduce ED symptomatology exceeding the natural developmental trajectory, especially considering that boys in general had low scores in ED symptomatology at the baseline, raising the issue of floor effects and leaving little room for improvement.

Reliable and relevant change in eating disorder symptomatology (unpublished)

The reliable and clinically relevant change was calculated to provide an additional perspective on our results. These results should be interpreted with caution because they, in contrast to the mixed linear model (Paper II), only include participants with data recorded at both the baseline and the 12-month follow-up, and the analysis is not adjusted for baseline scores or cluster. To our knowledge, only one universal ED prevention intervention has reported measures on reliable change (216), and none have included measures of clinically relevant change. In our study, intervention girls were more likely to experience a reliable favorable change in ED symptomatology. Moreover, control girls were twice as likely to experience clinically relevant deterioration of ED symptomatology than intervention girls were. Our results are roughly comparable to those of Wilksch and Wade (216). Additionally, compared to normative values for young females in Norway (290), the decreases in ED symptomatology from the baseline to the 12-month follow-up among intervention girls on average corresponded to a score representing the 75^{th} percentile to the 55^{th} percentile. These results might add to the support of the HBI program by suggesting that the effect observed among girls was reliable and relevant. Moreover, our results also underline the lack of intervention effect on ED symptomatology observed among boys. However, the reliable change index of 0.81 in boys

highlights the issue of floor effects since almost 60% of the boys could never experience a reliable (or clinically relevant) change since their ED symptomatology score was lower than 0.81 at the baseline.

Pathways of intervention effects on eating disorder symptomatology (Paper III)

A promising finding was the 12-month intervention effect on all secondary psychological outcome measures in girls. As such, the HBI intervention is the first intervention to create a 12-month effect on such a high number of outcomes in girls. In addition, our results bring novel findings to the field of universal ED prevention by suggesting several potential pathways to intervention effects on ED symptomatology in girls. Moreover, this is the first study to investigate gender-specific mediators in universal ED prevention, which has been requested by Wade, Wilksch (264). In contrast to girls, we did not observe any significant mediators in boys. However, this could be explained by the fact that we did not observe any intervention effect on ED symptomatology in boys. It is also possible that the changes in the mediators were too small to generate improvements in ED symptomatology in boys.

The included secondary outcomes are recognized as possible predictors or mediators for ED development within sociocultural frameworks and the developmental theory of embodiment (54, 57, 58, 321). However, few studies have investigated the relationship between the suggested predictors and mediators and the risk of ED development using a causal design. Our finding that change in thin appearance internalization mediated the effect of the intervention on ED symptomatology in girls is somewhat similar to studies that found that general media appearance internalization acted as a mediator for intervention effect in targeted (322-324) and universal (225, 264) ED prevention programs. The study by Agam-Bitton, Abu Ahmad (225) also found that the change in media literacy but not self-esteem mediated the effect of the intervention on body esteem. In the HBI intervention, all the suggested mediators except for muscular appearance internalization acted as significant mediators between the intervention and ED symptomatology in girls. It is not possible to disentangle what kind of intervention components might account for the change in the mediators since each session targeted multiple psychological constructs. Furthermore, the intervention was developed to communicate similar messages repeated in different ways to stimulate elaboration of the intervention content. Discussion about what intervention content could have created change in the mediator is therefore mainly speculation. Likewise, discussing change in one mediator is impossible without considering change in related psychological factors since the different outcomes interact and influence each other, creating a situation of multiple mediation. For example, it is possible that the

intervention effect on thin appearance internalization was mediated by the change in both self-esteem and perceived appearance pressure (58). Moreover, the relationship between the mediator and the outcome was contemporary since we assessed the mediator and the outcome within the same time period (325). This may raise the question of whether the change in the mediator occurred prior to the change in the outcome (326). For example, improving body image or reducing weight and shape concerns (which the EDEQ-11 also is a measure of) is likely to have a positive influence on self-esteem (28, 86, 139).

Other important factors unrelated to the HBI intervention could have caused a more favorable change in the mediators and ED symptomatology among intervention girls. Testing for baseline differences in randomized controlled trials is discouraged and should not be used as a tool to evaluate the quality of the randomization (327). However, differences in baseline characteristics may be relevant when discussing the effect of the intervention. Intervention girls had lower ED symptomatology, lower mental distress, and higher self-esteem than control girls did. Intervention girls also had a higher socioeconomical status than control girls did, which was reflected in immigrant status, parental education level, and annual family income. A more positive body image and higher self-esteem at the baseline may place intervention girls on a more favorable body image trajectory and predicted their mental health over time (328, 329). Moreover, higher self-esteem observed in intervention girls may have equipped them with important resources that could have made them more resilient and capable of coping with stressful life events in the future (330). Furthermore, higher mental distress, which was observed among control girls, could negatively predict their self-esteem over time (331). Finally, lower socioeconomical background predicts a more unfavorable development of both mental and physical health (332). Solely controlling for baseline values may not fully eliminate this effect. These mechanisms cold have been responsible for some of the observed intervention effects and may be considered as potential confounding factors.

Results from the mediation analysis in boys revealed that a favorable change in body image flexibility independent of group was associated with lower ED symptomatology 12 months after the intervention. This suggests that enhancing body image flexibility in boys could be a pathway to create an intervention effect on ED symptomatology in boys. Unfortunately, the intervention only created a temporary 3-month effect in body image flexibility in boys (Paper II). This may indicate that not enough time was spent on the intervention activities targeting psychological factors, which could have created a lasting effect in body image flexibility such as self-acceptance and self-

compassion (333, 334). A higher focus on self-compassion and self-acceptance could have made the boys more capable of behaving adaptively in response to unpleasant internal experiences of their body and reduced their risk of developing DE and EDs (321).

Intervention effect on supplement use (Paper II)

The study revealed small 3- and 12-month intervention effects in muscle-building supplement use in boys even if muscle-building and dieting supplement use was associated with dropout among control boys (article II). Additional analyses (not published) revealed that the HBI intervention prevented new cases of muscle-building supplement use 12 months after the intervention. As many as 26% and 8.5% of the boys in the control group who did not consume protein or creatine supplements at the baseline began to consume protein or creatine supplements, respectively, during the follow-up period. In contrast, less than 6% and 2% of new cases of protein and creatine supplement use, respectively, were observed in intervention boys at the 12-month follow-up. The HBI intervention brings novel knowledge to the field of the prevention of muscle-building supplement use by providing evidence that universal ED prevention interventions targeting body image, media literacy, and lifestyle could be successful in preventing muscle-building supplement use in boys. Moreover, this preventive effect on supplement use may be independent of the intervention effect on ED symptomatology or other body image-related outcomes. Surprisingly and promisingly, the intervention prevented new cases of protein supplement users in girls at posttest. Fortunately, but not in favor of the HBI intervention, the number of new cases of protein supplement use was reduced to the 12-month follow-up in control girls. The body of comparable interventions is limited since only one previous pilot study has aimed to prevent supplement use in regular high school boys (265). In contrast to our study, the study by Yager, McLean (265) did not create any intervention effect on supplement use, but they observed an intervention effect in body satisfaction. This finding also adds support to the benefit of combining supplement use and body image interventions.

Pathways of intervention effects on supplement use (Paper III)

Surprisingly, none of the suggested mediators explained the intervention effect on muscle-building supplement use in boys. We did expect that a change in muscular internalization would mediate the effect on both protein and creatine supplement use since muscular internalization acted as a significant explanatory factor for use in Paper I. This indicates that other change mechanisms may apply for muscle-building supplement use in boys. One previous study of female athletes suggested that increased knowledge about supplements and nutrition could be important mediators when aiming

to prevent muscle-building supplement use and DE behaviors (269). It could be that the intervention content targeting truths and myths related to muscle-building supplement use, exercise, and nutrition reduced the boys' intentions to use supplements, as in the study by Ranby, Aiken (269).

The results further suggest that enhancing thin appearance internalization in boys and girls and perceived appearance pressure in boys could reduce the use of creatine supplements. This makes partial sense since lower thin internalization was associated with more creatine supplement use among boys (Paper I). It may also be that boys and girls who consume creatine supplements internalize different appearance standards than those portrayed in media and the society in general as reflected in lower perceived media pressure and thin appearance internalization. Knowledge about adolescent girls' use of muscle-building supplements is limited. The significant indirect effect of the intervention on more frequent creatine supplement use through reduced thin appearance internalization was surprising. The finding may be explained by the fact that intervention girls perceived the thin appearance ideal as less desirable, thus lowering the barrier for consuming creatine supplements. However, our results are conflicting since no intervention effect on creatine supplement use was present for girls in the effect study (Paper II) and no difference between intervention and control girls in new cases of creatine supplement use was observed in the additional analyses (Table 9). Creatine supplements are some of a few muscle-building supplements with a documented effect on sport performance (198). To maintain credibility, authenticity, and authority, this was mentioned by the intervention deliverers when truths and myths related to dietary supplements were discussed in the third workshop. The participants also raised this topic. All of this may have lowered the barrier to creatine supplement use for some girls.

However, since adolescents may use creatine supplements to enhance their sport performance, the use of creatine supplements may be an expression of sport participation rather than mental health issues. Furthermore, sport and exercise in general may have a beneficial effect on body image because they may enhance self-esteem and physical self-efficacy (172, 173). Therefore, exercise and sport participation could be considered a potential confounding factor because it could influence both the mediator and the outcome in our study. This suspicion may be strengthened by the first paper in which we found that sport and exercise were independent explanatory factors for muscle-building supplement use among boys.

Gender differences in intervention effects

Among the studies with more than six months of follow-up that demonstrated an effect on risk or protective factors for ED development, only five studies reported positive results for a total of six outcomes in boys, whereas positive results were observed in six studies for 13 outcomes in girls (Table 1). With respect to psychological outcomes, our finding that gender moderated the effect in half of the outcomes is therefore in line with the trend for roughly comparable studies. Our finding supports previous research that existing universal ED prevention interventions have been less effective in boys (210).

The HBI intervention was performed in a classroom setting using only physically inactive components. Considering the knowledge that boys may benefit more from active learning styles, future studies should investigate whether interventions with more active elements could increase the intervention effect in boys.

The gender differences in learning trajectories might also partly explain a weaker intervention effect in boys. Often, gender differences in cognitive development favor adolescent girls because they tend to be one to two years ahead of boys in brain development (335). For example, girls' cerebral cortex and corpus callosum are more developed, and girls' brains contain a higher white to grey matter ratio than boys' brains do (335, 336). In addition, cognitive developmental advantages in the corpus callosum, frontal lobe, and limbic system makes girls process information between the two hemispheres more rapidly (335, 336). This could make girls respond to and process classroom information faster. Moreover, girls may be better at processing multiple messages and multitasking, whereas adolescent boys could benefit more from being educated in one topic at a time (337). Using a multicomponent intervention with cognitive elaboration may not have been optimal for boys.

It has previously been problematized that ED prevention interventions have not been (sufficiently) developed to target ED risk and protective factors in boys and that special features of the intervention content and delivery style may be important to consider (270, 338). A recent study by Doley, McLean (270) found several features that could be important when developing and conducting body image or ED prevention interventions in boys. The boys emphasized the importance of having a "safe space" for sharing personal information and the use of interactive and digital delivery styles. Scholars have identified that boys consider body image to be a "girl thing," which may increase the barrier to sharing and engaging in the intervention (338). Like other universal ED prevention interventions, the HBI intervention relied on a social code of trust and information sharing (270). This may be a natural

setting for girls because they are more prone to socialize with their peers by discussing their emotions than boys are (339). This may indicate that the intervention context may not have been optimal for boys. In retrospect, the HBI intervention could have been more aware of creating a safe space for boys to share since they may be more insecure about how their thoughts are received by others (270). However, boys expressed that they value the opportunity to discuss body image and mental health with trusted friends and that they appreciate the opportunity to hear others' opinions (270). An experience during the workshop was that performing the intervention for entire classes enabled the boys (and girls) to work and discuss with someone they trusted. We also got the impression that both boys and girls perceived the classroom setting as a safe space.

Scholars have debated whether interventions should be performed in a gender-specific or coeducational setting. "Girls only" interventions have been suggested for targeted ED prevention (317). However, the evidence supports conducting coeducational interventions for universal prevention. The study by Agam-Bitton, Abu Ahmad (225) found that a coeducational setting outperformed the "girls only" intervention. In support of a coeducational intervention, adolescents are in a time of development where social relations and peers are important influences for their self-perception and body image (340). Universal interventions performed in a natural social context of peers (e.g., a school class) may first result in important attitudinal changes on a group level, which in turn may facilitate improvements in ED risk and protective factors on an individual level. Moreover, research in the past years suggests that body ideals among girls and boys have become more similar since muscularity and leanness are also idealized in girls (113, 341). Developing interventions that also target muscularity-oriented body image may benefit boys as well as girls. However, the evidence for weaker intervention effects observed among boys in our study and previous studies raises the question of whether boys could benefit more from a "boys only" intervention. No study has compared the effect of a "boys only" intervention with a coeducational intervention. One may speculate whether boys as opposed to girls could benefit more from participating in a "boys only" intervention since this may enhance the focus on male-specific topics and the perception of a "safe space" for sharing personal and sensitive information.

In the HBI intervention, both facilitators were females. This could have benefited the girls, but the alliance with the boys may have been hampered since boys relate more to other males and could perceive a male deliverer as more credible, which influences how messages are elaborated (335). Additionally, even if the HBI intervention was piloted and included user involvement, the research

group was primarily comprised of females. Including young adult males in the planning, development, and delivery may have been favorable for the boys as suggested by Doley, McLean (270). However, in favor of the HBI intervention, both facilitators were professionals within the fields targeted in the HBI intervention and were therefore most likely perceived as trustworthy by the participants.

Internal validity

Study design

The randomized controlled design should have ensured that factors influencing the outcome were similar between the intervention and control groups. School size (numbers of available students) and demographic location were randomization factors. However, the randomization was performed at a group level and not at an individual level, which may have increased the risk of a skewed randomization.

The intervention group could be considered a healthier population than the control group since intervention boys and girls had more favorable outcomes on most measures. Moreover, the intervention group had higher socioeconomic status, which is likely to influence mental and physical health (332). Baseline scores of the outcomes were included as covariates, which increased the likelihood that the observed intervention effect was caused by the HBI intervention.

Repeated measures

Regression to the mean (i.e., more extreme values tend to naturally regress to more normal values when measures are repeated) is a normal phenomenon in study designs using repeated measures (342). Applying a randomized design may limit the consequence of regression to the mean because the randomization should ensure that the control and intervention groups have similar outcomes at the baseline. However, in our case, the intervention group appeared healthier than the control group, which may increase the risk of regression to the mean and weaken the ability to detect an intervention effect (e.g., the control group had a larger regression to the mean than the intervention group did).

The internal validity may be hampered by repeated measures since the participant could become familiar with the questionnaires and thus answer them more favorably over time. This could have resulted in improvements not caused by the intervention but rather by social desirability bias. This might especially apply among intervention participants who were exposed to intervention messages about desired and less desired attitudes or behaviors.

The questionnaire included a high number of instruments that could have created respondent fatigue, which could result in less reflective and sincere responses to later items. This could have made the intervention and control groups' answers to later items in the questionnaire more similar and diluted a possible intervention effect. This bias is likely to be similar in intervention and control groups since they received the same questionnaire, making this issue less problematic for the baseline questionnaire as opposed to the follow-up assessments. Moreover, the questionnaire was answered electronically outside school hours with the possibility of pausing at any time.

Response rate, attrition, and dropout

The study faced a significant loss of participants to the follow-up assessments, more notably among boys than girls. Moreover, the response rate was higher among intervention participants than among control participants. In addition, muscle-building and dieting supplement use in boys and muscle-building supplement use in girls were associated with dropout in the control group. This limits the validity of the results from the repeated measures since the data was missing at random and not missing completely at random. However, the statistical analyses used in Papers II and III have been found to produce unbiased results when data are missing at random (294, 343). With respect to the statistical power and power calculation, the loss of responders to follow-ups reduced the statistical power and increased the likelihood of a type II error, especially in boys. This may result in a situation with statistical power too low to detect an actual intervention effect. Importantly, the questionnaire had to be answered outside school hours, resulting in a lower response rate. There is a need to obtain ethical permission to answer questionnaires within school hours to reduce attrition in future studies.

Operationalizing and assessing eating disorder symptomatology

Instruments used to assess body image and ED symptoms have traditionally been developed for use by females. Additionally, the EDEQ (232) was developed for use by females and to discriminate between female ED patients and controls. Moreover, the brief version used in our study was also developed from data about a female sample (281). The EDEQ may perform moderate to high in reflecting overall ED symptomatology in males and has been found an acceptable method to identify EDs if the cutoff value is lowered (344). Scholars have thus argued that the EDEQ may not be an optimal instrument to measure ED symptomatology or body image concerns in boys (345-348) since many males may experience a muscularity-oriented phenotype of DE and EDs that is not captured by traditional instruments (349). Therefore, additional measures on muscularity-oriented attitudes and behaviors were included as advised by Murray, Nagata (349). This challenge may be reflected in the

presence of floor effects when EDEQ or EDEQ-11 is used in a nonclinical sample of boys. The mean EDEQ-11 score for boys in our study was close to the reliable change index. This resulted in a low number of boys with the potential to experience a reliable favorable change.

Another issue is the operationalization of ED symptomatology. The study developing the EDEQ-11 found that the brief version consisting of 11 items was an acceptable measure of overall ED pathology in a nonclinical sample (281). It is important to be clear that the EDEQ-11 only contains items from the weight and shape concerns subscales. This means that the EDEQ-11 may also be considered a measure of weight and shape concerns. Still, higher scores are associated with greater odds of either developing or having a clinical ED diagnosis, making the EDEQ-11 a measure of ED risk (281).

Intervention fidelity

Other important factors that may challenge internal validity are intervention fidelity and protocol adherence. If fidelity is low, one ends up evaluating the effect of an unknown or random intervention. However, several measures were taken to maximize fidelity. The same two professionals worked as a pair in both the preparation phase and during all the workshops at every school and were highly coordinated. The workshop materials and presentations were developed prior to the intervention start and were reused for each of the workshops. The materials and presentation provided a rigid and systematic overview of the content and topics to target and discuss for each workshop. Due to ethical considerations, the workshops were not video recorded, limiting the possible direct evaluation of protocol adherence.

Experimenter bias

A potential factor limiting the internal validity is the absence of blinding. Kethe M. E. Svantorp-Tveiten (KMEST) was engaged in all parts of the study such as intervention development, study design, school logistics, intervention delivery, writing of the papers, and statistical analyses (except from the analyses in Paper III). Due to the nature of the study and her role in the work, blinding was not possible. KMEST and the other PhD student (CSB) delivering the workshop were very motivated in the intervention delivery and convinced that the intervention would influence risk and protective factors for ED development. Importantly, KMEST and other members of the project group did not engage in the data collection, which limits the possibility that the lack of blinding influenced the validity of the findings.

Some of the participants in the control group could have been disappointed that they did not receive the intervention. This may be reflected in a lower participant rate in the control group and potentially favored those with a special interest in answering questions related to mental health and body image. However, differences in response rate were observed prior to randomization, which makes it unlikely that lower motivation due to group allocation caused a lower response rate. In addition, the control schools were informed that they could receive an abbreviated workshop after the study period. Resources such as gift cards, school and classroom visits, reminder emails, and SMS messages were used to enhance the response rate.

External validity

Generalizability of the intervention delivery

Several nonspecific and unmeasured features of an intervention could be highly responsible for the effect of an intervention (350). One of these factors could be the nature of the alliance and relationship between the intervention deliverer and the participant(s). The deliverer(s)' personal characteristics, age, profession, and competence stand out as important features for alliance development, perceived intervention credibility, and authority (270, 351). The students most likely perceived the two professionals who delivered the intervention, KMEST and CSB, as credible authorities. Experiences from intervention delivery were that we were able to create a positive atmosphere and safe space for sharing where most participants perceived the intervention as important and interesting. Moreover, the participants in the intervention (and control group) were told that by participating in the intervention, they were providing important knowledge about mental health and body image promotion. These factors stand out as important nonspecific factors in the HBI intervention that most likely had a positive influence on the intervention effect. However, these factors were not a part of the theoretical framework of the intervention and were not assessed. If other deliverers can reproduce the intervention, delivery remains uncertain. However, other professionals with a similar age and attitude in the field who are comfortable and competent in delivering intervention to adolescents could replicate the intervention delivery.

Generalizability of the results

The school response rate was 60%, which is an acceptable response rate (352). The schools were located in central, subrural, and rural areas with different socioeconomic statuses. However, limitations apply since our study includes a sample with a lower proportion of immigrants than the population in Oslo and Akershus counties. The proportion of adolescents with immigrant status in

Oslo and Akershus counties was 27% in 2016. Moreover, the only inclusion criteria were that schools had to offer a vocational study program and participants had to attend a vocational study program in the 12th grade. It is likely that the results from our study can be generalized to adolescents and schools in similar areas with a population with a lower proportion of immigrants.

Ethical considerations

The risk of harmful effects of the intervention

Being part of an intervention focusing on body image may raise awareness about own body image, society's appearance standards, and lifestyle in individuals who did not have any special experiences or reflections prior to the intervention or completing the questionnaires (221). However, one could argue that the HBI intervention minimized this risk since the emphasis was placed on promoting protective factors for ED development such as a positive body image, self-esteem, and individual and social rejection of appearance and lifestyle standards. The HBI intervention had a health promotive approach, which means that we not only aimed at reducing unhealthy influences or risk factors but also worked to strengthen and develop skills that the adolescents could use as tools to improve their own and their peers' body experience.

School resources

The schools are in a situation with limited resources. Having the school reallocate valuable school hours may raise ethical questions since teachers are already struggling to cover the obligatory class curriculum within the ordinary school hours. Moreover, some students could have an urgent need for the specific curricular education provided by their teachers to achieve the subjects' learning objectives. To accommodate the schools and students, we developed the intervention to suit the learning objectives in several different classes, limiting the perceived loss of subject-specific teaching time. In addition, since we did not rely on the teachers to deliver the workshops, they were free to perform other tasks that they often could not prioritize. Moreover, the intervention was developed as an answer to the Norwegian government's concern about the mental health of Norwegian adolescents and their request for school-based efforts to improve "life-managing skills" and body image (29, 30). Thus, the schools, teachers, and adolescents likely perceived the intervention as important and beneficial.

Funding sources

The HBI study was founded by the Norwegian Women's Public Health Association and the Dam Foundation. These two organizations are nonprofit organizations and represent valuable and essential

financial contributors to the field of public health promotion. An additional commercial sponsor (Tine AS) was found after the intervention was conducted and provided finances to send gift cards (for a movie ticket with a value of 150 NOK) to the participants who completed the questionnaire to increase the response rate. However, neither of the funders or sponsors participated in or influenced the study development, intervention delivery, assessments, data analyses, or dissemination of the results.

Conclusions

Paper I

The number of weekly muscle-building and dieting supplement users was high in this sample of late adolescents, and muscle-building supplement use was more common among boys compared to girls. Immigrant boys used more muscle-building and dieting supplements than their nonimmigrant counterparts, and creatine supplementation was more common among immigrant girls than nonimmigrant girls. The use of muscle-building and dieting supplements was associated with risk factors for ED development and participation in exercise and sports emphasizing power, leanness, and appearance in boys but not in girls. Prevention and policy change are warranted to avoid negative health consequences of muscle-building and dieting supplement use. Preventive efforts may also be targeted toward boys engaged in fitness center exercise and weight class, gravitational, and aesthetic sports.

Paper II

The HBI intervention was successful in reducing risk and enhancing protective factors for ED development with sustained effects found at the12-month follow-up. Girls benefited more from the intervention with respect to risk and protective factors for ED development. However, the HBI intervention was equally successful in enhancing self-esteem and reducing mental distress in girls and boys. Furthermore, the HBI intervention prevented muscle-building supplement use in boys with effects sustained to the 12-month follow-up.

Paper III

The results support that the HBI intervention effect on several risk and protective factors for ED development acted as mediators for the intervention effect on ED symptomatology in girls but not in boys. Our findings suggest that targeting self-esteem, body image flexibility, perceived appearance pressure, and thin appearance internalization is beneficial when aiming to reduce ED symptomatology in girls. No significant mediators were observed for muscle-building supplement use in boys or girls or for ED symptomatology in boys. However, our results indicate that enhancing body image flexibility could also facilitate reduced ED symptomatology in boys.

Scientific impact and future research

The HBI study has provided important knowledge about ED symptomatology and supplement use among adolescents and highlighted the need to prevent both EDs and supplement use in adolescents. The HBI study has also provided insight about immediate and 12-month effects of the HBI intervention on risk and protective factors for ED development and muscle-building supplement use in boys and girls. Moreover, the study has found gender differences in pathways of intervention effect and provided knowledge about mechanisms of change in ED symptomatology and supplement use in girls and boys.

Future studies could beneficially focus on replication and areas of improvement. First, the HBI intervention needs to be replicated to ensure its external validity.

Second, refining the intervention to improve intervention effect, especially in boys, is warranted. Future interventions could benefit from considering important intervention features identified by Doley, McLean (270) to improve the effect on boys. One important lesson learned from delivering the HBI intervention was the advantage of two professionals working in pairs when delivering the workshop. This enabled more active and dynamic workshops with the possibility to interact more closely with the students and meant that more time could be spent with each participant during discussions. In addition, utilizing two facilitators with different personal characteristics and competences may have made the intervention relevant to more participants. However, using two professionals requires good communication, preparation, and cooperation, which may require additional resources. Importantly, future intervention may benefit from including a male intervention deliverer to increase perceived relevance and credibility among boys.

Third, further knowledge regarding the prevention of supplement use is needed to determine whether it is possible to develop an intervention successful in both reducing the risk of ED development and preventing supplement use, especially since the use of muscle-building supplements and ED risk factors seemed to be unrelated in girls.

Fourth, the field of universal ED and supplement use prevention could benefit from more knowledge regarding pathways of intervention effects with a focus on multiple mediation models to better grasp the complexity in change mechanisms.

Fifth, the investigation of the dose-response relationship regarding how many workshops are necessary to achieve intervention effects may be beneficial to enhance the cost-benefit relationship.

Sixth, since we observed sleeper and maturation effects in several outcomes, future studies should include a follow-up period of more than 12 months in order to evaluate whether effects fade or emerge.

Finally, to strengthen the ability to draw conclusions about clinical relevance, future studies could benefit from including measures of EDs (e.g., clinical interviews) similar to the intervention study by Martinsen, Bahr (353). Moreover, interventions including boys would benefit from including measures more adapted for assessing ED symptomatology, body image, and EDs in boys.

Societal impact

Questions about clinical relevance should be raised since the effect of universal ED prevention programs is often small. This is not surprising since baseline outcome values in universal prevention interventions rarely reach a clinical level (14, 354). However, even minor improvements and small effect sizes for change in ED symptomatology in universal interventions could potentially result in important changes on a population level (355). Moreover, small improvements in several psychological variables could together have an impact on public health (356). After refinements and replication (318), the schools could benefit from implementing the intervention into their daily curriculum. The HBI intervention was developed to fit into existing school subject learning objectives. The intervention could therefore act as an additional resource for the schools since it would provide an alternative curriculum that may also have the benefit of promoting mental health and reducing the risk of ED development. The following are some suggestions of content from the HBI intervention that could be implemented in existing school subjects:

- Language classes could include the intervention content to strengthen the adolescents' ability to remain critical toward sources of information and communication.
- Social science classes could include content strengthening media literacy, such as discussing appearance internalization, social media, and the appearance industry.
- Natural science classes could include topics such as natural body development, growth and development, puberty, body composition, and the importance of energy availability in maintaining health. Natural science could also include topics addressing the association between psychological, social, and physical health.
- Food and health classes could put more emphasis on how eating habits can enhance well-being and mental health. Food and health classes could also include content to strengthen lifestyle literacy, making the adolescent resilient to unhealthy lifestyle trends portrayed in mass and social media.
- Physical education classes have the potential to directly influence mental health since engaging in physical activity may influence brain physiology (357) and enhance physical self-efficacy and global self-esteem (172, 173, 273). Further intervention content that could be implemented in physical education classes is knowledge about realistic exercise adaption and natural adolescent body development. Moreover, the emphasis should be on body functionality rather than appearance in relation to physical activity and exercise.

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Papers and appendices

Paper I

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Protein, Creatine, and Dieting Supplements Among Adolescents: Use and Associations With Eating Disorder Risk Factors, Exercise-, and Sports Participation, and Immigrant Status

Kethe Marie Engen Svantorp-Tveiten[1], Oddgeir Friborg[2], Monica Klungland Torstveit[3], Therese Fostervold Mathisen[4], Christine Sundgot-Borgen[1†], Jan Harald Rosenvinge[2], Solfrid Bratland-Sanda[5], Gunn Pettersen[6] and Jorunn Sundgot-Borgen[1]*

[1] Department of Sports Medicine, The Norwegian School of Sport Sciences, Oslo, Norway, [2] Department of Psychology, UiT -The Arctic University of Norway, Tromsø, Norway, [3] Department of Sport Science and Physical Education, University of Agder, Kristiansand, Norway, [4] Health and laboratory science, Department of Nursing, Østfold University College, Halden, Norway, [5] Department of Sports, Physical Education and Outdoor Studies, University of South-Eastern Norway, Kongsberg, Norway, [6] Department of Health and Care Sciences, UiT - The Arctic University of Norway, Tromsø, Norway

Objective: This study aimed to estimate the number of weekly users of protein, creatine, and dieting supplements and to explore whether weekly use was related to eating disorder (ED) risk factors, exercise, sports participation, and immigrant status.

Methods: In total, 629 and 1,060 high school boys and girls, respectively, self-reported weekly frequency of protein, creatine, and dieting supplement use, and weight and shape concerns, appearance internalization and pressure, self-esteem, mental distress, physical activity level, exercise context, and the type and weekly frequency of sport played. Multiple hierarchical regression analyses were performed to investigate explanatory factors for supplement use.

Results: More boys than girls used protein and creatine supplements. Immigrant boys had more frequent use of all supplements than non-immigrant boys, and immigrant girls used creatine supplements more frequently than non-immigrant girls. In total, 23–40 and 5–6% of the variation in the weekly frequency of supplement use in boys and girls, respectively, was explained by immigrant status, ED risk factors, and exercise and sports participation. More frequent use of protein, creatine and dieting supplements in boys was significantly explained by more weight and shape concerns, fitness center exercise, and weight-sensitive sports participation. Depending on the type of supplement, more frequent use of supplements in girls was significantly explained by lower self-esteem, more engagement in weight-sensitive sports, and less engagement in general sport and exercise activities.

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****Correspondence:***
Kethe Marie Engen Svantorp-Tveiten
kmengen@nih.no

†Present address:
Christine Sundgot-Borgen, Regional Department for Eating Disorders, Oslo University Hospital, Oslo, Norway

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Conclusion: Weekly supplement use was common and more frequent among boys than girls. The weekly use of protein, creatine, and dieting supplements was related to ED risk factors, exercise and sports participation, and immigrant status in boys but not in girls.

Keywords: dietary supplement, body image (MeSH), exercise (MeSH), mental health (MeSH), sport (MeSH), eating disorder, immigrant status, adolescent (MeSH)

INTRODUCTION

The sports supplement industry has grown rapidly during the past decade (Marqual IT Solutions Pvt., Ltd. Research and Markets, 2019). Sports supplements represent a large group of dietary supplements used by most adult and adolescent high-performance athletes, and they may have an indirect or direct and assumed or documented effect on sports performance (Knapik et al., 2016). Among the most commonly used sports supplements in the general adolescent population are protein, creatine, and dieting supplements, such as fat burners and appetite suppressants (Eisenberg et al., 2012; Tiwari, 2020), and are used to achieve a more muscular and lean appearance (Knapik et al., 2016).

The long-term health effects of protein and creatine supplements are not well-known (Pope et al., 2014). Even if properly administered use of non-contaminated creatine or protein supplements in experimental studies has not been linked to health risks in adults (Jagim et al., 2018), research suggests that use in a natural setting is related to several negative health outcomes in adolescents (Or et al., 2019; Tiwari, 2020); this is partially related to a high proportion of contaminated products (Walpurgis et al., 2020), leading to severe and unintended health consequences (Hoffman et al., 2008; Pope et al., 2014). In addition, the use of protein and creatine supplements may also act as a gateway to future steroid use (Backhouse et al., 2013; Hurst et al., 2020). Consequently, adolescents should not use supplements to enhance performance or appearance (Bergeron et al., 2015).

Previous studies involving older adolescents in the general population found that up to 50% of boys (Hoffman et al., 2008; Eisenberg et al., 2012; Yager and McLean, 2020) and 20% of girls (Eisenberg et al., 2012) had ever used or used protein supplements during the past year. Meanwhile, the estimated overall proportion of general adolescents currently or previously using creatine supplements varies from 0.6 to 22.2% in boys and 0.6 to 3% in girls (Hoffman et al., 2008; Jagim et al., 2018; Miech et al., 2020; Yager and McLean, 2020). A recent study also found the 30-day prevalence of diet pill use in late adolescent boys and girls to be 1.5 and 1.7%, respectively (Miech et al., 2020).

Several factors predict the use of protein and creatine supplements; among these is gender (Eisenberg et al., 2012). Ethnicity is suggested as another factor possibly explaining supplement use as a means of changing appearance (Eisenberg et al., 2012; Yager and McLean, 2020). Males of non-white ethnicities may experience more drive for muscularity (Swami, 2016) and body dissatisfaction and engage in more extreme body change strategies (Ricciardelli et al., 2007), while girls of some non-white ethnicities may experience less body dissatisfaction than white ethnicities (Kimber et al., 2015). In addition, boys of Asian ethnicity are found to use more "muscle enhancing" supplements than non-Asians (Eisenberg et al., 2012). However, existing findings are conflicting and inconclusive (Eisenberg et al., 2012; Kimber et al., 2015; Yager and McLean, 2020). Therefore, investigating immigrant status relative to supplement use, as opposed to ethnicity, may contribute further to the understanding of supplement use in adolescents. The experiences of first or second-generation immigrants could also potentially differ from those of later-generation immigrants (Forbes, 2010; Swami, 2016). This may partially be explained by how sociocultural characteristics fade over time with integration and how integrated individuals perceive themselves as more powerful and with less stress related to identity and masculinity (Liu and Concepcion, 2010). Other factors which may explain protein, creatine, and dieting supplement use are exercise and sports participation. Previous studies have examined the association between protein supplement use and sports participation, finding that a greater number of sports played (Yager and McLean, 2020), but not participating in a sports club in general (Eisenberg et al., 2012), was associated with protein supplement use. Furthermore, the association between supplement use and participation in weight training is conflicting (Yager and O'Dea, 2014; Yager and McLean, 2020). The role of exercise context and frequency of playing different types of sports in relation to protein, creatine, and dieting supplement use has not been investigated to date in the general adolescent population. Different sports and exercise contexts may be perceived as objectifying appearance (Sundgot-Borgen et al., 2021) and place a greater emphasis on muscularity and strength, which may lead to the use of supplements advertised as being muscularity and performance-enhancing (Sandvik et al., 2018).

Most studies investigating supplement use in adolescents have observed athletes, and less knowledge exists regarding such use in the general adolescent population, especially in girls. Previous studies have found that body image, self-esteem, and internalization of appearance ideals are associated with muscle-building behaviors in general, where supplement use is incorporated (Smolak et al., 2005; Smolak and Stein, 2010; Rodgers et al., 2020). However, only two studies have investigated the association between body image, exercise or sports participation, and protein supplement use in regular adolescents (Yager and O'Dea, 2014; Yager and McLean, 2020), finding that use is explained by body dissatisfaction (Yager and O'Dea, 2014), muscularity beliefs, number of sports activities,

and weight training (Yager and McLean, 2020). None of these studies included girls; however, one older study including both girls and boys found that supplement use in general was associated with body image and appearance idealization but not exercise and sports participation (Field et al., 2005). Furthermore, the inclusion of measures of a wider range of exercise and sports characteristics, such as physical activity level, exercise contexts, multiple types of sport activities, and the frequency of sports participation (Yager and McLean, 2020), have been requested. Creatine is considered one of the most potent legal sports supplements on the market, with a documented effect on high-intensity and short-duration physical performance (Hall and Trojian, 2013). Therefore, its use could be solely explained by exercise and sports participation and the desire for enhanced performance. No studies have investigated explanatory factors for creatine supplementation in general adolescents. However, recent studies including adults found that ergogenic supplement use (such as creatine) was explained by eating disorder (ED) cognitions and behaviors in both males and females (Nagata et al., 2020a); moreover, users had more positive attitudes toward doping (Hurst et al., 2019). As such, knowledge of whether and how creatine supplement use is associated with ED risk factors and exercise behaviors in adolescents is warranted.

The association between dieting supplement use and psychological factors is known in girls (Wang et al., 2014), yet knowledge on this matter in adolescent boys is sparse. Although several high-quality studies have reported on the annual or lifetime prevalence of protein, creatine, and dieting supplement use, no studies in the past decade have reported the proportion of adolescents using these supplements weekly or more often, this information is important for several reasons. More frequent users may differ from occasional users since they may be more driven toward enhancing performance and appearance. The sports supplement industry is growing, yet knowledge about the "severity" of use in adolescents is limited. Hence, knowledge regarding whether more frequent use is associated with more unfavorable outcomes is unknown. Such knowledge may indicate whether preventive efforts should be aimed at frequent users or users in general.

Therefore, this study aimed (1) to estimate the proportion of late adolescent boys and girls using protein, creatine, and dieting supplements weekly and (2) to investigate whether ED risk factors, exercise and sports participation, and immigrant status explain the variance in the weekly frequency of protein, creatine, and dieting supplement use.

MATERIALS AND METHODS

Recruitment

The current cross-sectional study included baseline assessments from an intervention study (Sundgot-Borgen et al., 2018) aiming to promote a positive body image and to reduce the risk of ED development (The healthy body image program; HBI) in 16–18-year-old high school adolescents. In the fall of 2016, all public and private high schools in the Oslo and Akershus counties were asked to participate in the study. The request, together with the study information, was presented to the school principals and administrators. Of the 50 eligible schools, 30 agreed to participate. A meeting was arranged at each school, and all students were thoroughly informed of the study aims and the implications of participation. The students subsequently received information and informed consent letters together with the questionnaires. **Figure 1** shows the school and participant flow. Of the 3,947 invited students, 2,446 gave their consent to participate in the study. In total, 757 students did not answer questions about supplement use, resulting in 1,689 students being included in the cross-sectional analyses.

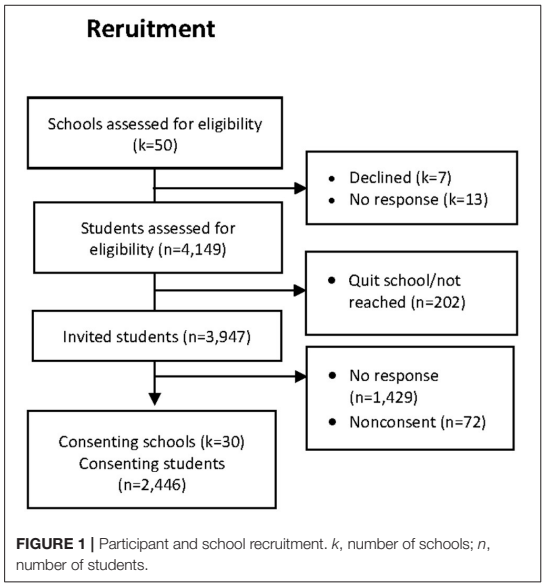

FIGURE 1 | Participant and school recruitment. *k*, number of schools; *n*, number of students.

Measures

Demographics and Body Mass Index

Participant age (years), body weight (kg), body height (cm), and immigrant status were assessed by self-report. Immigrant status was assessed according to the definition given by Statistics Norway regarding a first- or second-generation immigrant (two foreign-born parents) and did not include individuals who were foreign-born, had two foreign-born parents, or adopted by Norwegian-born parents. Self-reported body weight and height were used to calculate body mass index (BMI).

Protein, Creatine, and Dieting Supplement Use

Usage of protein, creatine, and dieting supplements were the main outcome variables. Outcomes were measured with self-developed questions on the weekly frequency of supplement use. Protein and creatine supplements included powders usually mixed with fluid. Dieting supplements included products consumed to aid weight or fat loss (i.e., fat burners, pills, and powders). Questions were scored on a five-point Likert scale from 1 (never) to 5 (daily). All students who reported

using supplements at least one time per week were defined as "weekly users."

Eating Disorder Risk Factors

Weight and shape concerns were measured with an empirically derived brief version of the Eating Disorder Examination Questionnaire (Friborg et al., 2013). The scale consists of 11 items scored on a Likert scale ranging from 0 to 6, where a higher score reflects greater weight and shape concerns. Cronbach's alpha in this sample was 0.91 and 0.94 for boys and girls, respectively.

The sociocultural attitudes toward appearance questionnaire-4 (Schaefer et al., 2015) was used to assess societal and interpersonal aspects of appearance ideals. Three subscales—thin/low body fat internalization (Thin internalization), muscular/athletic internalization (Muscular internalization), and perceived pressure from media (Media pressure)—were included in this study. Items were scored on a five-point Likert scale ranging from "strongly disagree" to "strongly agree," where a higher score indicates a higher degree of internalization or perceived pressure. Cronbach's alpha for the three subscales ranged from 0.85 to 0.94 in boys and 0.91 to 0.95 in girls.

The Rosenberg self-esteem scale (Rosenberg, 1965) measures global self-worth and was used as a measure of self-esteem. The scale consists of 10 items scored on a five-point Likert scale ranging from 1 to 4, where a higher score represents higher self-esteem. Cronbach's alpha was 0.90 and 0.92 in boys and girls, respectively.

Mental distress was measured by the Hopkins Symptom Checklist 10, which assesses symptoms of anxiety and depression (Strand et al., 2003). The scale comprises 10 items scored on a five-point Likert scale ranging from 0 to 4, where higher scores represent more mental distress. Cronbach's alpha for this present sample was 0.89 and 0.90 in boys and girls, respectively.

Exercise- and Sports Participation

Physical activity level was assessed by asking the participants how many hours and minutes they spent being physically active during a normal week. Physical activity was defined within the questionnaire as "any activity making you warm and slightly breathless (e.g., physical education, activities with your family, active transportation (i.e., walking and biking to school, exercise, sports, and self-organized activities)."

Exercise context was assessed by participants reporting whether they were active members and exercising at a fitness center or in organized sports using response categories. The questions were recoded into two dichotomous variables: fitness center exercise (0 = no, 1 = yes) and organized sport participation (0 = no, 1 = yes).

The type and weekly frequency of sports participation were assessed by a self-developed questionnaire listing several different types of exercise/sports and asking how many times per week they engaged in different exercise or sport activities. Participants scored each activity on a four-point Likert scale ranging from never to several times per week. To reduce the number of correlated sports and exercise variables and create meaningful groups of exercise and sport activities, a principal component analysis with varimax rotation was performed. The analysis yielded three components with Eigenvalues > 1.0. This three-factor solution aligned with previously suggested groupings of weight-sensitive sports (Sundgot-Borgen et al., 2013): (1) weight class and gravitational sports (martial arts, CrossFit, fitness, powerlifting, weightlifting and power sports), (2) aesthetic sports (gymnastics, diving, figure skating, dance, and yoga), and (3) general exercise and sports activities (endurance exercise, resistance exercise, and ball game sports). Factor structure, loadings, and explained variance are provided in the **Supplementary Table 1**.

Statistical Analyses

All analyses were performed using IBM SPSS statistics version 24. Continuous variables are presented as means and standard deviation, while categorical data are presented as the number of observations (n) and proportions (%). Between-group differences in demographic psychometric and exercise variables were tested using an independent sample t-test and Fisher's exact test. The Mann-Whitney U-test was performed to investigate overall differences between boys and girls regarding protein, creatine, and dieting supplement use. Cohen's d (d) and odds ratios were used as effect sizes for parametric and non-parametric comparisons, respectively. The alpha level was set to $p = 0.05$. Hierarchical multiple linear regression analysis was performed to investigate potential explanatory variables for protein supplement use, creatine supplement use, and dieting supplement use. Bootstrapping was performed to handle non-normal residual score distributions and was performed using a wild sampling method with unstandardized residuals as value variables. The number of bootstrap samples was set to 2000 with bias-corrected and accelerated 95% confidence intervals. The variance inflation factor ($\leq$5.0), condition number (<10), and variance decomposition proportion (>80%) were investigated, and no violations of cut points existed (Kim, 2019). All variables were standardized to Z scores to ease interpretation and to obtain standardized beta weights from the bootstrapped analysis.

The dependent variables were weekly protein, creatine, and dieting supplement use. The independent variables were included in three steps as follows. Step (1) immigrant status with BMI as the adjustment variable. Step (2) weight and shape concerns, thin internalization, muscular internalization, media pressure, self-esteem, and mental distress. Finally, Step (3) physical activity, sports, and exercise variables: physical activity hours/week, organized sports participation (no/yes), fitness center exercise (no/yes), weight class and gravitational sports, aesthetic sports, and general sports and exercise. The results are presented as the standardized beta weight and 95% confidence intervals. All analyses were stratified by gender.

Ethics

The study met the intent and requirements of the Health Research Act and the Helsinki Declaration regarding informed consent and unconditional withdrawal and was approved by the Regional Committee for Medical and Health Research Ethics (2016/142). This work was supported by the DAM foundation (2016/FO76521), through the Norwegian Woman's Public Health Association (H1/2016). A commercial sponsor

(TINE AS) supported the study after the study protocol was published (Sundgot-Borgen et al., 2018) but was not involved in data collection, data analysis, or the writing of the present article.

RESULTS

Students who did not answer questions about supplement use were classified as dropouts. They were not included in the analysis. Dropouts did not differ from respondents in demographic or psychometric measures.

Demographic characteristics, psychometric scores, and exercise and sport participation in girls and boys are presented in **Table 1**. Overall, boys used more protein ($U = 265514.50$, $Z = -10.73$, $p = <0.001$) and creatine ($U = 849429.50$, $Z = -10.09$, $p = <0.001$) supplements compared to girls. No between-group differences were observed for dieting supplement use (**Table 2**). Girls who used supplements consumed these less often than boys who used supplements, and boys were more likely than girls to use two or more supplements in combination (**Table 2**). Immigrant boys consumed protein ($U = 267184.50$, $Z = 3.58$, $p = <0.001$), creatine ($U = 25588.00$, $Z = 3.17$, $p = 0.002$) and dieting ($U = 23901.50$, $Z = 2.05$, $p = 0.040$) supplements more frequently than non-immigrant boys. Immigrant girls consumed creatine supplements more frequently than non-immigrant girls ($U = 66960$, $Z = 2.56$, $p = 0.010$).

The hierarchical multivariable regression analyses for weekly frequency of protein, creatine, and dieting supplement use in boys and girls are shown in **Tables 3**, **4**, respectively. In boys, the first step including immigrant status, adjusted for BMI, explained 1–2% of the variance in protein and creatine supplement use and 9% of the variance in dieting supplement use. The inclusion of psychometric measures in step 2 of the analyses significantly improved the explained variance to 13, 11, and 20% for weekly frequency of protein, creatine, and dieting supplement use, respectively. The inclusion of exercise and sport participation variables in the final step doubled the explained variance for both protein, creatine, and dieting supplement use.

In girls, the first step including immigrant status only explained 1, 3, and 5 % of the variance in the weekly frequency of protein, creatine, and dieting supplement use, respectively. Including psychometric variables in the second step and exercise and sport participation variables in the final step only marginally improved the explained variance.

DISCUSSION

As expected, boys were almost four times more likely to report weekly use of protein and creatine supplements and were more frequent users than girls. Interestingly, immigrant boys were more frequent users of all supplements, and immigrant girls used creatine supplements more frequently than their non-immigrant counterparts. The use of protein, creatine, and dieting supplements was more strongly associated with ED risk factors as well as exercise and sport participation in boys than in girls.

Boys

Boys who were more frequent users of protein, creatine, and dieting supplements could be characterized by higher weight and shape concerns, as fitness center exercisers, and as more active in weight-class and gravitational sports. Unsurprisingly, more frequent use of protein and creatine supplements was explained by higher muscular internalization, and more frequent use of creatine supplements was associated with less thin appearance ideal internalization. Experiencing lower levels of thin appearance internalization might be a positive outcome

TABLE 1 | Descriptive characteristics for boys and girls presented as the mean (standard deviation) or number of observations (percentage) with Cohen's d (d) or odds ratio (OR) as effect size (ES) for scale and dichotomous variables, respectively.

	Boys (n = 629)	**Girls (n = 1,060)**	***p***	**ES**
Age	16.76 (0.48)	16.78 (0.48)	0.437	
BMI (kg/m^2)	21.78 (2.80)	21.38 (2.84)	**0.005**	0.14^d
Immigrants, *n* (%)	82 (13.0)	140 (13.2)	0.951	
Weight and shape concerns	1.0 (1.6)	2.5 (1.7)	**<0.001**	1.05^d
Thin internalization	2.5 (0.95)	3.3 (1.1)	**<0.001**	0.36^d
Muscular internalization	3.2 (1.1)	3.0 (1.1)	**<0.001**	0.20^d
Media pressure	2.1 (1.2)	3.2 (1.2)	**<0.001**	0.88^d
Self-esteem	32.8 (6.0)	29.1 (6.2)	**<0.001**	0.61^d
Mental distress	1.6 (0.6)	2.2 (0.7)	**<0.001**	0.81^d
Physical activity (hours/week)	8.44 (6.11)	6.84 (5.19)	**<0.001**	0.28^d
Fitness center exercise, *n* (%)	346 (55.0)	441 (41.6)	**<0.001**	1.72^{OR}
Organized sports participation, *n* (%)	333 (52.9)	406 (38.3)	**<0.001**	1.81^{OR}
Weight class and gravitational sports, *n* (%)	243 (38.6)	271 (25.6)	**<0.001**	1.83^{OR}
Aesthetic sports, *n* (%)	61 (9.7)	348 (32.8)	**<0.001**	0.22^{OR}
General sports and exercise, *n* (%)	560 (89.0)	855 (80.7)	**<0.001**	1.95^{OR}

BMI, body mass index; ^{d}Cohen's d; ^{OR}odds ratio. Significant differences (p values) are highlighted in bold.

TABLE 2 | Supplement use, frequency of use and number of supplements used in boys and girls. presented as the number of observations (%).

	Boys (n = 629)	Girls (n = 1,060)	p	OR
Weekly protein supplement use, *n* (%)	**185 (29.4)**	**101 (9.5)**	**<0.001**	**3.96**
Frequency of use[a]				
1–2 days/week	70 (37.8)	54 (53.5)	**0.013**	**0.53**
3–4 days/week	65 (35.1)	27 (26.7)	0.185	
5–6 days/week	19 (10.3)	11 (10.9)	0.843	
Everyday	31 (16.8)	9 (8.9)	0.059	
Weekly creatine supplement use, *n* (%)	**105 (16.7)**	**32 (3.0)**	**<0.001**	**6.44**
Frequency of use [a]				
1-2 days/week	18 (17.1)	15 (46.9)	**0.002**	**0.23**
3-4 days/week	44 (41.9)	12 (37.5)	0.687	
5-6 days/week	11 (10.5)	3 (9.4)	1.000	
Everyday	32 (30.5)	2 (6.2)	**0.005**	**6.58**
Weekly dieting supplement use, *n* (%)	**50 (7.9)**	**74 (7.0)**	0.500	
Frequency of use[a]				
1–2 days/week	16 (32.0)	57 (77.0)	**<0.001**	**0.14**
3–4 days/week	14 (28.0)	11 (14.9)	0.109	
5–6 days/week	5 (10.0)	1 (1.4)	**0.039**	**8.11**
Everyday	15 (30.0)	5 (6.8)	**0.001**	**5.91**
Number of supplements/aids used				
Using one supplement/aid	102 (50.7)	128 (78.5)	**<0.001**	**0.28**
Using two supplements/aids	59 (29.4)	26 (16.0)	**0.003**	**2.19**
Using all three supplements/aids	40 (19.9)	9 (5.5)	**<0.001**	**4.25**

[a] *Frequency of use among users.*

Odds ratio (OR) is shown for significant between group differences was tested by applying Fishers exact test. Significant differences (p values) are highlighted in bold.

regarding ED development. However, results from previous research conclude that increased internalization of muscularity without thinness internalization is predictive of more severe muscle dysmorphia in males (Klimek et al., 2018). More frequent use of dieting supplements was explained by higher weight and shape concerns and more frequent participation in weight-class and gravitational and aesthetic sports was expected since disordered eating (DE) is more prevalent among athletes in these sports (Sundgot-Borgen et al., 2013). Our results suggest that more frequent use of protein, creatine, and dieting supplements in boys is associated with factors known to increase the risk of developing ED considering the higher weight and shape concerns, muscular internalization (Taylor, 2016; Schaefer et al., 2017), and engagement in exercise and sport participation emphasizing appearance and leanness (Sundgot-Borgen et al., 2013, 2021). The current study reflects and expands previous research findings that the use of protein and creatine supplements is associated with higher muscle-oriented body dissatisfaction (Yager and O'Dea, 2014) and drive for muscularity in adolescent boys (Yager and McLean, 2020), as well as ED pathology in males (Nagata et al., 2020a). In contrast, a roughly comparable study concluded that protein supplement use was only associated with the number of sports played and weight training and not body image (Yager and McLean, 2020). The current study expands current knowledge by indicating that one should consider the "severity" of supplement use rather than "any use." Furthermore, the findings indicate that it may be wise to give attention to boys who frequently consume supplements regularly since this may indicate a problematic relationship with body image and exercise.

Girls

More frequent use of protein- and creatine supplements was associated with having slightly lower self-esteem, higher muscular internalization (not creatine users), and performing weight-sensitive sports. Dieting supplement use in girls was, as expected, associated with more weight and shape concerns and less participation in general sports and exercise activities. Although the association was weak, self-esteem is considered a fundamental psychological state important for mental health and quality of life later in life and in the transition to adulthood (Boden et al., 2008). Interestingly, performing general endurance and strength exercises and ball game activities stood out as potential protective factors for dieting supplement use in girls. This is not surprising considering that general physical activity and exercise affect physical fitness, body composition, and physical self-efficacy, which in turn predict increased body esteem and global self-esteem in girls (Gothe et al., 2021). Importantly, immigrant status, ED risk factors, and exercise and sport participation variables only accounted for 5–6% of the variation in protein, creatine, and dieting supplement use in girls, thus more than 94% of the variance is explained by other non-measured factors or measurement error. Comparable

TABLE 3 | Bootstrapped hierarchical linear regression analysis of variables explaining the variance in boys' ($n = 629$) weekly (0–7) use of protein, creatine, and dieting supplements, respectively.

	Protein			Creatine			Dieting		
	Step 1	**Step 2**	**Step 3**	**Step 1**	**Step 2**	**Step 3**	**Step 1**	**Step 2**	**Step 3**
	ß 95%CI	**ß 95%CI**	**ß 95%CI**	**ß 95%CI**	**ß 95%CI**	**ß 95%CI**	**ß 95%CI**	**ß 95%CI**	**ß 95%CI**
Immigrant status (yes/no)	**0.13** 049|0.212	**0.12** 034|0.200	0.08 −0.009|0.159	**0.10** 021|0.190	0.08 −0.002|0.169	0.03 −0.050|0.121	**0.10**-022|0.184	0.05 −0.034|0.126	−0.01 −0.076|0.090
Weight and shape concerns		**0.20** 100|0.312	**0.18** 069|0.289		**0.26** 138|0.363	**0.22** 099|0.331		**0.42** 256|0.580	**0.38** 225|0.543
Thin internalization		−0.08 −0.177|0.014	−0.03 −0.128|0.069		**−0.14** −0.234|−0.035	**−0.11** −0.206|−0.011		0.04 −0.032|0.103	0.04 −0.034|0.102
Muscular internalization		**0.31** 227|0.385	**0.19** 0.092|0.297		**0.21** 118|0.297	**0.12** 018|0.220		−0.06 −0.111|−0.002	−0.08 −0.155|0.006
Media pressure		0.05 −0.076|0.095	−0.01 −0.083|0.088		0.04 −0.042|0.123	0.03 −0.057|0.112		0.02 −0.055|0.113	−0.01 −0.083|0.082
Self-esteem		0.01 −0.080|0.107	0.05 −0.042|0.148		0.04 −0.062|0.143	0.08 −0.022|0.180		−0.07 −0.177|0.036	−0.03 −0.134|0.075
Mental distress		0.01 −0.087|0.95	0.02 −0.076|0.110		0.01 −0.084|0.117	0.02 −0.079|0.131		−0.05 −0.161|0.078	−0.03 −0.140|0.093
Physical activity (hours/week)			−0.04 −0.124|0.052			0.02 −0.078|0.099			−0.04 −0.132|0.056
Fitness center exercise (yes/no)			**0.20** 0.122|0.276			**0.09** 011|0.168			**0.10** 024|0.170
Organized sports participation (yes/no)			−0.01 −0.101|0.083			−0.04 −0.132|0.048			0.08 −0.011|0.172
Weight class/gravitational sports			**0.25**0.147|0.360			**0.31** 196|0.425			**0.19** 088|0.290
Aesthetic sports			0.07 −0.016|0.151			**0.15** 056|0.249			**0.36** 244|0.474
General sports and exercise			0.01 −0.089|0.104			−0.01 −0.095|0.092			−0.04 −0.140|0.064
BMI (kg/m^2)	0.06 −0.001|0.134	−0.03 −0.104|0.045	−0.08 −0.147|0.002	−0.04-035|0.096	−0.05 −0.129|0.024	**−0.09** −0.170|−0.005	0.03 −0.043|0.095	**−0.10** −0.183|−0.023	**−0.12** −0.204|−0.041
F	7.50[a]	13.08[a]	15.837[a]	3.93[a]	8.85[a]	14.71[a]	3.77	16.49[a]	18.60[a]
Adjusted R^2	0.02[b]	0.13[b]	0.25[c]	0.01[c]	0.11[b]	0.23[b]	0.09[c]	0.20[b]	0.40[b]

BMI, body mass index. [a]*p = < 0.001,* [b]*p R^2 change = <0.001,* [c]*p R^2 change = <0.05; ß, standardized coefficient; 95%CI, 95% confidence interval.*
Significant ($p \leq 0.05$) beta weights and CI are highlighted in bold. All analyses were adjusted for BMI.

TABLE 4 | Bootstrapped hierarchical linear regression analysis of variables explaining the variance in girls' (n = 1,060) weekly (0–7) use of protein, creatine, and dieting supplements, respectively.

	Protein			Creatine			Dieting		
	Step 1 ß 95%CI	**Step 2** ß 95%CI	**Step 3** ß 95%CI	**Step 1** ß 95%CI	**Step 2** ß 95%CI	**Step 3** ß 95%CI	**Step 1** ß 95%CI	**Step 2** ß 95%CI	**Step 3** ß 95%CI
Immigrant status (yes/no)	0.05 −0.026|0.118	0.05 −0.016|0.124	0.04 −0.036|0.116	**0.10** 002|0.191	0.09 −0.002|0.172	0.08 −0.018|0.168	−0.03 −0.092|0.020	−0.03 −0.083|0.018	−0.04 -096|0.013
Weight and shape concerns		−0.01 −0.140|0.144	−0.01 −0.174|0.105		0.05 −0.167|0.268	0.05 −0.174|0.258		**0.21** 015|0.372	**0.20** 007|0.368
Thin internalization		−0.06 −0.153|0.034	−0.05 -186|0.031		−0.10 0.245|0.038	−0.09 −0.232|0.057		−0.04 −0.158|0.034	−0.03 −0.149|0.118
Muscular internalization		0.13 0.060|0.200	0.06 −0.030|0.131		0.02 −0.045|0.075	−0.04 −0.116|0.031		**0.07** 007|0.114	0.05 −0.024|0.118
Media pressure		−0.11 −0.181|0.039	−0.10 −0.067|0.068		−0.05 −0.120|0.028	−0.03 −0.104|0.045		−0.08 −0.105|0.079	−0.07 −0.091|0.093
Self-esteem		**−0.17** −0.258|−0.083	**−0.17** −0.258|−0.080		−0.16 −0.265|−0.054	**−0.16** −0.266|−0.047		−0.08 −0.172|0.015	−0.08 −0.174|0.021
Mental distress		−0.05 −0.133|0.022	−0.06 −0.152|0.013		−0.06 −0.162|0.041	−0.07 −0.169|0.031		−0.01 −0.105|0.080	−0.03 −0.116|0.068
Physical activity (hours/week)			0.07 −0.019|0.158			0.02 −0.075|0.122			0.05 −0.025|0.122
Fitness center exercise (yes/no)			0.01 −0.050|0.080			0.02 −0.069|0.093			0.04 −0.031|0.111
Organized sports participation (yes/no)			−0.05 −0.110|0.031			0.02 −0.075|0.093			0.01 −0.055|0.086
Weight class/gravitational sports			**0.14** 060|0.237			**0.16** 040|0.284			0.08 −0.023|0.201
Aesthetic sports			0.04 −0.021|0.108			**0.09** 008|0.174			0.06 −0.005|0.129
General sports and exercise			0.01 −0.072|0.086			−0.02 −0.102|0.067			**−0.09** −0.173|−0.016
BMI (kg/m^2)	−0.04 −0.098|0.016	0.04 −0.103|0.028	−0.04 −0.113|0.036	−0.03 −0.079|0.023	−0.04 −0.113|0.028	0.04 −0.109|0.035	**0.09** 035|0.153	0.04 −0.036|0.103	0.04 −0.035|0.107
F	5.58[a]	4.32[a]	4.82[a]	5.58[a]	4.23[a]	4.82[a]	5.13[b]	7.37[a]	5.953[a]
Adjusted R^2	0.03[c]	0.05[c]	0.05	0.01[d]	0.03[d]	0.06[d]	0.05[d]	0.06[d]	0.06[d]

BMI, body mass index. [a]*p = < 0.001,* [b]*p = < 0.01,* [c]*p = < 0.05,* [d]*p R^2 change = <0.001; ß, standardized coefficient; 95 % CI, 95% confidence interval.*
Significant ($p \leq 0.05$) beta weights and CI are highlighted in bold. All analyses were adjusted for BMI.

literature is lacking. However, the findings of the current study are in contrast to one recent study concluding that the use of ergogenic supplements is associated with ED pathology in adult women (Nagata et al., 2020a). The results of the current study add novel information about the association between supplement use and ED risk factors and exercise in adolescent girls. This study further refines current knowledge about the association between muscle-building strategies and DE in girls (Rodgers et al., 2020) by asserting that protein, creatine, and dieting supplement use in general may not be as relevant in the context of DE without considering motives for use (i.e., for appearance or performance reasons).

Immigrant Status

The significant explained variance from immigrant status regarding protein and creatine supplement use vanished when sport and exercise variables were entered into the analyses. The results of this study suggest that the difference in use among immigrant and non-immigrant boys found initially may be partially explained by differences in sport and exercise participation. This finding expands current research concluding that muscle-building behaviors differ between ethnicities (Eisenberg et al., 2012; Nagata et al., 2020b); this finding indicates that differences in sport and exercise participation may explain the previously observed ethnic differences in supplement use. The significant explained variance from immigrant status regarding dieting supplements disappeared when ED risk factors were included in the analyses, indicating that the difference between immigrant and non-immigrants use of dieting supplements found in our study could be partially explained by differences in psychological measures (e.g., higher weight and shape concerns) among immigrant boys compared to non-immigrant boys. That creatine supplement use was more common among immigrant girls than non-immigrant girls is a novel finding not reported in previous studies. However, the association between immigrant status and creatine supplement use was weak and not well explained by the variables included in the current study.

Number of Users

The findings of this study may indicate that protein and creatine supplement use is more common in Norwegian adolescents compared to American and Australian adolescents (Miech et al., 2020; Yager and McLean, 2020). This may raise the question of whether supplement use has increased over time (Field et al., 2005; Eisenberg et al., 2012) to a level comparable to what adult elite athletes used 15 years ago (Sundgot–Borgen et al., 2003). Previous research in adolescents has highlighted that adolescents do not hold a sufficient amount of knowledge regarding the proper use and potential health consequences of sports supplements (Whitehouse and Lawlis, 2017). Additionally, there was a notably high number of infrequent creatine supplement users in the current sample. For creatine supplementation to be effective, the supplement must be consumed daily in combination with exercise and not consumed as a "pre-workout supplement" (Hall and Trojian, 2013). This finding may suggest that knowledge about proper use may be poor in both genders. Increasing knowledge about proper use may be warranted. However, there may be several other explanations for infrequent use, such as lack of finances to purchase supplements or the lack of routines making it hard to remember to consume creatine daily. The large proportion of supplement users in the current sample raises further concerns due to potential negative health consequences (Or et al., 2019; Tiwari, 2020), unknown long-term health effects (Pope et al., 2014), high risk of consuming contaminated products (Hoffman et al., 2008; Pope et al., 2014; Walpurgis et al., 2020). and future steroid use (Backhouse et al., 2013; Hurst et al., 2020).

Strengths and Limitations

The strengths of this study include large sample size and the inclusion of both girls and boys. The study also assessed both protein and creatine and dieting supplement use, as well as more frequent use than previous research. The inclusion of several psychological measures and assessment of physical activity level, exercise contexts, and different types and weekly frequency of sports participation, as suggested by previous studies, is also of note. However, the proportion of non-responders was large, and the sample of girls who used supplements was small, increasing the risk of type II error for those results. Another limitation is the use of a cross-sectional design limiting the ability to draw conclusions regarding causality between the variables examined. Furthermore, we did not include measures of other dietary supplements that may be less associated with body image and ED outcomes (e.g., vitamin supplements) (O'Dea, 2003). Therefore, the findings cannot be generalized to other dietary supplements. This study did not include measures regarding the duration of or reasons for supplement use; therefore, reasons for use can only be considered speculations. It is likely that long-time users differ from short-time users in psychological, sport, and exercise variables. In addition, the study did not assess competitive level of sport participation which limits the ability to investigate the influence of competitive sport participation on the results. Finally, only measuring physical activity level by subjective measures as well as using self-reported body height and weight provides a well-known bias.

Implications and Future Research

Prevention of supplement use in adolescents is warranted due to the high proportion of young users in the current study. Prevention programs should aim to increase knowledge about supplements and resilience and literacy toward supplement advertising and marketing. Prevention efforts are also suggested to be especially aimed at adolescent boys exercising at fitness centers and those participating in weight-sensitive sports. Increasing knowledge about exercise adaptation, nutrition, and supplement use in adolescents among trainers in fitness centers and sports teams may also prevent adolescent use of supplements. Policy change and legislation are also needed to better regulate the industry and include statutory third-party testing of supplements to reduce the risk of large proportions of contaminated supplements reaching consumers (Cohen et al.,

2014). Future research should include measures of a wide range of DE and weight and body change strategies and aims to model how these factors explain supplement use in both males and females. Future studies should also aim to enlighten why general adolescents consume supplements, to better understand their personal rationale for use. Finally, interventions aiming to prevent DE or to promote a positive body image in adolescents should also target supplement use and include such use as an outcome measure, especially in boys.

CONCLUSION

The number of weekly supplement users was high in this sample of late adolescents, and protein and creatine supplement use was more common among boys compared to girls. Immigrant boys used more protein, creatine, and dieting supplements than their non-immigrant counterparts, and creatine supplementation was more common in immigrant girls than non-immigrant girls Use of protein, creatine, and dieting supplements was associated with some risk factors for ED development and participation in exercise and sport participation emphasizing power, leanness, and appearance in boys but not in girls. Interventions, prevention, and policy change are warranted to avoid negative health consequences from supplement use. Preventive efforts should be targeted toward boys engaged in fitness center exercise, weight class, gravitational and aesthetic sports.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Regional Committees for Medical and Health Research Ethics. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

KS-T, OF, MT, CS-B, SB-S, JR, GP, and JS-B contributed to the design and implementation of the research. KS-T, OF, and JS-B contributed to the analysis of the results. All authors contributed to the writing of the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fspor.2021.727372/full#supplementary-material

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Paper II

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Effect of a healthy body image intervention on risk- and protective factors for eating disorders: A cluster randomized controlled trial

Kethe Marie Engen Svantorp-Tveiten [a,*], Monica Klungland Torstveit [b], Jan H. Rosenvinge [c], Christine Sundgot-Borgen [a,1], Oddgeir Friborg [c], Solfrid Bratland-Sanda [d], Gunn Pettersen [c], Jorunn Sundgot-Borgen [a]

[a] Norwegian School of Sport Sciences
[b] University of Agder
[c] UIT, The Arctic University of Norway
[d] University of Southeastern Norway

A B S T R A C T

Objective: To investigate the immediate and 12-months effects of a school-based intervention aiming to reduce risk and enhance protective factors for eating disorder development in high school boys and girls.
Method: In total, 4,149 adolescents from 30 high schools were eligible for inclusion and 2,446 consented to participate and were randomly allocated to the Healthy Body Image (HBI) intervention or a control group (classes as usual). The HBI intervention is multicomponent consisting of three workshops targeting body image, social media usage and lifestyle. Linear mixed model and intention-to-treat analyses were applied to investigate the effects of group, time, and gender at posttest, 3-, and 12-months follow-up. The main outcome variable was eating disorder sympomatology, and secondary outcome variables were self-esteem, mental distress, body image flexibility, thin internalization, muscular internalization, drive for leanness, perceived media pressure, protein- and creatine supplement use, and diet aid use.
Results: The HBI intervention significantly reduced eating disorder risk factor scores related to eating disorder sympomatology, thin internalization and perceived pressure from media, which was particularly pronounced in girls. Positive intervention effects on body image flexibility were only observed at posttest for boys but grew increasingly larger for girls across the 12-month follow-up time span. Favorable intervention effects on protein and creatine supplement use were only present at 3-months follow-up in boys solely. A general favorable intervention effect was observed for self-esteem, mental distress, muscular internalization, and drive for leanness.
Conclusion: The HBI intervention produced consistent reductions in risk factors and enhancements in protective factors associated with eating disorder development in adolescents.

1. Introduction

Disordered eating (DE) and eating disorders (EDs) have a profound effect on health influencing all bodily systems (Herpertz-Dahlmann et al., 2015; Keski-Rahkonen & Mustelin, 2016; Westmoreland, Krantz, & Mehler, 2016). The high prevalence (13 - 50 %) of DE, clinical and subclinical and EDs among males and females warrants the invention of programs that may successfully prevent augmentation of risk factors related to the development of EDs (Hammerle, Huss, Ernst, & Bürger, 2016; Limbers, Cohen, & Gray, 2018; Mitchison et al., 2020; Ortega--Luyando et al., 2015; Sparti, Santomauro, Cruwys, Burgess, & Harris, 2019; Torstveit, Aagedal-Mortensen, & Stea, 2015).

Established risk factors for DE and ED replicated in several studies are perceived appearance pressure, thin- and muscular appearance internalization, appearance comparison, body dissatisfaction, weight and shape concerns, dissatisfaction with muscularity, muscle building behaviors and dieting (Girard, Chabrol, & Rodgers, 2018; Girard, Rodgers, & Chabrol, 2018; Rodgers, Ganchou, Franko, & Chabrol, 2012; Rodgers, McLean, & Paxton, 2015; Rodgers et al., 2020; Stice & van Ryzin, 2019). Moreover, low self-esteem, depression and anxiety also act as risk factors for DE and EDs (Cruz-Sáez, Pascual, Wlodarczyk, & Echeburúa, 2020; Maraldo, Zhou, Dowling, & Vander Wal, 2016; McClelland, Robinson, Potterton, Mountford, & Schmidt, 2020; Pearson et al., 2017). Studies also suggests that reducing appearance pressure, appearance internalization, and comparison will result in reduced body dissatisfaction (Rodgers et al., 2015) and prevent the onset of EDs (Stice & van Ryzin, 2019).Protective factors for ED development is suggested as a new paradigm in the prevention of ED (Levine & Smolak, 2016;

* Corresponding author:
E-mail address: kmengen@nih.no (K.M.E. Svantorp-Tveiten).
[1] Present address: Regional Department for Eating Disorders, Oslo University Hospital

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Piran, 2015). Protective factors include high self-esteem, body image flexibility, body appreciation and self-compassion (Gurung, Sampath, Soohinda, & Dutta, 2019; Halliwell, 2013; Maraldo et al., 2016; Meland, Breidablik, Thuen, & Samdal, 2021; Rogers, Webb, & Jafari, 2018). Features protective factors have in common are that they facilitate constructive coping mechanisms, self-care and emphasize the focus on body functionality rather that appearance (Levine & Smolak, 2016). However, protective factors are less studied in relation to ED prevention (Levine & Smolak, 2016; Piran, 2015).

Universal ED prevention programs show promising findings in adolescents as most programs are successful in improving at least one established risk- or protective factor for ED development (Le, Barendregt, Hay, & Mihalopoulos, 2017; Schwartz et al., 2019; Stice, Shaw, & Marti, 2007; Watson et al., 2016). Despite promising findings in universal ED prevention in general, most studies include girls only (Kusina & Exline, 2019; Levine, 2021). Studies recruiting mixed gender populations often show that boys benefit less than girls from such interventions (Schwartz et al., 2019; Warschburger & Zitzmann, 2018; Wilksch & Wade, 2013). However, only one universal, mixed gender ED prevention program using a randomized controlled design included adolescents above the age of 16 (Eickman et al., 2018), and two studies had a younger mean age, but included 15-16 year old adolescents in their sample (Agam-Bitton, Abu Ahmad, & Golan, 2018; Mora et al., 2015). The rationale for recruiting younger samples in universal prevention is that one should intervene before the age of 14-15 where ED risk factors increase to a level that may need professional attention (Stice & van Ryzin, 2019). However, the risk for ED development increases through adolescence where the mean age of ED onset is approximately 18 years (Volpe et al., 2016). This leaves a possible gap for universal prevention that until now has been understudied. In addition, it has been argued that universal prevention also includes features from targeted or selected prevention programs as a proportion of the participants already experience increased ED risk or suffer from an ED (Schwartz et al., 2019). This emphasizes one of the advantages of universal prevention as being both preventive and health promotive and may benefit participants independent of risk status (Schwartz et al., 2019; Stice & Shaw, 2004).

Several reviews have summarized hallmarks of successful universal ED prevention programs .(Kusina & Exline, 2019; Le et al., 2017; Schwartz et al., 2019; Stice et al., 2007; Watson et al., 2016; Yager, Diedrichs, Ricciardelli, & Halliwell, 2013) It's recommended that universal ED prevention programs are 1) led by a professional, 2) consist of multiple and interactive sessions, 3) targets media literacy, and 4) apply a model of change creating cognitive dissonance.

However, the efficacy of universal ED prevention programs may be improved by adapting intervention content to better target more current challenges in older adolescents' lives (Anderson & Jiang, 2018; Rodgers et al., 2020; Steinsbekk et al., 2021). The *first* area of improvement is related to the raising popularity of "new" appearance ideals focusing on a fit and toned appearance with extremely low body fat percentage (Wiklund, Jonsson, Coe, & Wiklund, 2017). Such ideals may enhance appearance internalization, comparison and negative body image (Dignard & Jarry, 2021; Jarman, Marques, McLean, Slater, & Paxton, 2021), and thereby increase the risk for DE, ED and muscle building behaviors (Rodgers et al., 2020). Especially in adolescent boys, the use of supplements, such as protein and creatine is highly prevalent and predicts negative body image and drive for muscularity (Yager & McLean, 2020; Yager & O'Dea, 2014). The use of muscle building supplements has been suggested as an important target of interventions aiming to prevent negative body image, particularly in boys (Yager & McLean, 2020; Yager & O'Dea, 2014). To our knowledge, no programs have targeted the athletic and fit body ideal in a mixed gender setting, and only two programs aiming to prevent muscle building supplements have been carried out for regular high school students in a universal or school-based setting (Lucidi et al., 2017; Yager, McLean, & Li, 2019).

A *second* arena for improving prevention programs addresses the major societal changes in communication and social influence, that has evolved from non-interactive media and commercials to a high number of different interactive social media platforms where almost 90 % of older adolescents report being online almost constantly (Anderson & Jiang, 2018). This growth makes social media an important domain of social influence acting as an arena for appearance comparison (Jarman et al., 2021; Rodgers et al., 2020) and unhealthy lifestyle and fitness inspiration (Sabbagh, 2019; Tiggemann & Zaccardo, 2016). To our knowledge, no previous universal intervention has targeted social media usage and social media literacy in a universal ED prevention program.

The present study complements existing research by investigating the immediate and 12-month follow-up effects of a universal school-based intervention. We hypothesized that a multicomponent, health promotion intervention (Sundgot-Borgen et al., 2018) targeting social media usage and literacy, body image awareness, social comparison, self-esteem, lifestyle, and lifestyle literacy. would reduce risk- and enhance protective factors for ED development in girls and boys with effects that sustain over time.

2. Materials and methods

2.1. Participants and procedure

In August 2016, all public and private high schools in the Norwegian counties Oslo and Akershus were asked to take part in the study. The request, together with the study information was presented to the school principals and administrators. In total, 30 out of the 50 eligible schools agreed to participate.

We arranged a meeting at each school, and all students were thoroughly informed of the study aims and the implications of participation. The students subsequently received an electronic information letter, and an informed consent letter together with the questionnaires. Fig. 1 shows the school and participant flow at all measurement points. A total of 4,149 students aged 16–18 years and attending the 12th grade was eligible for inclusion from the 30 consenting schools. The decision of only including the 12th grade was made in consultation with the school principals who expressed limited time resources to include all grades in the study. in order to proceed. After baseline, all students who completed the posttest questionnaire were offered a movie ticket (valued at $15). Due to limited funding, we were only able to invite participants who had consented and partially answered the baseline questionnaire to the posttest. Additional funding made it possible to re-invite all those who had consented at baseline for the 3-, and 12-month follow-up. A total of 1,228 adolescents were included in the effect analyses, as they responded at both baseline and on at least one follow-up measure. All questionnaires were completed electronically outside school hours using the web-based survey tool Survey XACT developed by Ramboll, Norway.

2.2. Randomization

The schools were randomly allocated to either the intervention (k=14) or control group (k=16) to equalize school size and to capture the urban-rural dimension, ensuring that all regions in the catchment area were included. A cluster randomized design with 1:1 ratio was applied to minimize contamination biases within schools. Each school represented an individual cluster to reduce the diffusion of effects due to information crossover between intervention and control students. The randomization was performed by a professional outside the research team.

2.3. The healthy body image (HBI) intervention

The universal and school-based intervention aim to reduce ED sympomatology through the promotion of students' critical understanding of the influence of social- and mass media and peers. The

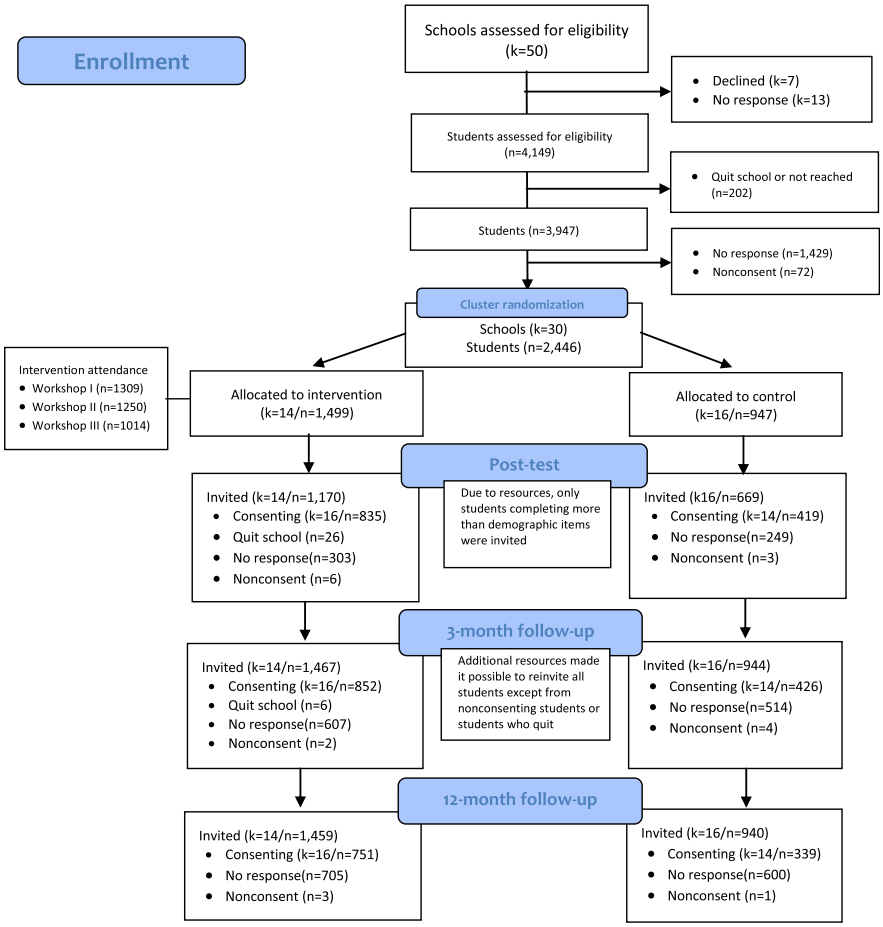

Fig. 1. Study flow, number of consenting participants, dropouts/nonresponders, and measurement time points. k=number of clusters, n=number of participants

intervention involved three 90-minute workshops including group and peer discussions, reflection, lectures, and short video clips.

The *first* workshop had a main theme of *body image* and included topics such as body image awareness, peer and family influences, appearance and social comparison, self-esteem and social media. The aim was to increase the students' awareness of what made them feel good about their body making them more able to take constructive actions to fill their daily life with positive influences, and to reflect upon how their own behavior could influence their peers' body image and self-esteem. The *second* workshop expanded content from the first workshop with a specific focus of *social media.* The objective was to make the students aware of how they could act and take responsibility for what type of content they got exposed to and how to make social media a positive social arena for themselves. We also aimed to increase the students' awareness of how themselves influenced their peers on social media making them critical about what content they posted, "shared" commented and "liked". The *final* workshop had an overarching theme of *lifestyle* and included topics such as exercise, supplement use and nutrition. The aims were to increase the students' literacy towards health information in social- and mass media, and to increase their understanding of how exercise and nutrition could be beneficial in improving their body experience. To achieve this, the workshop facilitators provided student-active tasks where they reflected upon how physical activity and healthy eating habits made them feel. A final aim was to discuss how social- and mass media make lifestyle a profitable industry, and to refute myths related to supplement use, nutrition and exercise. A comprehensive outline of the methodological and theoretical rationale for the HBI is described in the protocol paper (Sundgot-Borgen et al., 2018). On average, each workshop included 60 students; however, for practical reasons, workshop size varied between schools. The first and fourth authors, two women, headed the intervention. The workshops were obligatory for all students, as the intervention content reflected regular school curriculum and the different subjects' learning objectives. Workshop attendance (adherence to the intervention) was recorded for every workshop by the intervention facilitators. The intervention was held from September to December 2016, with an approximately three-week time interval occurring between each workshop. Several measures were taken to maximize intervention fidelity and reliability. The same two professionals worked as a pair both in the preparation phase and during all workshops at every school and were highly coordinated about how to make minor practical adjustments in naturalistic contexts. Materials and presentations were developed prior to intervention start. The materials and presentation provided a rigid and systematic overview of the content and topics to target and discuss

for each workshop. The intervention was piloted by the two professionals. All students and staff taking part in the pilot test were asked to provide information on areas of improvement. In addition, the pilot study was video recorded allowing for further refinement of content and delivery style.

2.4. Outcome measures

The main outcome variable was *ED sympomatology* and was measured by an empirically derived brief version (Friborg, Reas, Rosenvinge, & Ro, 2013) of the Eating disorder Examination Questionnaire (EDEQ) (Fairburn & Beglin, 2008). The EDEQ-11 is found to be a suitable measure of overall ED sympomatology (Friborg et al., 2013). The scale consists of 11 items scored on a seven-point Likert scale ranging from 0 to 6 were higher scores represent more severe ED sympomatology. All items are summed, and an average score was calculated. The Cronbach's alfa in our sample was .91 and .94 for boys and girls, respectively.

A summary of secondary outcome measures, instruments and internal consistency are presented in Table 1.

2.5. Statistical analyses

All analyses were performed using IBM SPSS statistics version 24.

Table 1
List of instruments included as secondary outcomes.

Instrument	Concept	Scale description	Cronbach's alpha boys/ girls
Rosenberg Self-esteem scale (Rosenberg, 1965)	Global self-worth	10-items, Likert scale (0-4), negative worded items are reversed, sum score. Higher score represents higher self-esteem	090/.92
SCL-10 (Strand, Dalgard, Tambs, & Rognerud, 2003)	Mental distress (symptoms of anxiety and depression)	10-items, Likert scale (1-4), average score. Higher score indicates more mental distress.	.89/.90
BIAAQ (Sandoz, Wilson, Merwin, & Kate Kellum, 2013)	Body image flexibility. Ability to constructively cope with negative emotions and situations challenging body image	12 items, Likert scale (1-7), negative worded items are reversed, sum score. Higher score represents more body image flexibility.	.85/.92
SATAQ-4 (Schaefer et al., 2015)	Societal and interpersonal aspects of appearance ideals subscales; thin and muscular internalization and media pressure	14 (5 + 5 + 4) items, Likert scale (1-5), average score. Higher scores equal greater experience of pressure and internalization.	.85-.94/.91-.95
DLS (Smolak & Murnen, 2008)	Drive for leanness. Degree of drive towards attaining	6 items, Likert scale (1-6), average score. Higher score indicates more drive for leanness.	.86/.86
Supplement use	Protein, creatine and diet aids use	3 standalone items asking about the weekly frequency of use. Likert scale (0-7). Higher scores represent more frequent use.	

SCL-10 = Hopkins symptom checklist 10, BIAAQ = Body image action and acceptance questionnaire, SATAQ-4 = Societal attitudes towards appearance questionnaire 4, DLS = Drive for leanness scale

The adequacy of the randomization procedure was tested with independent *t*- or chi-square tests examining whether group differences on the outcome variables at baseline were non-significant.

Cases without baseline or any follow-up data were defined as dropouts, otherwise retained. All baseline demographic measures correlating significantly with dropout status (Spearman's rho = > .19) were included as a covariate if significant in the final regression model. All analyses were intention-to-treat as all eligible participants with at least one post or follow-up assessment were included.

Due to several layers of dependency in the different outcome data, a linear mixed regression model (West, 2009) was specified. Dependency within the school clusters was accounted for by adding school as a random factor, whereas dependency between the repeated measures was accounted for by fitting a compound symmetry matrix to the residual matrices. The analysis is also robust against missing data because it analyzes all available data owing to the maximum likelihood function (restricted type used). To account for an imperfect randomization and to increase the statistical power, the baseline score of the outcome variable was added as a covariate. Fixed factors included *group* (mean difference between the intervention and control groups), *time* (mean change across the three measurement times), *gender* (mean difference between girls and boys), *group* × *time* (mean intervention difference at certain measurement occasions), *group* × *gender* (mean intervention difference between boys and girls) and *group* × *time* × *gender* (mean intervention difference at specific measurement occasions depending on gender). Type III F-tests were performed, and alpha values of < .05 were required. Hypothesized group differences observed at specific measurement times were examined as planned comparison tests (LSD). The weekly frequency of supplement use was recoded as follows: 1 (never) = 0, 2 (1-2 times per week) = 1.5, 3 (3-4 times per week) = 3.5, 4 (5-6 times per week) = 5.5 and 5 (every day) = 7.

The results are expressed as absolute numbers (n) and percentages (%) for categorical data and model estimated means including standard errors (SEs) and standard deviations (SDs) for continuous data. Effect sizes were calculated as standardized mean differences (or Cohen's $d = \frac{\text{estimated mean difference}}{\text{observed pooled SD}}$) and interpreted as negligible, small, moderate, or large when $d = <.20, .20 - .49, .50 - .79$, or $> .79$, respectively (Cohen, 1988). The power calculation used an α level of .05 and an average within-cluster sample size of 70 students. For each group, 10 clusters were needed to achieve a statistical power of 81 %. The total required sample size was calculated as 10 × 2 groups × 70 students in each cluster, resulting in 1,400 students.

2.6. Ethics

The study met the intent and requirements of the Health Research Act and the Helsinki declaration and was approved by the Regional Committee for Medical and Health Research Ethics (2016/142). The study was further enrolled in the international database of controlled trials, www.clinicaltrials.gov (ID: PRSNCT02901457). Students at consenting schools who did not want to participate in the study (i.e. not answer the questionnaires) did also receive the HBI intervention as the HBI content was founded in the subject curriculum.

3. Results

The response rate at baseline was 60 % of potential students with a higher number of girls than boys (girls 58 %, boys 42 %, $p = <.01$). Some significant differences in baseline variables between dropouts and responders were observed ($p = <0.01$). Control boy dropouts consumed more protein (1.71 vs. .97), creatine (1.50 vs. .69), diet aids (.86 vs. .19) per week than control boy responders, respectively. Control girl dropouts consumed more protein (.55 vs. .20) and creatine (.20 vs. .04) per week than control girl responders, respectively. No differences in psychometric variables were observed between dropouts and responders.

Table 2 presents workshop attendance in boys and girls who were included in the effect analysis of the main outcome (ED sympomatology). Demographic characteristics for the whole sample, and baseline and 12-months scores for outcome variables for participants included in the effect analyses are found in Table 3.

3.1. ED sympomatology

A significant overall *group, time* and *gender* effect was found for ED sympomatology (Table 4) with post hoc comparisons showing that the intervention group scored significantly lower than the control group at the 3- and 12-month follow-ups (Table 5). The intervention effect was moderated by *gender (group × gender)*, as girls benefitted from the intervention ($p = <.001$, $d = .21$) and boys did not (p = .470, $d = .05$) (Table 5).

3.2. Secondary outcomes

For self-esteem, a significant *group × time* effect was present (Table 4) as the control group had a small decrease whereas the intervention group had an increase in their score at the 12-month follow-up (Table 5).

A significant main effect of *group* was found for mental distress (Table 4) as the intervention group scored more favorably on mental distress than the control group (p = .035, $d = .10$). The intervention group maintained their mental distress over time while the control group increased their scores (*group × time* $p = < .001$, $d = .20$). Significant differences in mental distress between the intervention and control group were present at the 12-month follow-up (Table 5).

For body image flexibility, a significant *group × time × gender* effect was observed (Table 4) as girls from the intervention group increased their body image flexibility from the posttest to the 12-month follow-up (p = .001, $d = .16$) while control girls significantly decreased their scores between the 3- and 12-month follow-up (p = .004, $d = .21$) (Table 6). The 3-month effect observed in boys faded to the 12-month follow-up.

A *group × gender* effect was observed for thin internalization (Table 4) with a larger effect for girls ($p = <.001$, $d = .24$) than for boys (p = .052, $d = .15$). This effect was additionally moderated by *time* as a *group × gender × time* effect was present. The immediate effect in boys faded whereas the effect among girls sustained across the entire 12-month follow-up time span (Table 6).

A significant main effect was found for muscular internalization (Table 4) as intervention students scored lower than control students (p = .001, $d = .15$; Table 4). However, post-hoc comparisons revealed only 12-month effect in girls (Table 6).

A significant interaction between *group × gender* was observed for media pressure (Table 5) as effects were observed at all measurement timepoints in girls only (Table 6).

A significant main effect was found for drive for leanness (Table 4) as the intervention group had lower scores than the control group at all measurement time points (p = .003, $d = .12$) (Table 5).

For protein supplement use, a significant *group × time × gender* effect was present (Table 4) where the weekly frequency of protein supplement use in intervention boys remained stable while it increased for control boys across the 12-month follow-up period (p = .045, $d = .28$) with significant group differences found at the 3- and 12-month follow-ups (Table 6).

A significant *group × time × gender* was also present for weekly frequency of creatine supplement use (Table 4) as boys from the control group increased their creatine supplement use to the 12-month follow-up (p = .006, $d = .35$) with significant between group differences found at the 3- and 12-month follow-ups (Table 6). No main or interaction effects were observed for diet aid use.

Table 2
Workshop attendance among intervention boys and girls included in the effect analysis on ED sympomatology. Presented as percentage, and number of participants parenthesized.

	Boys (n = 276)	Girls (n = 590)
Attended at least one workshop	94.2 (260)	95.3 (562)
Attended all three workshops	64.5 (178)	57.5 (339)
Attended two workshops	25.4 (70)	29.7 (175)
Attended only one workshop	5.8 (16)	8.1 (48)
Attended the first workshop	88.0 (243)	88.6 (523)
Attended the second workshop	87.0 (240)	85.4 (504)
Attended the third workshop	73.6 (203)	65.8 (388)
Did not attend any workshops	5.8 (16)	4.7 (28)

4. Discussion

The aim of the HBI was to reduce risk and enhance protective factors for EDs in adolescent boys and girls. Our findings lend partial support for the universal impact of the HBI intervention being effective in addressing most of the risk and protective factors for ED development with sustained and even strengthened effects one year after the intervention. Both boys and girls benefited from the intervention; however, a tendency towards stronger and effects were present in girls.

Baseline levels of ED sympomatology in girls where higher compared to normative values of ED sympomatology previously reported in Norwegian and Swedish adolescents (Mantilla & Birgegård, 2016; Reas, Øverås, & Rø, 2012) and young adults (Reas et al., 2012). Fortunately, all boys reduced their ED sympomatology score over the follow-up period suggesting a decrease in ED risk. The reduction in ED sympomatology observed in boys is not surprising and may be explained by pubertal changes such as weight gain and increased muscle mass which brings boys closer to the male appearance ideal (McCabe, Ricciardelli, & Finemore, 2002), and increased circulating testosterone in post pubertal boys decreasing ED risk (Culbert, Burt, McGue, Iacono, & Klump, 2009). One may debate that it could be difficult to reduce ED sympomatology exceeding the natural developmental trajectory. Especially considered that boys in general had low scores on ED sympomatology at baseline raising the issue of floor effects leaving little room for improvement (Stice & Shaw, 2004). Our results on ED sympomatology align with two previous intervention programs (Wilksch et al., 2014; Wilksch & Wade, 2009). In contrast, one other intervention study has successfully reduced ED sympomatology in boys (Wade, Davidson, & O'Dea, 2003). These previous studies have thus included younger adolescents which may influence comparability as boys in early adolescence are less likely to have gone through puberty and may exist in a different sociocultural milieu than older adolescent boys.

The moderate effect size found in girls 12-months after the intervention gives hope for lasting effects in ED sympomatology in girls. The finding is promising as ED risk is found to increase from adolescence to early adulthood in girls (Slane, Klump, McGue, & Iacono, 2014) as the pubertal changes during puberty bring girls further away from the ideal body. Moreover, biological changes during puberty affect the genetic influence on ED development in girls (Culbert et al., 2009; Klump, Perkins, Burt, McGue, & Iacono, 2007) resulting in a post-pubertal increase in ED risk (Klump et al., 2007). The HBI intervention did not target ED sympomatology directly. The observed effect in girls is likely influenced by improvements in other factors targeted in the intervention, such as self-esteem, body image flexibility, appearance internalization, and media pressure.

A promising finding was the intervention effect in self-esteem and mental distress in both boys and girls at the 12-month follow-up. The reduced mental distress observed in the intervention students raises additional support for the HBI intervention as a health promotive and preventive intervention (Stice, Gau, Rohde, & Shaw, 2017). The reduced mental distress is also highly relevant considering the cross-sectional and longitudinal increase in mental distress observed the past two decades (Bakken, 2018; Kleppang, Thurston, Hartz, & Hagquist, 2019; Potrebny et al., 2019).

Table 3
Sample characteristics and 12-month follow-up score for participants included in the effect analyses shown as the mean and standard deviation (SD) or percentage and number of observations (N).

	Boys				Girls			
	N	Intervention	N	Control	N	Intervention	N	Control
Age (yrs.)	332	16.77 (.46)	175	16.73 (.49)	664	16.76 (.49)	324	16.78 (.48)
BMI (kg/m^2)	332	21.58 (2.64)	175	21.84 (3.16)	664	21.41 (2.79)	324	21.48 (3.11)
Parental income > $104,000, % (n)	332	48.8 (162)	175	44.0 (77)	664	34.9 (232)	324	25.5 (83)
Immigrant status % (n)	332	13.3 (44)	175	17.1 (30)	664	13.9 (92)	324	17.8 (58)
Paternal university education % (n)	332	76.8 (255)	175	64.0 (112)	664	72.9 (484)	324	63.4 (206)
Maternal university education % (n)	332	79.8 (265)	175	64.6 (113)	664	74.8 (497)	324	70.8 (230)
Eating disorder sympomatology								
Baseline	276	.97 (1.08)	131	1.14 (1.16)	590	2.38 (1.58)	276	2.68 (1.70)
12-month	155	.69 (.90)	67	.68 (.75)	436	1.59 (1.51)	177	2.44 (1.83)
Self-esteem								
Baseline	263	33.00 (5.63)	123	32.72 (6.37)	574	29.50 (5.97)	259	28.41 (6.50)
12-month	142	33.86 (6.00)	61	32.72 (6.95)	399	31.03 (6.11)	163	28.11 (7.41)
Mental distress								
Baseline	279	1.64 (.58)	134	1.77 (.62)	595	2.12 (.73)	261	2.25 (.78)
12-month	150	1.49 (.62)	65	1.72 (.75)	407	1.93 (.68)	166	2.23 (.78)
Body image flexibility								
Baseline	320	70.16 (9.35)	169	68.84 (11.05)	649	58.34 (15.32)	311	57.41 (16.53)
12-month	173	70.65 (11.31)	83	67.72 (12.66)	449	63.03 (16.00)	195	56.51 (19.43)
Media pressure								
Baseline	281	2.08 (1.13)	135	2.15 (1.17)	596	3.15 (1.25)	283	3.28 (1.27)
12-month	151	1.89 (1.03)	64	2.06 (1.09)	420	2.90 (1.27)	170	3.37 (1.23)
Thin internalization								
Baseline	281	2.48 (0.93)	135	2.63 (.92)	596	3.27 (1.07)	283	3.41 (1.14)
12-month	151	2.06 (.88)	64	2.26 (.79)	420	2.79 (1.13)	170	3.28 (1.19)
Muscular internalization								
Baseline	281	3.23 (1.11)	135	3.37 (1.03)	596	3.01 (1.09)	283	2.98 (1.05)
12-month	151	2.77 (1.06)	64	3.08 (1.09)	420	2.68 (1.03)	170	2.73 (1.09)
Drive for leanness scale								
Baseline	332	3.58 (1.02)	175	3.70 (1.09)	664	3.49 (1.00)	324	3.42 (1.06)
12-month	180	3.63 (1.01)	86	3.86 (.99)	467	3.37 (1.00)	202	3.56 (1.03)
Protein supplement use % (n)								
Baseline	294	22.8 (67)	137	30.7 (42)	613	6.9 (42)	286	7.3 (21)
12-month	158	8.9 (14)	68	29.4 (20)	440	5.0 (22)	185	5.4 (10)
Creatine supplement use % (n)								
Baseline	294	10.5 (31)	137	17.5 (24)	613	2.3 (14)	286	2.4 (7)
12-month	158	3.1 (9)	68	9.7 (9)	440	1.3 (8)	185	1.6 (3)
Diet aid use % (n)								
Baseline	294	5.4 (16)	137	8.0 (11)	613	3.9 (24)	286	4.5 (13)
12-month	158	1.0 (3)	68	1.4 (1)	440	2.4 (15)	185	1.6 (3)
Weekly frequency of protein supplement use (0-7)								
Baseline	294	.86 (1.83)	137	1.01 (1.80)	613	.21 (.93)	286	.23 (.98)
12-month	158	.56 (1.50)	68	.96 (1.77)	440	.26 (1.13)	185	.14 (.76)
Weekly frequency of creatine supplement use (0-7)								
Baseline	294	.46 (1.48)	137	.74 (1.82)	613	.07 (.56)	286	.04 (.30)
12-month	158	.25 (1.14)	68	.52 (1.46)	440	.05 (.47)	185	.02 (.19)
Weekly frequency of diet aid use (0-7)								
Baseline	294	.25 (1.16)	137	.24 (.95)	613	.10 (.60)	286	.10 (.60)
12-month	158	.06 (.59)	68	.02 (.18)	440	.08 (.60)	185	.05 (.19)

BMI = body mass index, immigrants = two foreign born parents, ED sympomatology = eating disorder pathology. Significant differences between the intervention and control groups are highlighted in bold.

The sleeper effect observed may be explained by the need for time to elaborate on the intervention content and implement skills and routines before it can facilitate a further change in outcomes. In addition, immediate improvements in other psychological variables may have facilitated a change in self-esteem and mental distress, such as social media usage (Rodgers et al., 2020), body image and ED sympomatology (Meland et al., 2021; Puccio et al., 2017). Sleeper effect may also be partially explained by delays in the improvements in peer environment, where change in (e.g.) social comparison, appearance conversation, fat talk and peer appearance focus need time to mature and develop before it results in change in the outcomes.

Several aspects of adolescent self-esteem development are important when interpreting the results. The small increase in self-esteem observed in the intervention group could be the result of a natural developmental course. In both girls and boys, self-esteem development follows a reversed u-shaped curve through life where it increases from childhood to early adolescence where it then remains stable, possibly explained by more rapid fluctuations due to external contingencies (Crocker & Wolfe, 2001). During late adolescence, self-esteem becomes less contingent and continues to increase into to midlife before it decreases in older age and elderly (Orth, Erol, & Luciano, 2018). Lastly, the intervention effect in mental distress and self-esteem may relate to baseline difference between intervention and control group in socioeconomic status which is a strong predictor of mental health development (Kivimäki et al., 2020; Orth & Robins, 2014).

Our lack of lasting effect with respect to body image flexibility are promising compared to one previous study finding no effect of an internet based universal prevention program on body image flexibility (Rodgers et al., 2018). Importantly, they did not include gender as a moderator in the analysis and the proportion of boys was small. In

Table 4
Type III test showing main and interaction effects for group, time and gender for all outcome variables adjusted for baseline outcome scores.

	Group			Group x Time			Group x Gender			Group x Time x Gender		
	df	F	p	df	F	P	df	F	p	df	F	p
Eating disorder sympomatology	41.87	8.90	**.005**	1895.40	2.20	.111	1197.50	3.90	**.048**	1895.90	1.28	.279
Self-esteem	27.98	11.79	**< .001**	1858.55	4.17	**.022**	1216.86	.23	.628	1859.73	.07	.928
Mental distress	33.75	4.76	**.036**	1881.96	8.68	**< .001**	1283.49	.04	.846	1882.83	.23	.792
Body image flexibility	22.20	18.63	**< .001**	2104.43	2.04	.131	1307.67	.27	.602	2104.80	4.48	**.011**
Media pressure	31.02	16.42	**< .001**	1963.22	.18	.836	1132.52	4.39	**.036**	1963.20	.07	.934
Thin internalization	38.84	20.94	**< .001**	1936.98	.02	.979	1290.61	4.23	**.040**	1937.68	.78	.460
Muscular internalization	35.44	12.92	**.001**	1938.00	1.75	.175	1306.63	.47	.492	1938.75	1.37	.255
Drive for leanness	36.94	9.77	**.003**	2118.03	.03	.967	1477.63	.45	.501	2119.61	.86	.423
Protein	32.06	5.11	**.031**	1924.36	1.56	.210	1070.81	11.73	**.001**	1925.55	3.49	**.031**
Creatine	19.33	2.06	.167	1891.91	8.43	**< .001**	1122.31	2.34	.127	1892.46	7.77	**< .001**
Diet aids	809.07	.06	.808	1585.40	1.00	.367	809.11	.90	0.343	1585.35	.31	.737

Group = intervention vs. control, Time = measurement timepoint, gender = boys vs. girls, Protein, Creatine and Diet aids = weekly frequency of use. Significant effects are highlighted in bold.

Table 5
Difference in outcome scores between intervention and control group showed as mixed model estimated marginal mean scores and standard errors (SEs) and effect size, Cohen's d (*d*). Adjusted for baseline outcome scores. Outcomes where the effect was moderated by gender are printed in grey font color.

	Intervention		Control		Mean difference (SE)	*P*	*d*
	N	Mean (SE)	N	Mean (SE)			
Eating disorder sympomatology **(covariate: 2.02)**							
Posttest	753	1.68 (.04)	360	1.79 (.05)	-.11 (.07)	.093	
3-month	664	1.70 (.04)	303	1.86 (.06)	-.16 (.07)	.022	.17
12-month	578	1.52 (.04)	244	1.79 (.06)	-.27 (.07)	.001	.27
Self-esteem (covariate: 30.33)							
Posttest	456	31.23 (.22)	739	30.39 (.27)	.84 (.35)	**.020**	**.15**
3-month	390	30.71 (.23)	654	30.10 (.30)	.62 (.37)	.103	
12-month	305	31.74 (.24)	562	30.03 (.32)	1.71 (.40)	**<.001**	**.33**
Mental distress (covariate: 2.01)							
Posttest	754	1.86 (.03)	347	1.86 (.03)	.00 (.04)	.993	
3-month	661	1.82 (.03)	292	1.88 (.03)	-.06 (.04)	.179	
12-month	557	1.82 (.03)	231	2.00 (.03)	-.18 (.04)	**<.001**	**.31**
Body image flexibility (covariate: 61.79)							
Posttest	778	63.44 (.43)	366	61.75 (.60)	1.70 (.74)	.026	.14
3-month	740	63.90 (.45)	352	61.26 (.61)	2.65 (.76)	.001	.22
12-month	622	64.28 (.48)	278	60.83 (.69)	3.45 (.83)	<.001	.30
Media pressure (covariate 2.86)							
Posttest	777	2.55 (.04)	372	2.75 (.05)	-.21 (.06)	.002	.20
3-month	687	2.59 (.04)	312	2.70 (.06)	-.20 (9.07)	.006	.19
12-month	571	2.57 (.04)	234	2.82 (.06)	-.246 (.08)	.002	.24
Thin internalization (covariate: 3.07)							
Posttest	777	2.65 (.03)	372	2.90 (.05)	-.20 (.09)	<.001	.26
3-month	687	2.62 (.04)	312	2.87 (.05)	-.15 (.10)	<.001	.26
12-month	571	2.61 (.04)	234	2.85 (.06)	-.11 (.11)	.001	.26
Muscular internalization (covariate 3.05)							
Posttest	777	2.75 (.04)	372	2.96 (.05)	-.204 (.06)	**.002**	**.20**
3-month	687	2.73 (.04)	312	2.99 (.05)	-.26 (.07)	**<.001**	**.26**
12-month	571	2.76 (.04)	234	2.89 (.06)	-.13 (.07)	.065	
Drive for leanness (covariate: 3.50)							
Posttest	785	3.48 (.04)	381	3.63 (.05)	-.15 (.06)	**.012**	**.16**
3-month	756	3.52 (.04)	371	3.69 (.05)	-.17 (.06)	**.008**	**.17**
12-month	624	3.56 (.04)	287	3.73 (.05)	-.17 (.06)	**.013**	**.18**
Weekly frequency of protein supplement use (covariate: .37)							
Posttest	769	.33 (.04)	377	.37 (.06)	-.05 (.07)	.461	
3-month	690	.32 (.04)	318	.53 (.06)	-.21 (.07)	.005	.20
12-month	598	.39 (.04)	253	.50 (.06)	-.10 (.08)	.213	
Weekly frequency of creatine supplement use (covariate: .17)							
Posttest	769	.18 (.03)	377	.12 (.04)	-.06 (.06)	.291	
3-month	690	.15 (.03)	318	.32 (.05)	-.17 (.06)	.008	.20
12-month	598	.15 (.03)	253	.26 (.05)	-.10 (.06)	.123	
Weekly frequency of diet aids use (covariate: .12)							
Posttest	769	.04 (.02)	377	.07 (.03)	-.03 (.04)	.442	
3-month	690	.06 (.02)	318	.08 (.03)	-.03 (.04)	.472	
12-month	598	.08 (.02)	253	.05 (.03)	.03 (.04)	.377	

Posttest = after intervention, SE = standard error of the estimated, *d* = Cohen's d. Significant effects are highlighted in bold.

contrast, intervention girls increased their body image flexibility relative to control girls who decreased their body image flexibility resulting in a 12-month effect among girls. Our findings suggest that the intervention girls increased their capacity to constructively cope with challenging perceptions, emotions, beliefs and thoughts without compromising chosen personal values. The increase in body image flexibility in girls may have reduce their risk of developing EDs, as it may protect them from engaging in DE behaviors to cope with stressful

Table 6
Post-hoc comparisons with gender as moderator. Scores are presented as mixed model estimated marginal mean scores and standard error (SE) and effect size, Cohen's d (*d*), for boys and girls. Adjusted for baseline outcome scores. Gender was included as moderator and the analyses were not stratified by gender.

	Boys							Girls						
	Intervention		Control		Mean difference (SE)			Intervention		Control		Mean difference (SE)		
	N	Mean (SE)	N	Mean (SE)		*P*	d	N	Mean (SE)	N	Mean (SE)		*P*	d
Eating disorder pathology (covariate: 2.02)														
Posttest	240	1.56 (.06)	115	1.63 (.08)	-.07 (.10)	.481		513	1.81 (.04)	245	1.96 (.06)	.15 (.07)	**.042**	**.16**
3 months	196	1.62 (.06)	88	1.69 (.09)	-.06 (.11)	.583		468	1.78 (.04)	215	2.04 (.06)	.26 (.08)	**.001**	**.28**
12-month	155	1.43 (.07)	67	1.55 (.09)	-.12 (.12)	.343		423	1.61 (.04)	177	2.02 (.06)	.41 (.08)	**<.001**	**.50**
Self-esteem (covariate: 30.33)														
Posttest	226	31.36 (.31)	230	30.70 (.41)	.66 (.51)	.195		230	31.09 (.23)	509	30.08 (.31)	1.02 (.38)	**.010**	**.21**
3-month	189	30.43 (.33)	201	29.85 (.47)	.58 (.57)	.310		201	31.00 (.24)	453	30.34 (.32)	.66 (.40)	.102	
12-month	142	31.99 (.36)	163	30.41 (.52)	1.59 (.62)	**.011**	**.38**	163	31.48 (.25)	399	29.66 (.34)	1.82 (.42)	**<.001**	**.39**
Mental distress (covariate: 2.01)														
Posttest	235	1.80 (.04)	116	1.78 (.05)	-.02 (.06)	.752		519	1.92 (.03)	231	1.94 (.04)	.02 (.05)	.681	
3-month	196	1.77 (.04)	88	1.82 (.06)	.05 (.05)	.444		465	1.87 (.03)	204	1.94 (.04)	.07 (.05)	.160	
12-month	150	1.74 (.05)	65	1.94 (.06)	.20 (.05)	**.009**	**.38**	407	1.89 (.03)	166	2.07 (.04)	.17 (.05)	**.001**	**.30**
Body image flexibility (covariate: 61.79)														
Posttest	247	63.65 (.70)	124	62.21 (.96)	-1.44 (1.18)	.223		531	63.23 (.49)	242	61.28 (.70)	-1.95 (.85)	**.024**	**.18**
3-month	225	64.00 (.73)	115	60.37 (.99)	-3.64 (1.22)	**.003**	**.34**	515	63.80 (.50)	237	62.14 (.71)	-1.65 (.86)	.057	
12-month	173	63.62 (.80)	83	61.79 (1.13)	-1.83 (1.37)	.181		449	64.92 (.52)	195	59.87 (.76)	-5.08 (.92)	**<.001**	**.47**
Media pressure (covariate 2.86)														
Posttest	244	2.35 (.06)	120	2.43 (.09)	.08 (.11)	.449		244	2.74 (.04)	120	3.07 (.06)	.33 (.08)	**<.001**	**.35**
3-month	201	2.38 (.07)	91	2.48 (.10)	.10 (.12)	.150		201	2.79 (.04)	91	3.09 (.06)	.30 (.08)	**<.001**	**.32**
12-month	151	2.36 (.08)	64	2.51 (.11)	.14 (.13	.291		151	2.78 (.05)	64	3.13 (.07)	.35 (.09)	**<.001**	**.38**
Thin internalization (covariate: 3.07)														
Posttest	244	2.52 (.06)	120	2.72 (.08)	.20 (.09)	**.029**	**.24**	533	2.78 (.04)	252	3.08 (.05)	.30 (.07)	**<.001**	**.34**
3-month	201	2.51 (.06)	91	2.66 (.08)	.15 (.10)	.140		486	2.74 (.04)	221	3.09 (.06)	.35 (.07)	**<.001**	**.40**
12-month	151	2.53 (.07)	64	2.64 (.09)	.11 (.11)	.341		420	2.69 (.04)	170	3.06 (.06)	.37 (.08)	**<.001**	**.44**
Muscular internalization (covariate 3.05)														
Posttest	244	2.78 (.06)	120	3.06 (.07)	.28 (.09)	**.003**	**.34**	244	2.72 (.04)	120	3.06 (.06)	.28 (.09)	.064	
3-month	201	2.82 (.06)	91	3.13 (.08)	.30 (.10)	**.003**	**.38**	201	2.64 (.04)	91	3.13 (.06)	.30 (.10)	**.004**	**.24**
12-month	151	2.78 (.06)	64	2.88 (.09)	.10 (.11)	.370		151	2.73 (.04)	64	2.88 (.06)	.11 (.13)	**.033**	**.19**
Drive for leanness (covariate: 3.50)														
Posttest	257	3.55 (.05)	127	3.70 (.07)	-.15 (.09)	.089		528	3.41 (.04)	254	3.57 (.05)	-.16 (.06)	**.018**	**.18**
3-month	231	3.64 (.05)	122	3.81 (.07)	-.16 (.09)	.065		525	3.40 (.04)	249	3.57 (.05)	-.17 (.07)	**.014**	**.19**
12-month	175	3.71 (.06)	86	3.80 (.08)	-.09 (1.00)	.347		449	3.42 (.01)	201	3.66 (.05)	-.24 (.07)	**.001**	**.26**
Weekly frequency of protein supplement use (covariate: .37)														
Posttest	248		120		-.09 (.11)	.408		521		257		-.01 (.07)	.911	

(*continued on next page*)

Table 6 (*continued*)

	Boys Intervention		Control		Mean difference (SE)			Girls Intervention		Control		Mean difference (SE)		
	N	Mean (SE)	N	Mean (SE)		*P*	d	N	Mean (SE)	N	Mean (SE)		*P*	d
		.41 (.06)		.50 (.90)					.24 (.04)		.25 (.06)			
3-month	202	.39 (.07)	93	.83 (.09)	-.47 (.12)	**<.001**	**.50**	452	.27 (.04)	215	.22 (.06)	.05 (.08)	.531	
12-month	158	.42 (.07)	68	.77 (.09)	-.35 (.13)	**.020**	**.43**	440	.35 (.05)	185	.23 (.07)	.12 (.08)	.178	
Weekly frequency of creatine supplement use (covariate: .17)														
Posttest	248	.31 (.05)	120	.19 (.07)	.12 (.09)	.203		521	.06 (.04)	257	.06 (.05)	.00 (.07)	.992	
3-month	202	.23 (.05)	93	.53 (.08)	-.30 (.09)	**.003**	**.40**	452	.08 (.04)	215	.11 (.06)	-.03 (.07)	.703	
12-month	158	.22 (.06)	68	.45 (.08)	-.23 (.11)	**.045**	**.32**	440	.08 (.04)	185	.08 (.06)	.00 (.07)	.979	
Weekly frequency of diet aids use (covariate: .12)														
Posttest	248	.02 (.03)	120	.05 (.05)	-.03 (.05)	.531		521	.08 (.02)	257	.09 (.03)	-.01 (.04)	.695	
3-month	202	.03 (.04)	93	.10 (.05)	-.07 (.06)	.261		452	.09 (.02)	215	.07 (.03)	.02 (.04)	.631	
12-month	158	.06 (.04)	68	.04 (.06)	.02 (.07)	.814		440	.10 (.02)	185	.05 (.04)	.05 (.04)	.185	

SE =standard error of the estimate, *d* = Cohen's d. Significant effects are highlighted in bold.

cognitions challenging their body image (Rogers et al., 2018; Wendell, Masuda, & Le, 2012). Increasing adolescent's literacy towards unhealthy appearance ideals, discussing truths and myths related to idealized lives, diets, and exercise as well as equipping them with skills to handle negative exposures and stressors, may have facilitated lasting improvements in body image flexibility in girls.

The girls in our sample experienced more thin internalization compared to previously reported scores for young women (Schaefer, Burke, & Thompson, 2019). Fortunately, intervention girls reduced their thin internalization relative to the control girls. The effect on thin internalization and perceived pressure is positive and has most likely contributed to the reduced ED sympomatology in girls. This finding is highly relevant as elevated thin internalization or experienced appearance pressure is present in almost half of adolescent girls who later develop an ED (Stice & van Ryzin, 2019).

Fortunately, both control and intervention boys decreased their thin internalization and media pressure scores. The lack of 12-month effect in both internalization, media pressure, and ED sympomatology reflects the theories explaining how change in perceived media pressure could facilitate reduced ED sympomatology through reduced appearance internalization (Schaefer, Rodgers, Thompson, & Griffiths, 2021). Our results are in contrast to previous universal interventions creating improvements in general internalization (Gonzalez, Penelo, Gutierrez, & Raich, 2011; Sharpe, Schober, Treasure, & Schmidt, 2013; Wilksch, Tiggemann, & Wade, 2006) and media pressure (Warschburger & Zitzmann, 2018). However, these studies have assessed general internalization and not thin or muscular internalization in particular and have included a younger sample than this present study.

Girls baseline scores on drive for leanness and muscular internalization underline that the athletic, muscular and lean appearance ideals and strives are not only relevant to boys. Our findings suggest that also targeting internalization of a wider range of appearances, not only thin internalization, may be beneficial when aiming to reduce ED risk in girls. Previous research has concluded that drive for leanness compromises of elements from both drive for thinness and drive for muscularity, and thus represents a unique dimension of body image (Smolak & Murnen, 2008). Therefore one could suggest that the reduction in both thin and muscular internalization observed in our study has facilitated a reduction in drive for leanness in girls (Tod, Edwards, & Hall, 2013). The HBI intervention created an *overall* effect on muscular and athletic internalization and drive for leanness as gender did not significantly moderate the intervention effect. The post-hoc comparisons, revealed, however, no 12-month effect on muscular internalization or drive for leanness in boys. Our results are still promising for muscular internalization even if the effect faded 12-months after the intervention due to a reduction in muscular internalization among control boys. The non-significant post-hoc comparisons with respect to muscular reinternalization and drive for leanness may also be partially explained by low statistical power as gender did not moderate the effect.

In theory, improvements in muscular internalization and drive for leanness could in turn facilitate change in supplement use, if such use is motivated by appearance or muscularity enhancement reasons. The 12-month effect on protein and creatine supplement use in boys may be partially related to the small improvements observed for muscular internalization and drive for leanness (Rodgers et al., 2020), and by the intervention content which aimed to increase knowledge and literacy towards nutrition and supplement advertisement. Such content may also be relevant to boys who use supplements for other reasons than appearance (e.g. performance or "because their friends do"). The stable scores on protein and creatine supplement use in intervention boys are fortunate, as one would expect an increase among boys as they age (Bartee, Grandjean, Dunn, Eddy, & Wang, 2004; Whitehouse & Lawlis, 2017), as observed among control boys. Importantly, control boys and girls who were characterized as dropouts consumed significantly more protein, creatine and dieting aids than control responders. Therefore, the fact that we found any improvements among boys were somewhat surprising, yet fortunate. In contrast to one previous study in girls (Austin, Field, Wiecha, Peterson, & Gortmaker, 2005) no improvement was observed for diet aids use. This is unfortunate, but aligned with current knowledge that universal prevention rarely show sustained effects in preventing DE or ED behaviors (Le et al., 2017). The results in boys may also be influenced by dropout status as control boy dropouts

consumed diet aids more often than control boy responders. Floor effects may also be present for supplement and diet aids use in girls and diet aids use in boys.

4.1. Strengths and limitations

Strengths to this study were the clustered randomized controlled design, equal number of control and intervention schools, and an equalization of error variance in questionnaire responses. The students represented wide ranges of socioeconomic and demographic backgrounds strengthening the study generalizability. Moreover, the large sample size provided adequate statistical power to detect both immediate and distal main effects. The benefit of a longitudinal design was, however, diminished as moderator analyses were hampered by a loss of power at the 12-month follow-up in boys. The statistical methods used to investigate the intervention effect may be considered a strength as individuals who missed one or two follow up-assessments were still included in the analyses. Another strength was the inclusion of baseline scores and school cluster as covariates (Smith, 2012), which could have compensated for the observed demographic and socioeconomic differences between the intervention and the control group. Challenges related to the validity and reliability of intervention delivery remain unaddressed since facilitator protocol adherence was not measured.

4.3. Implications and future research

The effect sizes raise issues of clinical importance. However, baseline outcome scores in universal prevention and health promotion interventions rarely reach a clinical level (Franko, Cousineau, Rodgers, & Roehrig, 2013). Additionally, even small changes in mental health outcomes in universal health promotion interventions may result in important changes at population level (Huppert, 2009). Gender differences in effects may be related to factors such as facilitators' gender, where only using female facilitators might have influenced relevance and credibility for boys, and the intervention setting and learning trajectories which might favor girls preferences and developmental stage (Honigsfeld & Dunn, 2003; Van Houtte, 2004). In addition, taking these factors into consideration. Further replication of our findings is necessary to prove the efficiency of the HBI program. Also, the inclusion of a longer follow-up period could determine if effects fade or increase over time. Clinical interviews should be performed to investigate if the HBI intervention is successful in reducing ED onset, which will help determining the clinical relevance of the HBI intervention. Lastly, future studies should aim to perform the assessments within the school hours to prevent unnecessary dropout.

5. Conclusion

The HBI intervention was successful in reducing risk and enhancing protective factors for ED development with sustained effects found at 12-month follow-up. The HBI intervention was equally successful in increasing self-esteem and reducing mental distress in girls and boys.

Conflict of Interest

None

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.mhp.2021.200225.

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Paper III

The Healthy Body Image intervention and reduction in eating disorder symptomatology and muscle building supplement use in high school students: a study of mediating factors

Svantorp-Tveiten, K. M. E.*[, 1], **Ivarsson**, A.[2,3], **Torstveit**, M. K.[3], **Sundgot-Borgen**, C.[1, †], **Mathisen** T. F.[4], **Bratland-Sanda**, S.[5], **Rosenvinge**, J. H.[6], **Friborg**, O.[6], **Pettersen**, G[7]. & **Sundgot-Borgen**, J[1].

[1] Department of Sports Medicine, The Norwegian School of Sport Sciences, Oslo, Norway.

[2] Centre of Research on Welfare, Health and Sport, Halmstad University, Halmstad, Sweden.

[3] Department of Sport Science and Physical Education, University of Agder, Kristiansand, Norway.

[4] Faculty of Health, Welfare and Organisation, Østfold University College, Halden, Norway.

[5] Department of Sports, Physical Education and Outdoor Studies, University of South-Eastern Norway, Kongsberg, Norway.

[6] Department of Psychology, UiT -The Arctic University of Norway, Tromsø, Norway.

7 Department of Health and Care Sciences, UiT -The Arctic University of Norway, Tromsø, Norway.

[†] Present address: Regional Department for Eating Disorders, Oslo University Hospital., NO-0424 Oslo, Norway

*** Correspondence:**
Kethe Marie Engen Svantorp-Tveiten
kmengen@nih.no

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Abstract

Background: Mediation analysis in intervention studies are important to test the theoretical framework underpinning the intervention which may improve the development of more effective interventions. We therefore aimed to investigate if the Healthy Body Image (HBI) intervention's effect on eating disorder (ED) symptomatology and muscle building supplement use was mediated by the change in risk- and protective factors for ED development and muscle building supplement use.

Methods: This study used data from the HBI intervention: a cluster randomized controlled universal intervention aiming to promote positive embodiment and reduce the risk for ED development including 30 schools in Norway. A total of 1,713 (37 % boys) were included in the analyses. Conditional latent growth curve analyses were performed to test for indirect effects on ED symptomatology and weekly frequency of protein- and creatine supplement use measured at the 12-month follow-up via change in the proposed mediators.

Results: In girls, the reduction in ED symptomatology was mediated by favorable changes in protective factors (self-esteem and body image flexibility) and risk factors (perceived media pressure and thin appearance internalization). Comparable changes in boys played no mediating role and no significant mediators were found for muscle building supplement use in boys nor girls.

Conclusion: Interventions aiming to reduce the risk of ED development in girls may benefit from aiming to enhance self-esteem and body image flexibility and reduce perceived media pressure and thin appearance internalization. Future studies should further investigate the casual relationship between muscle building supplement use and risk- and protective factors for ED development in both girls and boys.

1 Introduction

Evidence suggests that interventions aiming to prevent eating disorders (ED) should target established risk- and protective factors for ED development such as internalization of appearance ideals, perceived appearance pressure, self-esteem, peer environment, and positive emotion coping strategies, such as body image flexibility. (1-5). Reviews also highlight that targeting media literacy using interactive education, challenging cognitive dissonance with multiple sessions, seems to be effective in universal ED prevention in adolescents (1, 6-8).

The sociocultural theory focus on the role of social and cultural influences on individual development, and that learning is mainly a social process (9, 10). This framework is often used to describe and understand how social and cultural factors influence ED development. Sociocultural theories has the past decade also included muscular oriented body image and muscle building behaviors (11-15). Sociocultural theories of body image, ED symptomatology and muscle building behaviors have been tested and modelled in cross sectional and longitudinal studies (12-21). In all, these studies suggest that perceived appearance pressure from sociocultural sources (e.g. media, family, and peers) explains body image, ED symptomatology and muscle building behaviors through mechanisms of appearance internalization and social comparison. Moreover, recent studies has suggested the role of social media as a source of appearance pressure in explaining body dissatisfaction, ED symptomatology, and muscle building behaviors (11, 22). Perceived media pressure is normally targeted in ED prevention programs alongside with internalizing of a general media or thin appearance ideal (23). However, perceived media appearance pressure has not been evaluated as a potential mediator for intervention effect. Three studies have investigated general media internalization as a mediator in universal prevention interventions (24-26) with various results. However, the previous studies have assessed general media internalization, and no studies, to the best of our knowledge, have investigated actual thin appearance internalization as a mediator in universal ED prevention programs. In addition, no studies have included athletic- and muscular appearance internalization, which may be important in studies including boys and girls who identifies within the muscular oriented dimension of body image. Moreover, no study has investigated these mediators in girls and boys separately. Such knowledge may be important when refining and developing universal prevention programs as current evidence suggest that boys tend to benefit less from universal ED prevention programs than girls (1).

Further, recent evaluations of sociocultural models of body image and ED symptomatology have also include the role of protective factors within the field of positive body image (27), such as self-esteem, self-compassion and body image flexibility. These models highlights that self-esteem may act as a protective factor against appearance pressure, internalization, and comparison (11, 20), which suggests that individuals with higher self-esteem may experience less appearance pressure, internalization of unrealistic appearance standards and more likely to resist comparing themselves with others. Also, studies find that self-compassion and body image flexibility act as moderators between appearance internalization and social comparison and ED symptomatology (17, 28). This indicates that individuals who holds a high body image flexibility and self-compassion may experience appearance internalization without the consequence of comparing their appearance with others', or that they may experience social comparison without increasing their ED symptomatology.

Body image flexibility is a component of positive body image and reflects the ability to maintain behaviors that are consistent with chosen values when negative feelings, thoughts, body sensations or memories related to one's own appearance are experienced (29). High levels of body image flexibility is found to be inversely associated with less adaptive emotion coping strategies, disordered

eating and negative body image and positively linked to positive emotion regulation strategies, body satisfaction, self-compassion, well-being and quality of life (5). . Importantly, there is evidence that body image flexibility could be an important component in the ability to hold a positive body image whilst experiencing body dissatisfaction (30). As such, body image flexibility is viewed as a protective factor for eating disorder development and maladaptive behaviors (5). However, this construct has not been targeted in ED prevention programs and has therefore not been considered as a mediator for intervention effect.

Low self-esteem is viewed an universal risk-factor for different EDs (31). High self-esteem may act as a buffer against stressful life events and pressures (32) and equip adolescents with important life managing skills which they bring into adulthood (33). As such, self-esteem is targeted in numerous eating disorder prevention programs (25, 34-36), however, only one study has included self-esteem as a potential mediator for intervention effect (25). However, this study reported outcomes in girls only.

In contrast to dieting or weight reduction behaviors, muscle building behaviors have been given less attention in ED prevention interventions (37). Research suggests that the use of muscle building supplements, such as protein- and creatine supplements correlates with negative body image and positively with muscular oriented body dissatisfaction and use of muscle building behaviors in adolescents (38, 39). Muscle building supplement use has also been found to be explained by core ED symptoms, shape concerns, and restrictive eating in young adult males and females, binge eating and compulsive exercise in males, and bulimic behaviors in females (40). In addition, engagement in muscle enhancing behaviors, which include supplement use, predicts dietary restraint in both boys and girls (11). Yet, a recent study indicates that protein and creatine supplement use could be considered a symptom of DE in boys, but not girls (41). To capture a broader range of factors related to ED symptomatology, especially in boys, it seems reasonable to include muscle building supplement use within an intervention aiming to reduce the risk for ED development in a sample also including boys. It may be reasonable to assume that interventions with similar methodological strategies as successful ED prevention programs could be effective in preventing muscle building supplement use, as the sociocultural framework which are often used in ED prevention interventions are also found to be suitable to explain muscle building behaviors (11). In addition, the media literacy approach is found to be a successful in preventing a wide range of unhealthy behaviors and attitudes other than DE and EDs (11, 42).

Few studies have tested if the change in the suggested and targeted risk factors is the actual cause for the intervention's effect on ED symptomatology or similar main outcomes in universal ED prevention. Further, no study has included protective factors for ED symptomatology, beyond self-esteem, as mediators in universal ED prevention. Importantly, no studies have considered these mediators in relation to muscle building supplement use and within a randomized controlled trial design allowing to draw casual conclusions. Additionally, investigating if mediation and mechanisms of change from ED prevention intervention differs between girls and boys has been requested by others (24). Knowledge about mediating constructs in interventions is important to test the theoretical foundation that the intervention builds on (7), to increase the understanding of the causality among variables (43), and to determine which risk and protective factors may have been most important to target in the current intervention in order to develop or fine-tune the intervention.

The Healthy Body Image (HBI) intervention (44), is a universal school-based intervention aiming to promote positive image and reduce the risk of ED development through targeting risk- and protective factors within the sociocultural theory and positive body image (11, 20, 45, 46). The HBI

intervention targeting body image, media literacy, and lifestyle is multicomponent in nature and uses an interactive delivery strategy aiming to reduce risk for ED development through the promotion of students' critical understanding of the influence of social- and mass media and peers (44). The HBI intervention has shown to be effective in reducing several risk factors for- and enhancing protective factors against ED development in adolescent girls and boys (47), muscle building supplement use in adolescent boys (47), to positively affect eating habits and sleep duration (48), and to strengthen positive body image in girls (49) through increased self-esteem (50). However, the effect of the HBI intervention were weaker among boys compared to girls with respect to psychological outcomes. This present study extends current knowledge about ED symptomatology and muscle building supplement use as outcomes following participation in the HBI intervention. Additionally, the present study brings ahead new knowledge about the mediating role of a broader set of risk- and protective factors that may explain why the intervention works. Formally, we examined if the previously reported reduced ED symptomatology observed in girls and muscle building supplement use observed in boys (47) were mediated by the change in self-esteem, body image flexibility, thin appearance internalization, athletic-and muscular appearance internalization, and perceived media pressure. We also aimed to explore if change mechanisms were similar girls and boys. We hypothesized that the intervention effect on ED symptomatology and muscle building supplement use were mediated by the change in thin appearance internalization, athletic- and muscular internalization, perceived media pressure, self-esteem, and body image flexibility in boys and girls.

2 Materials and methods

2.1 Participants and procedure

In the fall of 2016, all public and private high schools in the Oslo and Akershus counties in Norway were asked to take part in the study. The request and information about the study was presented to the school principals and administrators. Of the 50 eligible schools, 30 agreed to participate. A total of 3,947 students, aged 16–18 years, and attending the 12^{th} grade were eligible for inclusion. We arranged a meeting at each school and all students were thoroughly informed about the study aims and the implication of participation. They were also requested to provide their e-mail address to be reachable. The students subsequently received an information letter, an invitation to take part in the study, and an informed consent letter together with the questionnaires.

After baseline testing, all students who completed the posttest questionnaire were offered a movie ticket (valued at $15). Due to limited funding, we were only able to invite participants who had consented and partially answered the baseline questionnaire (T1) to the posttest (T2). Additional funding made it possible to re-invite all those who had consented at T1 for the 3-month follow-up (T3), thereby increasing the number of students participating from T2 to T3. All consenting students at T1 were re-invited to the 12-month follow-up (T4). The T2 questionnaire was sent out to the students within 7 days after they had participated in the last workshop.

For the current study, a total of 1,713 adolescents (intervention group n = 1,130, 37 % boys, control group n = 583, 37 % boys) responded on all included questionnaires at baseline and were included in the analyses. All questionnaires were completed electronically outside school hours using the web-based survey tool Survey XACT, by Ramboll, Norway. Figure 1 shows the number of consenting schools and participants at all measurement points for the main intervention study

2.2 Randomization

The schools (s) were randomly allocated to either the intervention (s = 14) or control group (s = 16) to equalize school size and to capture the urban-rural dimension, ensuring that all regions in the catchment area were included. To minimize contamination biases within schools, a 1:1 ratio for cluster randomization was applied by an external professional unaffiliated with the project team. Each school represented an individual cluster to reduce the diffusion of effects due to information crossover between intervention and control students.

2.3 The Norwegian Healthy Body Image (HBI) intervention

The aim of the intervention was to promote positive body image and reduce the risk for ED development. The intervention involved three classroom-based and interactive 90-minute workshops, focusing on the three topics; body image and self-esteem, social media, and lifestyle. The workshops were led by two female researchers specializing in body image, mental health, and sports and exercise science. Workshop attendance was recorded for every workshop by the intervention facilitators. A comprehensive outline of the HBI intervention rationale, procedure, and content are described in a protocol paper (44), and a brief summary of the content is given in Table 1. The control schools had classes as usual and were informed that they could receive an abbreviated workshop after the 12-month follow-up.

2.4 Outcomes

2.4.1 Main outcome variables

ED symptomatology was the main outcome variable and was measured with an empirically derived (51) brief version of the Eating Disorder Examination Questionnaire (52) consisting of 11 items (EDEQ-11). The items are scored on a seven-point Likert scale ranging from "no days"/"not at all" to "every day"/"Markedly" (e.g *"Have you had a definite desire to have a totally flat stomach?"* or *"Has your shape influenced how you think about (judge) yourself as a person?"*). All items were added, and an average score was computed. The abbreviated version was found to correspond well with the complete 22-item instrument (51) which discriminates well between ED patients and healthy individuals (53). The internal consistency (α) of the EDEQ-11 was 0.94 and 0.91 in girls and boys, respectively.

Muscle building supplement use included protein- and creatine supplement use. Protein- and creatine supplement use were measured with self-developed questions on the use of supplements and on how many times per week supplementation was consumed (e.g. *"How often during a regular week do you consume protein supplements (e.g. powders/shakes)?"*) with values ranging on a five-point Likert scale scored: 0 (never), 1.5 (1-2 days), 3.5 (3-4 days), 5.5 (5-6 days) and 7 (every day).

2.4.2 Mediators

The Rosenberg self-esteem scale (54) is a 10-item instrument measuring global self-esteem using both negative and positive worded items which are scored on a four-point Likert scale ranging from strongly agree to strongly disagree (e.g. "*I feel that I'm a person of worth, at least on an equal plane with others")*. The total score ranges from 0 to 30 and negatively worded items were reversed so that a higher score represents a higher level of global self-esteem. In the present study, internal consistency (α) was 0.90 and 0.92 for boys and girls, respectively.

The body image acceptance and action questionnaire (BIAAQ) (29) is a measure of body image flexibility. Body image flexibility is the ability to openly experience and accept stressful emotions, thoughts, and experiences challenging body image without compromising chosen values (e.g. not

engage in DE behaviors). The scale includes 12 items (e.g. *"I shut down when I feel bad about my body shape or weight"*) which are scored on a seven-point Likert scale ranging from "never true" to "always true". The score ranges from 12 to 84 where negatively worded items were reversed for a higher score to reflect more body image flexibility. The internal consistency was 0.92 in girls and 0.85 in boys in our sample.

The sociocultural attitudes towards appearance questionnaire-4 (55) was developed to assess societal and interpersonal aspects of appearance ideals. The questionnaire consists of five individual subscales scored on a five-point Likert scale ranging from "strongly disagree" to "strongly agree". The three subscales; thinness/low body fat internalization (SATAQ Thin), athletic and muscular internalization (SATAQ Muscular), and perceived pressure from media (SATAQ Media) were included in this study. The subscale scores range from 1-5 where a higher score indicates a higher degree of internalization or perceived pressure (e.g. *"I want my body to look very lean"*, "*I spend a lot of time doing things to look more muscular"*, and *"feel pressure from the media to improve my appearance").* Internal consistency between 0.85 and 0.94 for the boys and between 0.91 and 0.95 for the girls.

2.5 Data analysis

Independent sample t-test or Mann Whitney U-test were performed to test if baseline characteristics differed between responders (responded at T1 and one follow-up measure) or drop-outs (responded at T1 only).

To test if there were indirect effects from the intervention to the outcomes, measured at T4, through change in the proposed mediator's (T1-T4), conditional latent growth curve (LGC) analyses were performed in Mplus 8.4 (56). All models were performed with the robust maximum likelihood estimator (MLR). Separate models were estimated for each of the proposed mediators, and for both boys and girls. In the conditional models, group belonging (intervention, control) was included as an independent variable, EDE-Q, weekly frequency of protein supplement use and creatine supplement use were included as dependent variables, together with the four waves of the proposed mediators. In all models, the intervention group was coded as 0 and the control group was coded as 1. Within all analyses we controlled for the baseline scores of all dependent variables (57).

To evaluate model fit we used a combination of the following fit indices (58); Comparative Fit Index (CFI; >.90), Standardized root mean residual (SRMR, <.08), and the root mean square error of approximation (RMSEA; <.08). Full information maximum likelihood (FIML) was used to deal with missing data. More specifically, FIML is considered as the state-of-the-art missing data technique when data are considered to be missing at random (59).

For each parameter within the model standardized regression coefficients were calculated together with a *p*-value. For all parameters a *p*-value <.05 was considered to indicate a statistically significant effect within the model. In line with suggestions within the literature we inspected non-symmetric bootstrap confidence intervals (*CI*) to assess mediation (60). These intervals were based on 10000 bootstrap sample and together why provide an empirical representation of the sampling distribution of the indirect effect (*ab*). The indirect effect was considered to be statistically significant if the 95% *CI* did not include zero (61).

Because the participants were from different schools, we performed sensitivity analyses to investigate if the inclusion of school belonging as a covariate would improve model fit. The Akaike information criterion (AIC) and the Bayesian information criterion (BIC) were inspected to determinate if the

inclusion of the covariate improved model fit. The results from all the path analyses showed that the inclusion of school as a covariate did not improve model fit. We therefore decided to present the results for the models without the covariate included.

2.6 Ethics

The study met the intent and requirements of the Health Research Act and the Helsinki Declaration regarding informed consent and unconditional withdrawal and was approved by the Regional Committee for Medical and Health Research Ethics (2016/142). This work was supported by the DAM foundation (2016/FO76521), through the Norwegian Woman's Public Health Association (H1/2016). A commercial sponsor (TINE AS) supported the study after the study protocol was published (44) but was not involved in data collection, data analysis, or the writing of the present article.

3 Results

A total of 7,336 data points in the variables of interest had no values and were, therefore, treated as missing data (26.17%). A total of 20,692 data points were included in the analyses. Baseline characteristics and outcomes at T4 in intervention and control boys and girls are shown in table 2. Control boy dropouts consumed significantly more protein (1.71 vs. .97) and creatine (1.50 vs. .69) per week than control boy responders, respectively. Control girl dropouts consumed more protein (.55 vs. .20) and creatine (.20 vs. .04) per week than control girl responders, respectively. No statistically significant differences in psychometric variables at T1 were observed between dropouts and responders. Path analyses and parameter estimates are illustrated in Figure 2a-e and model fit indices and slope estimates are presented in table 3.

3.1 Self-esteem

As illustrated in Figure 2a, there was a significant positive relationship between group belonging and change in self-esteem indicating a less steep decrease in self-esteem for boys in the intervention group in comparison to boys in the control group (*a* path). In girls, the results showed a significant positive relationship between the group belonging and protein supplement use and creatine supplement use at T4 (*c path).* Also, there was a significant positive relationship between group belonging and change in self-esteem between T1 and T4 (*a* path), as girls in the intervention group showed, on average, a significant higher increase in self-esteem than the girls in the control group. Also, there was a significant inverse relationship between change in self-esteem and EDEQ at T4 indicating that an increase in self-esteem from T1 to T4 was associated with lower levels of EDEQ at T4 (*b* path). Finally, there was a significant indirect effect of group belonging to EDEQ at T4 via change in self-esteem (Figure 2a) in girls.

3.2 Body image flexibility

The only significant path for boys was between change in BIAAQ and EDEQ (*b* path) at T4 indicating that an increase in BIAAQ was associated with lower levels of EDEQ (Figure 2a). As shown in Figure 2b, girls in the intervention group used, on average, significant more protein supplement use measured at T4 than girls in the control group (*c* path). Girls in the intervention group showed, on average, a significant higher increase in BIAAQ than the girls in the control group (*a* path). Also, there was a significant inverse relationship between change in BIAAQ and EDEQ at T4 indicating that an increase in BIAAQ was associated with lower levels of EDEQ (*b* path). Last, there was a significant indirect effect of group to EDEQ at T4, via change in BIAAQ (*ab* path).

3.3 Thin internalization

As presented in Figure 2c, in boys, there was a significant inverse relationship between change in SATAQ thin and level of creatine supplement use at T4 (*b* path). For girls, there was a significant inverse relationship between group belonging and change in SATAQ thin between T1 and T4 (*a* path). More specifically, girls in the intervention group showed, on average, larger decrease in SATAQ thin compared to the girls in the control group. Also, there was a significant positive relationship between change in SATAQ thin and EDEQ at T4, as well as a significant inverse relationship between change in SATAQ thin and creatine supplement use (*b* paths). This indicates that a greater decrease in SATAQ thin from T1 to T4 was associated with lower EDEQ, but more creatine supplement use at T4. Lastly, there was a significant indirect effect of group belonging to EDEQ as well as creatine supplement use both measured at T4, via change in SATAQ thin.

3.4 Muscular internalization

As illustrated in Figure 2d, there were no significant direct or indirect effects in boys. In girls, the results showed a significant positive relationship between the group belonging and creatine supplement use at T4 (*c* path). Also, there was a significant inverse relationship between group belonging and change in SATAQ muscular between T1 and T4 (*a* path). More specifically, girls in the intervention group showed, on average, larger decrease in SATAQ muscular compared to the girls in the control group.

3.5 Perceived media pressure

As shown in Figure 2e, there was a significant inverse relationship between group belonging and creatine supplement use measured at T4 in boys (*c* paths). In girls, there was a significant inverse relationship between group belonging and change in SATAQ media between T1 and T4 (*a* path). More specifically, girls in the intervention group showed, on average, larger decrease in SATAQ media compared to the girls in the control group. Also, there was a significant positive relationship between change in SATAQ media and EDEQ (*b* path). Lastly, there was a significant indirect effect of group belonging to EDEQ in girls (Figure 2e).

4 Discussion

The main aim of this study was to investigate potential mediators accounting for the effect of the HBI intervention on ED symptomatology and muscle building supplement use in adolescent boys and girls. We hypothesized that the intervention effect on ED symptomatology and supplement use was mediated by the change in thin appearance internalization, athletic and muscular internalization, perceived media pressure, self-esteem, and body image flexibility in boys and girls.

Our hypothesis was partially supported as the reduction in ED symptomatology observed at the 12-month follow-up in intervention girls was explained by an increase in self-esteem and body image flexibility, and a reduction in thin internalization and perceived pressure from media. However, the change in the tested mediators did not explain the 12-month follow-up score on ED symptomatology in boys or muscle building supplement use in boys nor girls.

4.1 Self-esteem

We found that the increase in self-esteem in intervention girls relative to control girls from baseline to 12-months follow-up explained the lower ED symptomatology among intervention girls at 12 months follow up. This is a novel finding and is in contrast to a previous study who did not find that

self-esteem mediated the effect of an universal ED prevention program on body image or body esteem (25). There may be several potential explanations why increased self-esteem may facilitate reductions in ED symptomatology. Studies suggest that body dissatisfaction negatively influences self-esteem (62), where self-esteem may act as an important mediator between body dissatisfaction and ED symptomatology through influencing negative affect (63). in contrast, other suggests that contingencies of self-esteem, as opposed to global self-esteem, related to encouraging love, appearance, and social acceptance may protect against ED development as they predict lower body surveillance and higher body satisfaction (64). Lastly, high self-esteem may explain lower dietary restraint both through lower body dissatisfaction and by possibly reducing appearance internalization and upwards appearance comparison (11). As such, the increased self-esteem observed in the intervention girls could have caused the reduced ED symptomatology either directly or through influencing other risk- or protective factors for ED symptomatology. The HBI intervention aimed to make the students recognize and value their own personal characteristics and what they appreciate in their significant others. This may have enhanced beliefs that their personal characteristics are important and valuable, independent of how they look, which is suggested as an important factor for self-esteem (64). In addition, targeting social media usage and reducing exposure to content that negatively influences body image may have facilitated the increase in self-esteem (65).

4.2 Body image flexibility

We also observed a greater increase in body image flexibility over the study period among intervention girls compared to control girls. This intervention effect on body image flexibility further explain why intervention girls, relative to control girls, had reduced their ED symptomatology 12-months after the intervention. Body image flexibility is an important component of positive body image, and a measure of the ability to openly experience and constructively cope with emotions, events and thoughts challenging their body image (29). Therefore, an increase in body image flexibility may result in less engagement in unhealthy appearance modifying behavior; a characteristic and less favorable coping strategy to stress in those prone to EDs. Hence, increased body image flexibility may protect against developing EDs. Body image flexibility is associated with numerous psychological outcomes related to wellbeing and psychopathology (4). However, most studies are cross-sectional and do not investigate the causal relationship. Therefore, our finding, that the change in body image flexibility over 12-months predicted the 12-month intervention effect on ED symptomatology in regular adolescent girls, is therefore a novel and encouraging finding not described elsewhere. Previous research finds that holding a more positive body image is associated with higher self-care, being more connected to one's body, and being more engaged in health promotive behaviors (46, 66, 67). Promoting positive body image and embodiment was targeted in the HBI intervention by challenging the students to recognize how lifestyle choices made them feel. They were encouraged to intentionally make lifestyle choices which could enhance their own body experience and functionality rather than focusing on appearance. In addition, content aiming to make the students recognize unhealthy and untrustworthy lifestyle information from influencers and media in general could have made them more literate against the use of unhealthy methods to change appearance, and rather stay true to their own chosen values reflected in strengthened body image flexibility. Lastly, having the students discuss and share both positive and challenging thoughts, feelings and experiences could have helped to normalize their experiences and emotions and removed some of the stigma often associated with mental health and body image, and made the girls more acceptive towards their feelings and emotions.

Our findings, that both body image flexibility and self-esteem act as significant mediators for the intervention effect on ED symptomatology, supports the suggestion that a health promotive approach

with a focus on positive body image may be beneficial in future programs aiming to prevent EDs in girls from an universal population (46).

4.3 Perceived appearance pressure and internalization

The mediating effect of perceived appearance pressure and thin appearance internalization on ED symptomatology is in line with different sociocultural models of EDs (13, 18, 20). These models suggest that perceive appearance pressure explains DE or ED symptomatology through the pathways of increased appearance internalization, appearance comparison and negative body image. This means that the reduction in perceived appearance pressure is expected to make girls less likely to internalize unrealistic appearance ideals and upwards appearance comparison (3, 18). The favorable changes in perceived appearance pressure and thin appearance internalization observed among our intervention girls could, in light of sociocultural models, have resulted in the girls being less concerned about their appearance, prevented ED symptomatology, and finally reduced their risk of developing EDs (3, 11, 18). Several pathways to reduce appearance internalization and its negative impact on body image and ED risk has been suggested in the literature. McLean et al (2013; 2016) describes the importance of increased media literacy to strengthen critical thinking and evaluation of media messages related to appearance. This is thought to reduce internalization and it's negative impact on body image and ED risk (68, 69). The HBI intervention targeted media literacy (the typical idealization portrayed in social media, the origin of idealization, personal reflection on emotional responses), which may have strengthened the girls media literacy, made them more resilient towards social media messages and idealization and internalization of a thin appearance ideal. The students were also challenged to be more selective on what social media content they would prioritize, in order to feel good about themselves. By addressing the perfectionistic life in social media, and creating an arena for the students to reflect and discuss on this, may have made the girls more aware, critical, and literate (42). This content could also have strengthened the girl's health literacy, which may be a successful strategy when aiming to improve body image, reduce appearance internalization and reduce the risk for ED development (70). The result from such discussions and reflections, could be development of cognitive dissonance against idealized appearance standards (71). Lastly, Wade, Wilksch (24) point out the importance of change in attitudes towards appearance standards in the peer environment, which was also aimed for within the HBI intervention. This could have acted as another pathway towards reduced appearance pressure and internalization in our sample. Peers plays an important role in adolescents body image and ED symptomatology as they may be important sources of appearance pressure (72) and predict body dissatisfaction and DE behaviors in adolescents (73). The HBI intervention aimed to create a collective change in attitudes towards appearance by discussing and provide the students with tools and skills to create a more body image friendly and accepting peer environment with less emphasis on appearance. To reduce unhealthy appearance focus transmitting in the peer environment, the HBI intervention aimed to reduce "fat talk" and worked with the students to eliminate appearance focus in their daily communication. Moreover, the students practiced focusing on personal characteristics in their communication with their peers. In addition, the HBI intervention aimed to make the student aware of how themselves could be positive influences for their friends and peers in social media and make them less likely to "like", "share", comment, and post appearance focused content on different social media platforms. Additionally, a novel finding was that targeting and creating change in muscular appearance internalization did not explain the girls ED symptomatology 12 months after the intervention. This suggests that targeting muscular idealization may be unnecessary in future ED prevention interventions in girls.

However, other factors may also explain the relationship between the intervention, the tested mediators and ED symptomatology 12 months after the intervention. The intervention girls had a

higher self-esteem and less ED symptomatology than the control girls at baseline. This may indicate that girls from the intervention group already possessed several favorable resources making them more robust towards challenging life events and emotions. These positive characteristics could in turn nurture a more beneficial development in self-esteem, body image flexibility, appearance internalization, perceived media pressure and ED symptomatology (32, 74).

None of the tested mediators accounted for ED symptomatology at the 12-month follow-up in boys. This may be explained by the fact that we did not observe any effect of the HBI intervention on ED symptomatology in boys in the effect analyses (47). A direct effect between group and body image flexibility, and between body image flexibility and ED symptomatology was observed. This suggest that strengthening body image flexibility could prevent ED symptomatology in boys. Our results, however, also indicate that the HBI intervention did not create enough enhancements in body image flexibility to create any reductions in ED symptomatology among boys. Surprisingly, our results also suggest that creating enhancements in self-esteem, reduced perceived media pressure, and appearance internalization, not necessary facilitate changes in ED symptomatology in boys as no other direct effects between the mediator and ED symptomatology was observed.

4.4 Muscle building supplement use

We have previously found that the HBI intervention had no effect on muscle building supplement use in girls (47). However, we assume that the association found between muscle building supplement use and drop-out at follow-up in boys and girls most likely has influenced the results and ability to draw conclusions. Possibly influenced by drop-out, the mediation analyses showed more frequent supplement use in intervention girls relative to control girls at 12-month follow-up which was further partly explained by a reduction in thin internalization. This contrast to previous research findings in girls that muscle building behaviors or muscularity concerns are positively explained by appearance pressure and internalization either directly (13) or through the pathway of appearance comparison and body dissatisfaction (11). As such, our results highlight a possible complexity when aiming to prevent *both* muscle building supplement use *and* ED development in girls which has not been described previously. Similar findings were present in boys as our results suggest that a greater reduction in perceived appearance pressure and thin internalization explained more creatine supplement use in boys at 12-months follow-up independent of group belonging. This findings are in contrast to previous literature explaining muscle building behaviors which suggest that higher appearance pressure and muscular appearance internalization may lead to muscle building behaviors (11, 14). Our finding may indicate that the use of muscle building supplements is multifaceted in nature and that adolescents use muscle building supplements for other reasons than enhancing muscularity. Especially in girls, where we previously found that use was not associated with ED risk factors, and that engagement in sport and exercise were important independent explanatory factors for muscle building supplement use in boys (41).

Even if the HBI intervention prevented muscle building supplement use in boys (47), none of the tested mediators accounted for the prevention effect on muscle building supplement use in boys. These findings indicate that enhancing self-esteem and body image flexibility may be unnecessary if the only aim is to prevent muscle building supplement use in boys. It may also suggest that other topics in the HBI-intervention, which were not measured, were the reason for these changes, such as increased knowledge and literacy towards nutrition, exercise, and health information (i.e., that eating well-balanced, regular meals with ordinary food is more important that using supplements). Our results on muscle building supplement use are in line with findings from a roughly comparable study aiming to prevent muscle building supplement use and doping (75). This study found that using a

media literacy approach and targeting nutritional knowledge and literacy prevented use off muscle building supplements. The hypothesis that increased knowledge may explain the effect in supplement use among boys is strengthened by previous mediation analyses from the ATHENA program showing that improving knowledge about nutrition and supplement was some of the the initial mediator accounting for the change in several psychological and attitudinal constructs explaining muscle building supplement use and DE behaviors in adolescent athlete girls (76).

4.5 Strengths and limitations

A strength of this study was the use of a cluster randomized control trial with a longitudinal design including four measurement timepoints allowing for testing change over time and use of standardized and validated psychological instruments. Another strength is the inclusion of several potential mediators, analyses stratified by gender, and including mediators not tested previously in universal ED prevention interventions, and the fact that this is the first study to investigate mediating factors for intervention effects on muscle building supplement use in a universal sample of boys and girls.

Moreover, the sample size was larger than in most previous prevention studies. We did, however, face a substantial loss to follow-up and reduced statistical power at the 12-month follow-up. Also, drop-out status was associated with muscle building supplement use in the control group. In addition, the use of single mediation models makes limits the ability to draw conclusion about how interactions between the different mediators might have influenced the outcomes. Moreover, the analyses did not allow for randomization of the relationship between the change in mediator and the outcome. Therefore, caution should be made when evaluating the casual relationship between the estimated mediator slope and the main outcome. The relationship between the mediator and outcome is contemporary as the change in the mediator and the outcome occurs within the same time period (77). Change in outcome may however causes the change in the mediator when the mediator and the outcome are measured at the same time (78).

4.6 Implications

Professionals working with adolescent girls could aim to increase their literacy towards (social) media messages, provide them with tools to help them make reflected choices regarding their own social media behaviors, and aim to strengthen their resilience towards unhealthy and unrealistic appearance standards, notably a thin appearance ideal. Moreover, professionals could have additional focus on enhancing adolescents' ability to accept and constructively cope with thought, emotions, and experiences challenging their body image, and perform tasks and discussions to strengthen adolescent girls' self-esteem. Future studies should further investigate the casual relationship between psychological and behavioral factors and muscle building supplement use in both girls and boys, as our study did not confirm previous research explaining muscle building behaviors. In addition, more knowledge on mechanisms of change related to ED symptomatology in boys are warranted. Future studies could also investigate mediators in a serial multiple mediation model to disentangle how the potential mediators are related and how they together explain ED symptomatology and muscle building supplement use in boys and girls

4.7 Conclusion

The results support that the HBI intervention is successful in changing mediators within the sociocultural theory and positive body image in girls. Our results suggest that targeting self-esteem, body image flexibility, perceived appearance pressure and thin appearance internalization are

beneficial when aiming to reduce the risk for ED development in adolescent girls, but not boys. None of the suggested mediators acted as mediators for muscle building supplement use in boys nor girls.

5 Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

6 Author Contributions

K.M.E.S-T, O.F, M.K.T, C.S-B, S.B-S, J.R, G.P and J.S-B contributed to the design and implementation of the research, A.I, K.M.E.S-T and J.S-B contributed to the analysis of the results, and all authors contributed to the writing of the manuscript.

7 Acknowledgments

We like to thank all participating schools and students.

8 Contribution to the Field Statement

Several universal programs aiming to prevent EDs has showed promising results. This has resulted in numerous reviews summarizing intervention features which may be implemented to create an ED preventive or risk reduction effect. However, these suggestions are made on a basis of what characterize successful intervention programs and results from cross sectional data on how psychological constructs are related to body image and EDs. Moreover, no studies aiming to prevent both EDs and the use of muscle building supplements has been performed in a universal setting including regular adolescent boys and girls. Little knowledge exists regarding how targeting different psychological factors within an intervention may facilitate actual change in ED risk or use of muscle building supplements. Such knowledge may be important to determine which psychological factors to target in an intervention to create an intervention effect. Such knowledge may improve the development of more successful prevention programs. This current study is the first to investigate several mediators accounting for the effect of an intervention aiming to reduce the risk for ED development and muscle building supplement use. This research may be an important contribution to the understanding of Universal prevention of EDs and muscle building supplement use.

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Table 1. Overwiev of the content and aims of the three workshops in the HBI intervention

#1 Body image	
Main content:	Aim:
Project introduction	Experience of meaningfulness and motivation
Influencing factors on body perception. What promotes and reduces positive body image, and how can we enforce the health promoting factors?	Body image and body acceptance
Where does body idealization come from? Why does it conflict with positive body image, and potential health consequences from striving for the idealized body?	Reduce idealization and internalization of body ideals
Fat talk and focus on lifestyle only related to appearance in everyday communication. To what degree do we participate, how does it make us feel, and can we reduce it?	Reduce fat talk and negative body talk Improve peer environment
Introduction to self-talk and self-esteem in WS#2	Stimulate motivation for next workshop
#2 Social media	
Main content:	Aim:
Social media perception and use. Empower yourself to choose mood enhancing over mood destructive content	Enhance media literacy
Extreme exposure without filter equals need to be critical to sources of information and awareness of retouching	Enhance media literacy
The nature of comparison, how to recognize destructive comparison and reduce its presence in everyday life	Reduce amount of comparison
Strengthen acceptance and love for individual differences, defining characteristics of ones' own and among friends. Students tell and write down compliments to a friend and him/herself unrelated to appearance.	Improve positive self-talk Improve self-compassion Improve peer environment
Experiences and benefits of positive self-talk	Improve skills to strengthen self-esteem
#3 Lifestyle	
Main content:	Aim:
Benefits on body experience from listening to bodily needs such as physical activity and healthy eating	Improve experience of embodiment
Truths and myth about lifestyle products and literature	Improve ability to reject exercise and nutritional myths - health information literacy
From aesthetic to functional focus; how can change in focus improve body experience and healthy lifestyle that again benefit well-being?	Change from potential unhealthy focus to healthy focus on the body
How may regular exercise and smart nutrition promote positive body image and what are the basic recommendations?	Body experience enhancing attitudes and behaviors

Retrieved and adapted from Sundgot-Borgen, C., Bratland-Sanda, S., Engen, K. M. E., Pettersen, G., Friborg, O., Torstveit, M. K., . . . Rosenvinge, J. H. (2018). The Norwegian healthy body image programme: study protocol for a randomized controlled school-based intervention to promote positive body image and prevent disordered eating among Norwegian high school students. *BMC Psychology, 6*(1), 8. doi:10.1186/s40359-018-0221-8

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Table 2. Sample characteristics shown as the mean and standard deviation (SD) or percentage and number of observations (N).

	Boys				Girls			
	Intervention		Control		Intervention		Control	
	T1	T4	T1	T4	T1	T4	T1	T4
Sample size (n)	276	155	131	67	590	436	276	177
Age (yrs)	16.81 (.46)		16.70 (.51)		16.79 (.49)		16.77 (.50)	
EDEQ	.96 (1.15)	.70 (.90)	1.12 (1.24)	.69 (.75)	2.41 (1.61)	1.80 (1.51)	2.66 (1.72)	2.44 (1.83)
Self-esteem	33.01 (5.69)	33.79 (5.99)	32.42 (6.48)	32.68 (6.90)	29.45 (5.95)	30.99 (6.10)	28.47 (6.43)	28.11 (7.42)
BIAAQ	70.53 (9.52)	71.33 (1.60)	70.26 (1.24)	69.77 (1.84)	58.20 (15.71)	62.94 (16.13)	57.00 (16.83)	56.98 (19.39)
SATAQ Thin	2.49 (.97)	2.07 (.89)	2.64 (.92)	2.26 (.79)	3.31 (1.08)	2.79 (1.13)	3.39 (1.13)	3.28 (1.19)
SATAQ Muscular	3.21 (1.12)	2.77 (1.07)	3.30 (1.03)	3.09 (1.09)	3.02 (1.09)	2.68 (1.03)	2.99 (1.05)	2.74 (1.10)
SATAQ Media	2.10 (1.16)	1.90 (1.03)	2.24 (1.16)	2.06 (1.09)	3.19 (1.24)	2.90 (1.27)	3.22 (1.26)	3.37 (1.23)
Weekly protein use % (n)	22.8 (63)	8.9 (14)	30.7 (40)	29.4 (20)	6.9 (41)	5.0 (22)	7.3 (20)	5.4 (19)
Weekly creatine use % (n)	10.5 (29)	3.1 (5)	17.5 (23)	9.7 (7)	2.3 (14)	1.3 (7)	3.2 (9)	1.8 (3)

T1 = Baseline scores, T4 = 12-month follow-up scores, BMI = body mass index, EDEQ = ED symptomatology, BIAAQ = body image acceptance and action scale, SATAQ Thin = thinness internalization, SATAQ Muscular = muscular and athletic internalization, SATAQ Media = perceived appearance pressure from media.

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Table 3: Intercept, slope and model fit indices for the mediation models for each mediator.

	Self-esteem		BIAAQ		SATAQ thin		SATAQ muscular		SATAQ media	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Intercept	32.79[a]	29.23[a]	70.45[a]	58.00[a]	2.49[a]	3.28[a]	3.20[a]	2.93[a]	2.11[a]	3.16[a]
Slope	-.08[a]	.30[a]	.05	.92[a]	-.13[a]	-.11[a]	-.09[a]	-.09[a]	-.05[a]	-.04[a]
Model fit indices										
X2	75.86[b]	123.32[b]	50.29[b]	62.51[b]	66.00[b]	85.21[b]	52.88[b]	99.05[b]	52.13[b]	72.89[b]
CFI	.92	.96	.97	.99	.94	.98	.96	.96	.96	.97
RMSEA	.06	.06	.04	.04	.05	.05	.04	.05	.04	.04
90% CI	.04, .07	.05, .07	.02, .05	.03, .05	.03, .06	.04, .06	.02, .05	.04, .06	.02, .06	.03, .05
SRMR	.12	.11	.07	.03	.06	.04	.05	.04	.05	.03

Slope = Mean change at each timepoint, intercept = Mean score at T1, [a] p = <.05, [b] p = < .01. , BIAAQ = body image acceptance and action scale, SATAQ Thin = thinness internalization, SATAQ Muscular = muscular and athletic internalization, SATAQ Media = perceived appearance pressure from media.

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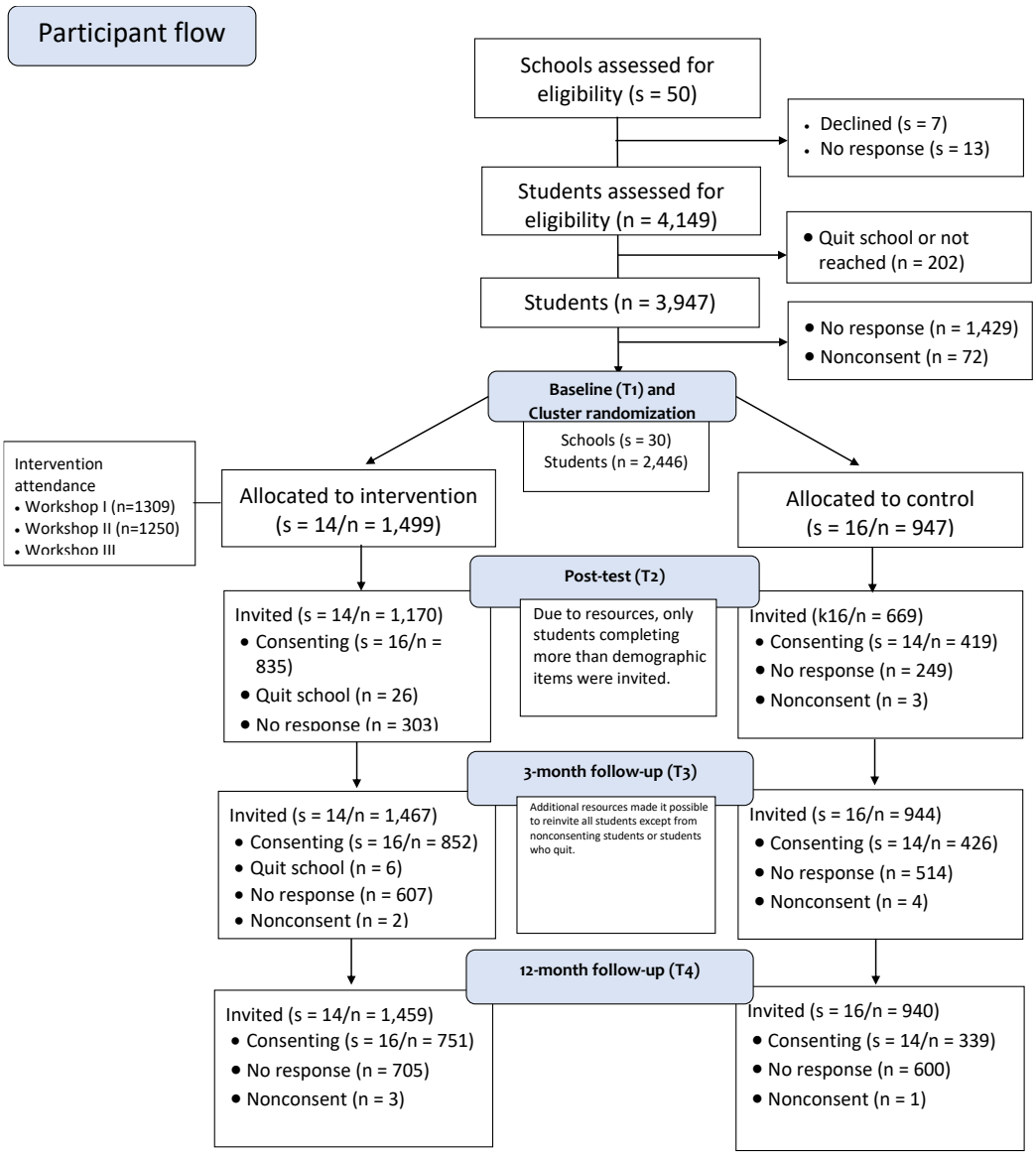

Figure 1 Recruitment, randomization and participant flow. s = number of schools (clusters), n = number of students. The figure presents number of consenting students. The number of students for the outcome measures varies between the different instruments.

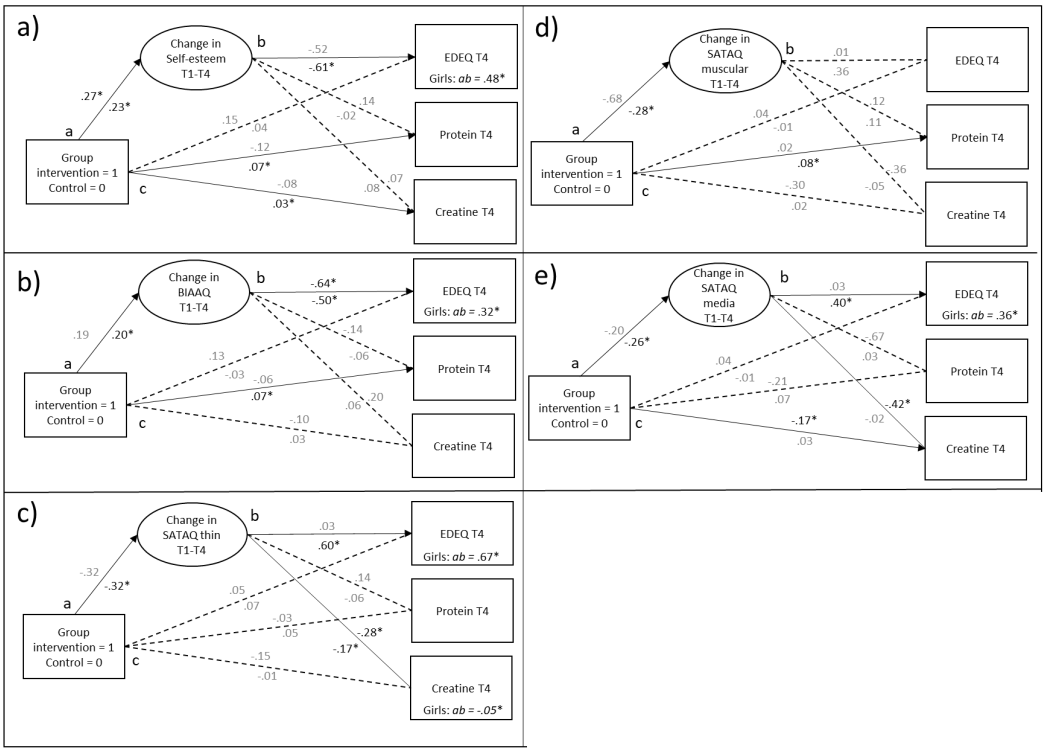

Figure 2a-e. Presents the direct and indirect effects of the HBI intervention on EDEQ, protein supplement use and creatine supplement use via change in a) BIAAQ (body image flexibility), b) self-esteem, c) SATAQ thin (thin internalization), d) SATAQ muscular (muscular and athletic internalization), and e) SATAQ media (perceived media pressure). Standardized coefficients for boys are placed above the path and for girls under the path. Indirect effects (ab path) are shown as unstandardized coefficients. Significant coefficients are printed in solid black and nonsignificant coefficients are printed in grey. T1 = baseline, T2 = posttest, T3 = 3-month follow-up, T4 = 12-month follow-up. * p = <0.05. The baseline values for the main outcome variables were included as co-variates.

Appendix I

- Approval letter from the Reginal Committees for Medical Research Ethics
- Registration by the Clinical Trials Registration

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK sør-øst	Claus Henning Thorsen	22845515	10.03.2016	2016/142/REK sør-øst C
			Deres dato:	**Deres referanse:**
			12.01.2016	

Vår referanse må oppgis ved alle henvendelser

Jorunn Sundgot-Borgen
Norges idrettshøgskole
Postboks 4014 Ullevål Stadion
0806 Oslo

2016/142 Sunn kroppsopplevelse: et intervensjonsprosjekt

Forskningsansvarlig: Norges idrettshøgskole
Prosjektleder: Jorunn Sundgot-Borgen

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK sør-øst) i møtet 18.02.2016. Vurderingen er gjort med hjemmel i helseforskningsloven (hfl.) § 10, jf. forskningsetikkloven § 4.

Prosjektomtale
Et sunt kroppsbilde er viktig for både jenter og gutter og fungerer som en prediktor for god livskvalitet. Mange ungdommer har et problematisk kroppsbilde og norske studier viser at opptil 60% av jentene og 45% av guttene i videregående skole er misfornøyd med kroppen sin. Kroppsmisnøye er forbundet med psykiske problemer og lidelser. Betydningen av å utvikle effektive programmer for å fremme en sunn kroppsopplevelse blant ungdom er åpenbar. Den planlagte RCT-studien har et helsefremmende formål, ved det at programmet skal fremme et positivt forhold til egen kropp og dermed til å redusere forekomsten av de negative konsekvensene av en dårlig kroppsopplevelse blant ungdom på norske videregående skoler. Prosjektet søker å oppnå dette ved å undersøke effekten og aksept av et nytt skolebasert intervensjonsprogram rettet mot selvfølelse, sunn livsstil (spise-og fysisk aktivitet vaner og søvnkvalitet), dysfunksjonell perfeksjonisme og mediekunnskap hos elever i videregående skole i Norge

Vurdering
Man skal i prosjektet undersøke effekt og aksept av et nytt skolebasert intervensjonsprogram rettet mot selvfølelse, sunn livsstil (spise- og fysisk aktivitetsvaner og søvnkvalitet), dysfunksjonell perfeksjonisme og mediekunnskap hos elever i videregående skole i Norge.

Det legges i søknaden betydelig vekt på at programmet har en helsefremmende tilnærming, samtidig som det erkjennes at det kan argumenteres for at intervensjonsprogrammet kan bidra til et uheldig fokus på de forhold som programmet forsøker å forhindre, noe som foranlediger behov for back up og personlig oppfølging. Komiteen mener at prosjektgruppen har reflektert godt omkring dette, og forutsetter at den i søknaden skisserte prosedyre for oppfølging av elever med behov for støtte blir en realitet.

Komiteen har generelt vært skeptisk til skoleforskning hvor klasseromsettingen benyttes ved besvarelse av sensitive spørreskjemaer. I denne studien har man forlatt klasseromsettingen, elevene besvarer spørsmålene i hjemmemiljø uten risiko for påvirkning fra medelever, noe komiteen anser som en tilstrekkelig betryggende løsning.

Det er lagt opp til elektronisk samtykke via mail. Forutsatt at samtykket kun gjelder det de svarer på, og ikke oppkobling til helseopplysninger (journal), mener komiteen at løsningen kan aksepteres. Komiteen kan imidlertid ikke akseptere at man aktivt må si nei til deltakelse, og kan for øvrig heller ikke se at skulle være behov for en slik fremgangsmåte.

Komiteen vil i den forbindelse påpeke at man selvfølgelig står fritt til å trekke seg fra studien (ved gjenkjenning via IP-adresse) også etter at man har besvart og sendt inn spørreskjemaene.

Prosjektet skal benytte et stort antall spørreskjemaer. Disse er navngitt i en oversikt, men komiteen ber for ordens skyld om at skjemaene oversendes.

Informasjonsskrivene
Komiteen har merket seg at det i informasjonsskrivet til elevene fremgår følgende: «*Vi vil også innhente karakterer på alle elevene fra et eget register*.» Komiteen kan ikke se at innhenting av karakterer er omtalt eller begrunnet i søknad eller protokoll, og komiteen forutsetter derfor at dette tas ut.

Komiteen mener videre at det bør tydeliggjøres at det er frivillig å delta. Det er naturlig at dette tas inn i informasjonsskrivets første avsnitt **Bakgrunn og hensikt**. Videre bør det opplyses om antallet spørreskjemaer, og at noen av disse berører psykisk helse.

I informasjonsskrivet til rektor er man i teksten ikke tydelig nok på å spørre om deltakelse. Skrivet er også upresist og generelt forhold til hvilke data som skal samles inn.

For begge informasjonsskrivs vedkommende mangler informasjon om retten til å trekke seg fra studien, og at man kreve innsamlede opplysninger slettet dersom dette blir aktuelt. Videre bør det opplyses at deltakerne i henhold til helseforskningsloven § 50 er dekket av pasientskadeloven (NPE-ordningen).

Komiteen ber om at informasjonsskrivene revideres, og anbefaler at man ved revisjonen ser hen til malen for informasjonsskriv som ligger på REKs hjemmesider.

Ut fra dette setter komiteen følgende vilkår for prosjektet:
1. Spørreskjemaene som skal benyttes i prosjektet oversendes komiteen til orientering
2. Informasjonsskrivene revideres i henhold til ovennevnte og sendes komiteen til orientering.

Vedtak
Prosjektet godkjennes under forutsetning av at ovennevnte vilkår oppfylles, jf. helseforskningslovens §§ 9 og 33.

I tillegg til vilkår som fremgår av dette vedtaket, er tillatelsen gitt under forutsetning av at prosjektet gjennomføres slik det er beskrevet i søknaden og protokollen, og de bestemmelser som følger av helseforskningsloven med forskrifter.

Tillatelsen gjelder til 01.03.2019. Av dokumentasjons- og oppfølgingshensyn skal opplysningene likevel bevares inntil 01.03.2024. Opplysningene skal lagres avidentifisert, dvs. atskilt i en nøkkel- og en opplysningsfil. Opplysningene skal deretter slettes eller anonymiseres, senest innen et halvt år fra denne dato.

Komiteens avgjørelse var enstemmig.

Sluttmelding og søknad om prosjektendring
Dersom det skal gjøres endringer i prosjektet i forhold til de opplysninger som er gitt i søknaden, må prosjektleder sende endringsmelding til REK. Prosjektet skal sende sluttmelding på eget skjema, se helseforskningsloven § 12, senest et halvt år etter prosjektslutt.

Klageadgang
Du kan klage på komiteens vedtak, jf. forvaltningslovens § 28 flg. Klagen sendes til REK sør-øst C. Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK sør-øst C, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering.

Med vennlig hilsen

Britt-Ingjerd Nesheim
prof.dr.med.
leder REK sør-øst C

Claus Henning Thorsen
Rådgiver

Kopi til: *turid.sjostedt@nih.no; Norges idrettshøgskole: postmottak@nih.no*

ClinicalTrials.gov PRS
Protocol Registration and Results System

ClinicalTrials.gov Protocol Registration and Results System (PRS) Receipt
Release Date: February 23, 2018

ClinicalTrials.gov ID: NCT02901457

Study Identification

Unique Protocol ID:	JCSB
Brief Title:	"The Healthy Body Image" (HBI) Program: A Program to Promote a Positive Body Image
Official Title:	"The Healthy Body Image" (HBI) Program: A Program to Promote a Positive Body Image. A School-based Randomized Controlled Trial
Secondary IDs:	

Study Status

Record Verification:	February 2018
Overall Status:	Completed
Study Start:	August 2016 []
Primary Completion:	February 2018 [Actual]
Study Completion:	February 2018 [Actual]

Sponsor/Collaborators

Sponsor:	Norwegian School of Sport Sciences
Responsible Party:	Principal Investigator Investigator: Professor Jorunn Sundgot-Borgen [jsundgot-borgen] Official Title: Professor Affiliation: Norwegian School of Sport Sciences
Collaborators:	The Norwegian Women´s Public Health Association Norwegian Extra Foundation for Health and Rehabilitation University of Tromso University College of Southeast Norway University of Agder

Oversight

U.S. FDA-regulated Drug:	
U.S. FDA-regulated Device:	
U.S. FDA IND/IDE:	No
Human Subjects Review:	Board Status: Approved Approval Number: 2016/142 Board Name: Regional Committees for Medical and Health Research Ethics Board Affiliation: Regional Committees for Medical and Health Research Ethics

Phone: 22845515
Email: post@helseforskning.etikkom.no
Address:

Gullhaugveien 1-3
0484 Oslo
Norway

Data Monitoring: No

FDA Regulated Intervention: No

Study Description

Brief Summary: Too many Norwegian adolescents experience severe body dissatisfaction (40-70 %), and strive to accomplish the “perfect body”. At the same time, only 50 % meet the government`s recommendations on physical activity and intake of fruits and vegetables. Also, 14-24 % has unhealthy sleeping habits. Optimizing these lifestyle factors is associated with physical and psychological health. These factors, along with the pressure to obtain the “perfect” body, are threatening the adolescent`s physical and psychological health, jfr. Meld St nr 19. It is now a need for knowledge on how the investigators can contribute to promote positive body experience among the adolescents.

It has recently, through a controlled study on elite youth athletes at Norwegian sports high schools, been shown that it is possible to change eating habits, improve body image and reduce new cases of eating disorder. It is now desirable to test an adapted program through a school-based program at regular Norwegian high school students (12th grade). Today, no controlled, school-based intervention studies with long-term follow-up have been conducted.

The main aim of this project is to investigate if it is possible, through a school-based intervention program (Healthy Body Intervention), to promote positive body image, increase physical activity level, and healthy eating and sleeping habits in both boys and girls at Norwegian high schools.

The intervention program will contribute with new evidence-based knowledge on the effect of an adapted health-promoting program.

Detailed Description: The design is a school-based randomized controlled trial (RCT) intervention, using the methods questionnaire and interview to obtain data. Based on statistical power analyses, all high schools in Oslo and Akershus County will be asked to participate in the study. After the schools have responded, consenting schools will be stratified (by size and geographical affiliation) and randomized to the intervention or the control condition. To minimize contamination biases within schools, the investigators prepare a cluster-randomized design.The population should contain 17-20 schools (1400 students at 2nd year). Data collection is conducted through pre-test and post-test 1, 2, and 3 (acute, 3, and 12 month post-intervention). At post-test 1, a selection is invited to participate in an interview about feasibility in addition to the questionnaire. It is an intervention for students containing interactive lecturers with discussion, team work, discussions and home assignments.

Conditions

Conditions: Quality of Life
Eating Behaviors
Physical Activity

Keywords:	Body Image

Study Design

Study Type:	Interventional
Primary Purpose:	Other
Study Phase:	N/A
Interventional Study Model:	Parallel Assignment
Number of Arms:	2
Masking:	None (Open Label)
Allocation:	Randomized
Enrollment:	4193 [Actual]

Arms and Interventions

Arms	Assigned Interventions
Experimental: Healthy Body Image Students receive the Healthy Body Image intervention containing 3x90 minutes of interactive workshops with the addition of related homework after each workshop.	The "Healthy Body Image" intervention Interactive workshops (3 x 90 minutes) include training techniques to increase media literacy, enhance self-esteem, positive body image, awareness of perfectionism, and include discussions related to truths and myths related to life style factors. Homework is an extension of each workshop that is simple and not time-consuming tasks to increase reflection and awareness of how all the mentioned factors are a part of their lives. Other Names: • Healthy Body Image
No Intervention: Control group Students do not receive the intervention program.	

Outcome Measures

Primary Outcome Measure:

1. Proximal and distal effect of the "Healthy Body Intervention" (HBI) program on change in positive body image
   Participants are asked to respond to questions by choosing from different responses presented on a likert scale. Positive body image is assessed by the Experience of Embodiment Scale.

   [Time Frame: Participants are asked to complete the questionnaire at post-tests planned at week 1, 3 months and 12 months after intervention]

Secondary Outcome Measure:

2. Proximal and distal effect of the HBI program on change in self-esteem
   Participants are asked to respond to questions by choosing from different responses presented on a likert scale. The scale used is the Rosenberg Self-esteem scale.

   [Time Frame: Participants are asked to complete the questionnaire at post-tests planned at week 1, 3 months and 12 months after intervention]

3. Proximal and distal effect of the "Healthy Body Intervention" (HBI) program on change in the prevalence of students meeting the recommendations for health promoting physical activity.
   The outcome will be measured through a self-developed Physical Activity level/habit questionnaire, including choosing a specific response on a likert scale and response through open ended questions.

[Time Frame: Participants are asked to complete the questionnaire at post-tests planned at week 1, 3 months and 12 months after intervention]

4. Experience of the intervention program and the feasibility of running the HBI program in schools.
   To measure the outcome, a self-developed interview guide in addition to a self-developed questionnaire asking students and school staff about the experience of the intervention program and the feasibility of the intervention. When answering the questionnaire, participants are asked to respond by choosing a response on a likert scale.

   [Time Frame: Post-test is planned within first week after intervention]

5. Proximal and distal effect of the HBI program on change in eating behavior (nutrition intake
   The outcome will be measured through a self-developed Food frequency questionnaire where responses are chosen from a likert scale.

   [Time Frame: Participants are asked to complete the questionnaire at post-tests planned at week 1, 3 months and 12 months after intervention]

6. Proximal and distal effect of the HBI program on change in sleeping quality and sleep patterns
   The outcome is measured through The Bergen Insomnia Scale, 6 items and 3 items assessing delayed sleep phase and by asking the participants (using a likert scale) how many hours of sleep they usually get per night during a normal weekday and a weekend day.

   [Time Frame: Participants are asked to complete the questionnaire at post-tests planned at week 1, 3 months and 12 months after intervention]

7. Proximal and distal effect of the HBI program on change in academic achievements
   Participants are asked to choose the correct grade they received on their last report card, from a scale presenting the possible grades.

   [Time Frame: Participants are asked to complete the questions included in the questionnaire package at post-tests planned at week 1, 3 months and 12 months after intervention]

8. Proximal and distal effect of the "Healthy Body Intervention" (HBI) program on change in health related quality of life
   Participants are asked to respond to questions by choosing from different responses presented on a likert scale. Health related quality of life will be assessed through the "Screening for and Promotion of Health Related Quality of Life in Children an Adolescents - a European Public Health Perspective - 10" (KIDSKREEN-10).

   [Time Frame: Participants are asked to complete the questionnaire containing all the below presented measures at post-tests planned at week 1, 3 months and 12 months after intervention]

9. Proximal and distal effect of the HBI program on change in symptoms of eating disorders
   Symptoms of eating disorders is assessed by the Eating Disorder Examination Questionnaire - 11 (EDE-Q 11)

   [Time Frame: Participants are asked to complete the questionnaire at post-tests planned at week 1, 3 months and 12 months after intervention]

Eligibility

Minimum Age:	16 Years
Maximum Age:	19 Years
Sex:	All
Gender Based:	
Accepts Healthy Volunteers:	Yes
Criteria:	Inclusion Criteria:

- Norwegian high schools
- High schools located in either Oslo or Akershus County
- Students in the 2nd grade fall 2016
- Students within academic specialization education programs
- Teachers teaching included students in Norwegian, Social studies, Physical education, and contact teachers

- School nurses working at the randomly selected schools
- School administrators at randomly selected schools

Exclusion Criteria:

- Schools that follow foreign school systems
- Students within vocational education programs
- School departments connected to prison

Contacts/Locations

Central Contact Person: Christine Sundgot-Borgen, MS
Telephone: 90754948 Ext. +47
Email: christine.sundgot.borgen@gmail.com

Central Contact Backup:

Study Officials: Jorunn Sundgot-Borgen, Phd
Study Chair
Norwegain School of Sports Sciences

Locations: **Norway**
Norwegian School of Sports Sciences
Oslo, Norway, 0806
Contact: Jorunn Sundgot-Borgen, Phd 92241745 Ext. +47 jorunn.sundgot-borgen@nih.no

IPDSharing

Plan to Share IPD: Undecided

References

Citations: Strand BH, Dalgard OS, Tambs K, Rognerud M. Measuring the mental health status of the Norwegian population: a comparison of the instruments SCL-25, SCL-10, SCL-5 and MHI-5 (SF-36). Nord J Psychiatry. 2003;57(2):113-8. PubMed 12745773

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Links:

Available IPD/Information:

Appendix II

Informed Consent

- Information letter to the students

NORGES IDRETTSHØGSKOLE

Forespørsel om deltakelse i forskningsprosjektet til elever ved x videregående skole

"Sunn kroppsopplevelse"

Bakgrunn og hensikt
Dette er et spørsmål til deg om å delta i en forskningsstudie der hensikten er å undersøke om det er mulig å fremme et godt forhold til egen kropp, forebygge kroppsmisnøye og redusert livskvalitet blant både jenter og gutter i videregående skole. Forskningsprosjektet du inviteres inn i gjennomføres på vegne av Norges Idrettshøgskole, og i samarbeid med Universitetet i Tromsø, Universitetet i Agder og Høgskolen i Sørøst-Norge. Det er selvfølgelig helt frivillig å delta i denne undersøkelsen. Du kan også trekke deg fra studien etter at du har sendt inn spørreskjemaet, eller si nei til senere spørreskjemaundersøkelser eller et eventuelt intervju selv om du nå samtykker til deltagelse.

Hva innebærer studien?
Dersom din skole, i en tilfeldig uttrekning, blir trukket som intervensjonsskole, vil det bli gjennomført et undervisningsopplegg som inngår i ordinær skoletid og går over en tre måneders periode. I løpet av denne tiden vil det gjennomføres 3 x 90 minutters undervisningsbolker med tema som selvfølelse, perfeksjonisme, kropp, media, kosthold og fysisk aktivitet. Det vil også være noen små individuelle hjemmeoppgaver som tar minimalt med tid. Dersom din skole blir trukket til å delta i en såkalt kontrollgruppe, betyr det at dere ikke får noen annen undervisning enn det som er planlagt fra skolens side når det gjelder de temaene som er nevnt ovenfor. Skolen vil allikevel bli tilbudt en fagdag i etterkant av intervensjonsperioden, hvor ovenfor nevnte tema inngår.
Dersom du sier ja til å delta i studien (uavhengig av om din skole havner i intervensjonsgruppa eller i kontrollgruppen), vil du via en lenke i denne e-posten bli forespurt om du kan tenke deg å svare på et spørreskjema før, rett etter, ved 3, 6 og 12 måneder etter dette 3-mnd programmet (for forsøksgruppa) er gjennomført. På de skolene som trekkes som intervensjonsskole, vil et tilfeldig utvalg av elevene kunne bli forespurt om å delta i et intervju for å kartlegge hvordan elevene opplevde det å være med i en slik undersøkelse (programmets brukervennlighet). Dersom du sier ja til å delta i spørreskjemaundersøkelsen men ikke skulle ønske å delta i et eventuelt senere intervju er det helt greit, og du kan eventuelt si nei til det dersom du skulle bli en av de som trekkes ut til intervju.
Spørreskjemaet er sammensatt av flere ulike spørreskjema og det er spørsmål knyttet til livsstil (kosthold, aktivitet og søvn), sosiale medier, kroppsbildet, selvfølelse og hvordan du har det. Spørreskjemaet kan gjennomføres på PC, Mac, nettbrett og smarttelefoner. Dersom vi skulle få ytterligere midler til dette forskningsprosjektet vil det også være mulig ved en senere anledning å gjøre noen oppfølgende undersøkelser. Det er imidlertid IKKE det du svarer på nå, men det er til informasjon dersom du ved en senere anledning skulle få en ny

henvendelse fra prosjektgruppen. Det vil ved den potensielle nye forespørselen, selvsagt være mulig å takke nei til deltagelse.

Mulige fordeler og ulemper
Fordelene ved å delta i dette forskningsprosjektet vil kunne være at du lærer noe nytt om de temaene som inngår i undervisningspakken, at du opprettholder eller bedrer dine livsstilsvaner, ditt kroppsbilde og din selvfølelse. I tillegg vil du som deltaker være med i trekningen av et Universal gavekort på kr. 500,-. Vi har gjort denne type forskning i andre videregående skoler (rene toppidrettsgymnas og ved vanlig videregående skoler) UTEN at det har medført/vært meldt inn noen ulemper ved deltakelse i prosjektet. Men, det kan selvfølgelig ikke utelukkes at enkelte kan føle at det blir en uheldig opplevelse ved økt fokus på noen av de ovenfor nevnte tema. Dersom det skulle skje så kan prosjektleder kontaktes og hun har da ansvaret for å svare på dine spørsmål og veilede deg videre slik at du kan få kontakt med en helsesøster eller annen voksenperson som du kan snakke med.

Hva skjer med informasjonen om deg?
Informasjonen som registreres vil bli behandlet uten navn og avidentifisert. Det betyr at de opplysningene du gir i spørreskjemaet vil ikke kunne knyttes til ditt navn når data behandles. Prosjektledelsen vil så ha en liste der ditt nummer (kode) er knyttet til deg slik at, dersom din skole er intervensjonsskole, så kan prosjektleder kontakte deg dersom du er en av de som blir trukket ut og forespurt om et senere intervju. Det er altså kun prosjektleder som har adgang til navnelisten og som kan finne tilbake til deg. De det gjelder har taushetsplikt.

Det vil ikke være mulig å identifisere deg i resultatene av studien når disse publiseres.

Frivillig deltakelse
Det er frivillig å delta i studien.
Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke til å delta i studien. Du samtykker til deltagelse ved å gå inn på linken som er vedlagt. Om du nå sier ja til å delta, kan du senere trekke tilbake ditt samtykke, og kreve innsamlede opplysninger slettet dersom dette er aktuelt. Videre opplyses det om du i henhold til helseforskningsloven paragraf 50 er dekket av pasientskadeloven (NPE-ordningen).
Dersom du har spørsmål til studien, kan du kontakte prosjektleder og professor Jorunn Sundgot-Borgen på telefon 23262335/jorunn.sundgot-borgen@nih.no

Obs!
Dersom du nå velger å delta i undersøkelsen trykker du på linken og velger alternativ ”jeg samtykker” for å gå videre og du vil da få tilgang til spørreskjemaet.

Mvh

Prosjektleder
Professor Jorunn Sundgot-Borgen

Appendix III

Questionnaires

- Demographic questions
- Eating disorder examination questionnaire - 11
- Rosenberg self-esteem Scale
- Body Image Action and Acceptance Questionnaire
- Hopkins Symptom Checklist – 10
- Sociocultural Attitudes Towards Appearance Questionnaire
- Drive for Leanness
- Supplement use
- Physical activity, exercise and sport participation

Demographic Questions

1. Gender
   - ☐ Boy
   - ☐ Girl

2. What study program are you enrolled in?
   - ☐ General
   - ☐ Arts, design and architecture
   - ☐ Media and communication
   - ☐ Sport
   - ☐ Music, dance and drama
   - ☐ Other_____

3. Have you or both your parents immigrated to Norway? (multiple responses posssible)

   - ☐ Yes, I have immigrated
   - ☐ Yes, both my parents have immigrated
   - ☐ No, neither me nor my parents

4. What educational level does your parent/parents have?

   Mother
   - ☐ Primary school
   - ☐ High school
   - ☐ College/university
   - ☐ Do not know

   Father
   - ☐ Primary school
   - ☐ High school
   - ☐ College/university
   - ☐ Do not know

5. What do you believe your parents' (combined if applicable) total income is per year?

   - ☐ Less than NOK 200.000
   - ☐ NOK 200.000 - 400.000
   - ☐ NOK 500.000 - 800.000
   - ☐ NOK 900.000 - 1 million
   - ☐ More than NOK 1 million

6. What is your current weight (kg)?
   Answer:_____

7. How tall are you (cm)?
   Answer:_____

Short version : Eating Disorder Examination Questionnaire (EDEQ-11)

Friborg, O., Reas, D. L., Rosenvinge, J. H., & Rø, Ø. (2013). Core pathology of eating disorders as measured by the Eating Disorder Examination Questionnaire (EDE-Q): The predictive role of a nested general (g) and primary factors. International journal of methods in psychiatric research, 22(3), 195-203.

Fairburn and Beglin (2008). In Fairburn, C. G. (2008). Cognitive Behavior Therapy and Eating Disorders. Guilford Press, New York.

Instructions: The following questions are concerned with the past four weeks (28 days) only.

	On how many of the past 28 days ...	No days	1-5 days	6-12 days	13-15 days	16-22 days	23-27 days	Every day
6	Have you had a definite desire to have a totally flat stomach?	0	1	2	3	4	5	6
10	Have you had a definite fear that you might gain weight?	0	1	2	3	4	5	6
11	Have you felt fat?	0	1	2	3	4	5	6
12	Have you had a strong desire to lose weight?	0	1	2	3	4	5	6

	On how many of the past 28 days ...	Not at all	Slightly		Moderately		Markedly
22	Has your **weight** influenced how you think about (judge) yourself as a person?	0	1	2	3	4	5	6
23	Has your **shape** influenced how you think about (judge) yourself as a person?	0	1	2	3	4	5	6
24	How much would it have upset you if you had been asked to weigh yourself once a week (no more, or less, often) for the next four weeks?	0	1	2	3	4	5	6
25	How dissatisfied have you been with your **weight?**	0	1	2	3	4	5	6
26	How dissatisfied have you been with your **shape?**	0	1	2	3	4	5	6
27	How uncomfortable have you felt seeing your body (for example, seeing your shape in the mirror, in a shop window reflection, while undressing or taking a bath or shower)?	0	1	2	3	4	5	6
28	How uncomfortable have you felt about **others** seeing your shape or figure (for example, in communal changing rooms, when swimming, or wearing tight clothes)?	0	1	2	3	4	5	6

Rosenberg Self-Esteem Scale

Rosenberg, M. (1965). Society and the adolescent self-image. Princeton, NJ: Princeton University Press.

Below is a list of statements dealing with your general feelings about yourself. Please indicate how strongly you agree or disagree with each statement.

		Strongly agree 4	Agree 3	Disagree 2	Strongly disagree 1
1	On the whole, I am satisfied with myself.	☐	☐	☐	☐
2	At times I think I am no good at all.	☐	☐	☐	☐
3	I feel that I have a number of good qualities.	☐	☐	☐	☐
4	I am able to do things as well as most other people.	☐	☐	☐	☐
5	I feel I do not have much to be proud of.	☐	☐	☐	☐
6	I certainly feel useless at times.	☐	☐	☐	☐
7	I feel that I'm a person of worth, at least on an equal plane with others.	☐	☐	☐	☐
8	I wish I could have more respect for myself.	☐	☐	☐	☐
9	All in all, I am inclined to feel that I am a failure.	☐	☐	☐	☐
10	I take a positive attitude toward myself.	☐	☐	☐	☐

Items 2, 5, 6, 8, 9 are reverse scored. Higher scores indicate higher self-esteem.

Body Image Acceptance and Action Questionnaire

Sandoz, E.K., Wilson, K.G., Merwin, R.M., Kellum, K.K. (2013). Assessment of body imageflexibility: The Body Image-Acceptance and Action Questionnaire. Journal of Contextual Behavioral Science, 39-48.

Directions: Below you will find a list of statements. Please rate the truth of each statement as it applies to you.

		7	**6**	**5**	**4**	**3**	**2**	**1**
		Never true	Very seldom true	Seldom true	Some-times true	Freq-uently true	Almost always true	Always true
1	Worrying about my weight makes it difficult for me to live a life that I value.	☐	☐	☐	☐	☐	☐	☐
2	I care too much about my weight and body shape.	☐	☐	☐	☐	☐	☐	☐
3	I shut down when I feel bad about my body shape or weight	☐	☐	☐	☐	☐	☐	☐
4	My thoughts and feelings about my body weight and shape must change before I can take important steps in my life.	☐	☐	☐	☐	☐	☐	☐
5	Worrying about my body takes up too much of my time.	☐	☐	☐	☐	☐	☐	☐
6	If I start to feel fat, I try to think about something else.	☐	☐	☐	☐	☐	☐	☐
7	Before I can make any serious plans, I have to feel better about my body.	☐	☐	☐	☐	☐	☐	☐
8	I will have better control over my life if I can control my negative thoughts about my body.	☐	☐	☐	☐	☐	☐	☐
9	To control my life, I need to control my weight.	☐	☐	☐	☐	☐	☐	☐
10	Feeling fat causes problems in my life	☐	☐	☐	☐	☐	☐	☐
11	When I start thinking about the size and shape of my body, it ‘shard to do anything else.	☐	☐	☐	☐	☐	☐	☐
12	My relationships would be better if my body weight and/or shape did not bother me	☐	☐	☐	☐	☐	☐	☐

Higher scores indicate higher body image flexibility

The Hopkins Symptom Checklist-10

Strand, B. H., Dalgard, O. S., Tambs, K., & Rognerud, M. (2003). Measuring the mental health status of the Norwegian population: a comparison of the instruments SCL-25, SCL-10, SCL-5 and MHI-5 (SF-36). Nordic journal of psychiatry, 57(2), 113-118.

Listed below are some symptoms or problems that people sometimes have. Please read each one carefully and decide how much the symptoms bothered or distressed you during the last week, including today:

		Not at all	A little	Quite a bit	Extremely
1	Suddenly scared for no reason	☐	☐	☐	☐
2	Feeling fearful	☐	☐	☐	☐
3	Faintness, dizziness or weakness	☐	☐	☐	☐
4	Feeling tense or keyed up	☐	☐	☐	☐
5	Blaming yourself for things	☐	☐	☐	☐
6	Difficulties in falling asleep or staying asleep	☐	☐	☐	☐
7	Feeling blue	☐	☐	☐	☐
8	Feelings of worthlessness	☐	☐	☐	☐
9	Feeling everything is an effort	☐	☐	☐	☐
10	Feeling hopeless about the future	☐	☐	☐	☐

Sococultural Attitudes Towards Appearance Questionnaire – 4

Schaefer, L.M., Burke, N.L., Thompson, J.K. et al (2015). Development and Validation of the Sociocultural Attitudes Towards Appearance Questionnaire-4 (SATAQ-4) American Psychological Association, Vol. 27, No. 1, 54–67

Please read each of the following items carefully and indicate the number that best reflects your agreement with the statement.

		Definitely disagree 1	Mostly disagree 2	Neither agree nor disagree 3	Mostly agree 4	Definitely agree 5
	Thin/low body fat internalization					
3	I want my body to look very thin.	☐	☐	☐	☐	☐
4	I want my body to look like it has little fat.	☐	☐	☐	☐	☐
5	I think a lot about looking thin.	☐	☐	☐	☐	☐
8	I want my body to look very lean.	☐	☐	☐	☐	☐
9	I think a lot about having very little body fat.	☐	☐	☐	☐	☐
	Athletic/muscular internalization					
1	It is important for me to look athletic.	☐	☐	☐	☐	☐
2	I think a lot about looking muscular.	☐	☐	☐	☐	☐
6	I spend a lot of time doing things to look more athletic.	☐	☐	☐	☐	☐
7	I think a lot about looking athletic.	☐	☐	☐	☐	☐
10	I spend a lot of time doing things to look more muscular.	☐	☐	☐	☐	☐
	Appearance pressure from media					
19	I feel pressure from the media to look in better shape.	☐	☐	☐	☐	☐
20	I feel pressure from the media to look thinner.	☐	☐	☐	☐	☐
21	I feel pressure from the media to improve my appearance.	☐	☐	☐	☐	☐
22	I feel pressure from the media to decrease my level of body fat.	☐	☐	☐	☐	☐

Drive for Leanness Scale

Smolak, L. & Murnen, S.K. Drive for leanness: Assessment and relationship to gender, gender role and objectification. Body Image 5 (2008) 251–260

		never	Rarely	Some-times	Often	Very often	always
1	I think the best looking bodies are well-toned	☐	☐	☐	☐	☐	☐
2	When a person's body is hard and firm, its says they are well-disciplined	☐	☐	☐	☐	☐	☐
3	My goal is to have well-toned muscles	☐	☐	☐	☐	☐	☐
4	Athletic looking people are the most attractive people	☐	☐	☐	☐	☐	☐
5	It is important to have well-defined abs	☐	☐	☐	☐	☐	☐
6	People with well-toned muscles look good in clothes	☐	☐	☐	☐	☐	☐

Supplement use

Think about what you consume at home, during school hours and during leisure time. Tick off the box you feel is most representative for you

How often during a regular week do you consume……

	Never/ not weekly	1-2 days	3-4 days	5-6 days	Everyday
Protein supplements (powder/shakes)	☐	☐	☐	☐	☐
Creatine supplements	☐	☐	☐	☐	☐
Dieting supplements (powders, pills, fat burners etc.)	☐	☐	☐	☐	☐

Physical activity, exercise and sport participation

1. Physical activity level

Physical activity is defined as all bodily movement that lead to an increase in body temperature and light-heavy shortness of breath. Physical activity can therefore be activities such as walking, cycling (incl. back and forth to school), skating, dancing, resistance training, hiking, and doing sports (including physical education, leisure time organized- or unorganized activities, family activities).

How many hours per week do you take part in physical activity to the extent that you become warm and experience light-heavy shortness of breath?

Answer: Hours_____ and _____minutes

2. Exercise context

Are you an active and participating member of a sports team or club?

- ☐ Yes
- ☐ No, but I used to be
- ☐ No, I've never been member

Do you exercise in a fitness center or at a gym?

- ☐ Yes
- ☐ No, but i exercised at a gym/fitness center in the past
- ☐ No, never, or only occasionally in the past

3. Sport participation

How often, on average, have you engaged in following sport activity during the past 12 months?

	Newer	Less than one time per week	1 time per week	Multiple times per week
Resistance exercise	☐	☐	☐	☐
Endurance exercise	☐	☐	☐	☐
Fitness (e.g. Bikini-, body-, or athletic fitness)	☐	☐	☐	☐
Dancing	☐	☐	☐	☐
Martial arts	☐	☐	☐	☐
Ball game sports	☐	☐	☐	☐
Aesthetical sports (e.g. gymnastics, RG, figure skating)	☐	☐	☐	☐
Technical sports	☐	☐	☐	☐
Strength- or power sports (e.g. weightlifting, powerlifting, javelin)	☐	☐	☐	☐
Yoga	☐	☐	☐	☐
CrossFit	☐	☐	☐	☐
Board activities (e.g. in lines, skate board, snow board)	☐	☐	☐	☐
Other_____	☐	☐	☐	☐