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Physical activity and sport participation among adolescents: associations with mental health in different age groups. The Young-HUNT Study, Norway

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Abstract

Objective: Knowledge of how physical activity (PA) and sport participation are related to mental health throughout adolescence is scarce. Our objective was to describe PA levels and sport participation in a population-based sample of adolescents, and to explore how they relate to mental health in different age groups.

Design: A popuation-based cross-setional study.

Setting and participants: The adolescent part of the Nord-Trøndelag Health Study (Young-HUNT3) which is a Norwegian population-based health survey conducted from 2006–2008. Of 10464 invited participants (age 13-19 years), 7619 (73%) participated, of whom 3785 (50%) were boys.

Outcome measures: Mental health outcomes included psychological distress assessed using a short version of the Hopkins Symptom Check List (SCL-5), self-esteem assessed using a short version of The Rosenberg Self-Esteem Scale (RSE) and general well-being measured with a question about life satisfaction.

Method: Logistic regression models were used to estimate the likelihood of mental health problems (psychological distress, low self-esteem, low life satisfaction), according to PA level and type of sport participation, stratified by gender and school level (junior vs senior high school).

Results: Fewer senior high school students participated in team sports compared to junior high school students (p<0.001). Physically active adolescents had higher self-esteem and life satisfaction. A high PA level, compared to a low PA level, was associated with reduced odds of psychological distress among senior high school students (Odds ratio [OR] = 0.63, 95% confidence interval [CI] [0.46-0.86] for girls and OR = 0.46, 95% CI [027-0.79] for boys). Team sport participation was related to better mental health status.

Conclusion: A high PA level was favorably associated with various dimensions of mental health, especially for adolescents in senior high school. Team sport participation may have a positive impact on mental health and should therefore be encouraged.

Article summary

Strengths and limitations of this study

- Large population-based sample of adolescents with a high participation rate.
- Comprehensive information about sport participation and validated measures of mental health across adolescent age groups.
- Stratified analysis that takes potential age and gender differences during adolescence into account, and adjustments of possible confounders including exposures to interpersonal violence (physical violence, bullying, sexual abuse).
- The main limitation of this study is the cross-sectional study design.
- Measures of PA were self-reported.

Introduction

Physical activity and psychological well-being are essential to healthy development and quality of life in adolescence [1-3]. Health behaviours, including the habit of engaging in regular physical activity, are often established during this period [4 5], paving the way for long-term health prospects.

Maintenance of PA throughout adolescence is of major importance in a public health perspective. Engaging in PA and sports during adolescence has a positive influence on the development of lifelong PA [6-8] and psychological well-being [1 9]. Yet adolescents tend to be less physically active with increasing age [10]. The most dramatic decrease in PA is found to occur between the ages of 15 and 16, around the transition from junior to senior high school [11]. Although few adolescents are satisfying the recommended 60 minutes of PA per day worldwide [12 13], sport participation is found to be high in some population-based studies [6 14]. However, information about participation rates in various type of sports throughout adolescence is lacking.

Mental health problems are another major challenge among adolescents; currently the leading cause of health-related disability within this age group, affecting up to 20% of adolescents worldwide [15 16]. Prevalence rates of mental health problems increase with age, especially from the mid-teens (14-16 years) [11 17]. Poor mental health also tends to carry over into adulthood [17 18], highlighting the importance of preventive efforts during adolescence. Currently the evidence indicates that PA may have a positive impact on psychosocial outcomes among adolescents, although our knowledge is limited [1]. Studies commonly assess these relationships without attending to different developmental stages during adolescence. Further, the need for measures of PA which account for various types of sports/activities has been emphasized [1]. No large population-based studies have evaluated PA levels and type of sport participation in relation to mental health among girls and boys in different adolescent

age groups. Identification of these relationships could have implications for preventive programs and may contribute to more accurate strategies for increasing engagement in PA and improving mental health among adolescents.

The aim of this study was to describe PA levels and the frequency of sport participation in a large population-based sample of adolescents in relation to age and gender, and to explore the associations between PA level, type of sport participation, and mental health, including psychological distress, self-esteem, and life satisfaction.

Methods

Study sample

From 2006-2008 all adolescent residents (age 13-19 years) of the Nord-Trøndelag county in Norway (N=10464) were invited to participate in the third wave of the population-based Nord-Trøndelag Health Study (Young-HUNT3). The attendees completed a comprehensive health-related questionnaire during school hours. Of those invited, 7716 (74%) adolescents responded to the questionnaire and attended a clinical examination. The response rate was 82% among junior high school students and 69% among senior high school students. Participants not enrolled in school (N=84) and participants ≥20 years of age (N=13) were excluded from the analyses in this study. Thus, the study population comprised 7619 participants (73%) (Appendix), of whom 4615 (61%) went to junior high school. All participants in senior high school were ≥16 years old.

Exposure variables

Leisure time PA level was assessed by a validated question on frequency of PA from the World Health Organization Health Behavior in Schoolchildren (WHO HBSC) Survey

Questionnaire [19]: Not during the average school day: "How many days a week do you play sports or exercise to the point where you breathe heavily and/or sweat?". Response alternatives were: every day, 4-6 d/week, 2-3 d/week, 1 d/week, less than every week, less than every month, and never. Responses were categorized into three levels of PA: ''Low PA'' (≤1 d/week) (reference group), ''moderate PA'' (2-3 d/week), and ''high PA'' (≥4 d/week).

Type and frequency of sport participation was assessed by the question: "How often have you participated in the following activities/sports in the last 12 months?"; endurance sports (e.g. cross-country skiing, swimming, running), team sports (e.g. soccer, volleyball, handball), strength sports (e.g. weightlifting, bodybuilding), technical sports (e.g. track and field, alpine skiing, snowboard) , aesthetic sports (e.g. dance, gymnastics), martial arts (e.g. judo, karate, boxing), extreme sports (e.g. rafting, rock climbing, paragliding), jogging/walking, and other (Table 2). Jogging/walking was not defined as a sport, and responses to this variable were excluded. Four alternatives were given for describing the frequency of participation in each of the sport categories: 0, <1, ≥1 time per week. A frequency of "≥1 time per week" was defined as active participation. Furthermore, adolescents were classified by their participation in sports into team sports (e.g. soccer, volleyball, handball) or individual sports (all other sports). The reference group consisted of those with no or infrequent participation (<1 time/week) in all the sport categories, as well as those who reported a low level of PA (≤1 day/week). The groups were mutually exclusive.

Outcome variables - Mental health

Psychological distress was assessed using a short version of the Hopkins Symptom Check List (SCL-5) [20], including the phrases: "During the last 14 days: I have been constantly afraid and anxious; I have felt tense or uneasy; I have felt hopeless about the future; I have felt dejected or sad; I have worried too much about various things". Responses were scored

according to four response alternatives ranging from "not at all bothered" (1) to "extremely bothered" (4). A mean score was calculated, and a cut-off for symptoms of anxiety and depression was set at a mean score above two [20].

Self-esteem/feelings of self-worth was measured using a short version of The Rosenberg Self-Esteem Scale (RSE) (original 10 items) [21], including four statements: "I have a positive attitude toward myself", "I feel rather useless at times", "I feel that I don't have much to be proud of", and "I feel that I am a valuable person, at least equal to other people". Response alternatives were measured on a 4-point scale ranging from ''I strongly agree'' (1) to ''I strongly disagree'' (4). For the first and last items the scores were inversed. A mean score was calculated (range 4-16), with higher scores indicating higher levels of self-esteem. A cut-off was set at a mean score of 10 (midpoint of the scale) to separate low and high self-esteem, corresponding to the recommended cut-off at 25 on the original 10-item RSE scale (range 10-40) [22].

General well-being was measured with a question about life satisfaction: "Thinking about your life at the moment, would you say that you by and large are satisfied with life, or are you mostly dissatisfied?" Response alternatives were measured on a 7-point scale ranging from "very satisfied" (1) to "very dissatisfied" (7), and were coded into a dichotomous outcome variable where adolescents who responded 1-3 were classified as "high life satisfaction", and those who responded 4-7 were classified as "low life satisfaction".

Potential confounders

Data on gender and age were obtained from the Norwegian National Population Registry. Socioeconomic status was based on participants' reports of perceived family economy. Pubertal development was assessed by self-reported pubertal status using the validated Pubertal Development Scale (PDS) [23]. Participants were asked to rate their own growth and to

assess pubic hair growth. Further, boys were asked to assess changes in voice and facial hair growth, while girls were asked about age at menarche and breast development. Pubertal changes were reported on scales ranging from 1 (has not begun) to 4 (development completed). Menarche was dichotomized into yes (coded 4) and no (coded 1). The items were summed up and an average PDS score was calculated.

Exposure to interpersonal violence was assessed by asking: "Have you ever experienced any of these events?" (no or yes): 1) Been subjected to violence (beaten or injured), 2) Been subjected to unpleasant/disagreeable sexual acts by someone approximately your own age, 3) Been subjected to unpleasant/disagreeable sexual acts by an adult, and 4) Been threatened or physically harassed by fellow students at school over a period of time. Responses were categorized as "prior violence", "prior sexual abuse" (by peer or adult), and "prior bullying"[24].

Statistical analyses

Categorical variables were described with counts and percentages, and continuous variables with mean and standard deviation (SD). Possible associations between gender and age distribution were assessed with Chi-square tests.

The associations between 1) PA level and 2) type of sport participation and the mental health outcomes were evaluated using multiple logistic regression models. The results are expressed as odds ratios (OR) with 95% confidence intervals (CI). Analyses were stratified by gender and school level (junior and senior high school). To adjust for potential confounding, age, puberty development (PDS), socio-economic status, prior violence, sexual abuse (by peer or adult), and bullying were all included in the multiple models. All tests were two-sided, and the significance level was set to 5%. Analyses were performed using SPSS version 21 (SPSS Inc., Chicago, IL).

Due to missing data on pubertal development (PDS score) (13% in girls, 15% in boys), a model-based imputation for this variable was performed. Linear regression models stratified by gender were fitted with age and body mass index (BMI). Residuals for both models followed standard normal distribution and the model fit was very good. The missing values were replaced with the predicted values. The predicted variables and the original variables for both genders were highly correlated, r=0.75 and r=0.85 for boys and girls, respectively.

Ethics

The current study has been approved by the Regional Committee for Medical Research Ethics (2014/1228/REK Sør-Øst A). The Young-HUNT Studies have been approved by REK and the Data Inspectorate of Norway. Participation in the study was voluntary. Inclusion in Young-HUNT was based on written consent from participants 16 years of age or older, and from the parents of those under 16 years of age, in accordance with Norwegian law.

Results

Characteristics of the study population

In total, 3785 boys and 3834 girls were included in the analyses. Characteristics of the study population are summarized in Table 1. The mean age was 15.8 years (SD 1.7). About 10% reported living in families with an economy below average, and reports of exposure to interpersonal violence was higher among senior as compared to junior high school students, with physical violence being more common in boys, sexual violence more common in girls, and bullying more evenly distributed between the sexes. Girls reported more mental health problems than boys, with the highest levels of psychological distress found among girls in high school (Table 1).

Table 1 Characteristics of the study population (n =7619)

	Girls (%)		Boys (%)	
Characteristics	**Junior high N = 2298**	**Senior high N = 1536**	**Junior high N = 2317**	**Senior high N = 1468**
Age, mean (SD)	14.6 (0.89)	17.6 (0.86)	14.6 (0.89)	17.5 (0.84)
Socioeconomic status; family economy, n (%)				
Above average	297 (12.9)	264 (17.2)	402 (17.4)	319 (21.7)
Average	1644 (71.5)	1077 (70.1)	1521 (65.6)	939 (64.0)
Below average	204 (8.9)	144 (9.4)	141 (6.1)	136 (9.3)
Missing	153 (6.7)	253 (10.9)	253 (10.9)	74 (5.0)
Puberty (PDS score), mean (SD)	2.90 (0.68)	3.49 (0.51)	2.56 (0.61)	3.34 (0.47)
Missing	10 (0.4)	5 (0.3)	-	1 (0.0)
Interpersonal violence, n (%)				
Physical violence	122 (5.3)	138 (9.0)	200 (8.6)	246 (16.8)
Missing	96 (4.2)	34 (2.2)	167 (7.2)	65 (4.4)
Sexual abuse	123 (5.4)	169 (11.0)	50 (2.2)	44 (3.0)
Missing	103 (4.5)	32 (2.1)	170 (7.3)	58 (4.0)
Bullying	140 (6.1)	129 (8.4)	183 (7.9)	117 (8.0)
Missing	107 (4.7)	32 (2.1)	170 (7.3)	58 (4.0)
Mental health outcomes				
Psychological distress (SCL5)*, mean (SD)				
SCL5 ≥2	350 (15.2)	362 (23.6)	111 (4.8)	110 (7.5)
SCL5 <2	1892 (82.3)	1138 (74.1)	2093 (90.3)	1302 (88.7)
Missing	56 (2.4)	36 (2.3)	113 (4.9)	56 (3.8)
Self-esteem (RSE)†, mean (SD)				
RSE <10	660 (28.7)	442 (28.8)	304 (13.1)	192 (13.1)
RSE ≥10	1499 (65.2)	1029 (67.0)	1847 (79.7)	1199 (81.7)
Missing	139 (6.0)	65 (4.2)	166 (7.2)	77 (5.2)
General well-being, n (%)				
Low life satisfaction	722 (31.4)	469 (30.5)	373 (16.1)	223 (15.2)
High life satisfaction	1525 (66.4)	1050 (68.4)	1872 (80.8)	1212 (82.6)
Missing	51 (2.2)	17 (1.1)	72 (3.1)	33 (2.2)

PDS = Pubertal Development Scale
* Range 1-4, †Range 4-16

PA level and sport participation

More boys reported a high level of PA (45.2%) compared to girls (35.4%) ($p < .001$). For both genders, junior high school students reported significantly higher levels of PA than senior high school students (Table 2). Of the various sports, team sports were most commonly reported by both girls and boys, with almost two thirds of the adolescents participating in such sports at least once a week (Table 2). For both genders, participation in team and technical sports was less common among senior high school students as compared to junior high school students ($p < .001$). In contrast, a significantly higher proportion of both girls and boys in senior high school were engaged in strength sports compared to those in junior high school. Significantly, more girls than boys participated in aesthetic sports, while a higher proportion of boys participated in strength sports and risk sports, in both age groups (Table 2).

Table 2 Physical activity (PA) level and sport participation rates in relation to gender and school level

	Girls (%)			Boys (%)		
	Junior high	**Senior high**	***p*-value**	**Junior high**	**Senior high**	***p*-value**
PA level						
High PA	38.4	32.4		46.5	43.8	
Moderate PA	39.9	34.3		33.1	28.0	
Low PA	20.2	31.6	**<0.001***	18.5	27.2	**<0.001***
Missing	1.5	1.6		1.9	1.0	
Sport participation (≥1 d/week)						
Team sports	**64.7**	**49.9**	**<0.001**	**65.8**	**56.7**	**<0.001**
Endurance sports	46.0	45.5	0.63	51.4	49.4	0.06
Aesthetic sports	25.9	27.3	0.43	6.0	5.2	0.25
Strength sports	**20.5**	**29.7**	**<0.001**	**33.8**	**47.6**	**<0.001**
Martial arts	3.5	4.4	0.17	7.6	7.6	0.85
Technical sports	**28.0**	**16.7**	**<0.001**	**26.8**	**20.8**	**<0.001**
Risk sports	1.0	0.8	0.71	4.6	4.7	0.99

Bold: statistically significant, p<0.05, * chi-square test for trend
Low PA = ≤1 day/week, moderate PA = 2-3 days/week, high PA = ≥4 days/week).

PA and mental health

A high level of PA, compared to a low level of PA, was significantly associated with reduced odds of low self-esteem and low life satisfaction among all students (Table 3). In senior high school students, a high level of PA was significantly associated with reduced odds of psychological distress (OR = 0.63, 95% CI [0.46-0.86] for girls and OR = 0.46, 95% CI [0.27-0.79] for boys).

Sport participation and mental health

Participation in team sports, compared with no/infrequent sport participation, was significantly associated with reduced odds of low self-esteem for girls, both in junior high school (OR = 0.45, 95% [0.32-0.64]) and senior high school (OR = 0.57, 95% CI [0.39-0.84]). A similar non-significant trend was observed in boys (Table 4). Participation in individual sports was significantly associated with reduced odds of low self-esteem among senior high school boys (OR = 0.37, 95% CI [0.18-0.76]).

Participation in team sports was associated with reduced odds of low life satisfaction, especially among girls (Table 4). Among girls in senior high school, team sport participation was also significantly associated with reduced odds of psychological distress (OR = 0.70, 95% CI [0.49 – 1.00]). In boys and junior high school girls, no statistically significant associations between sport participation and psychological distress were revealed in the adjusted models (Table 4).

Table 3 Associations between levels of physical activity and mental health problems (psychological distress, low self-esteem, and low life satisfaction) among girls and boys in junior and senior high school.

	Outcome			
	OR (OR, 95% CI) for psychological distress*			
	Junior high school		Senior high school	
Physical activity (PA) level	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]
Girls				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	0.80 (0.59 – 1.07)	0.86 (0.62 – 1.21)	**0.68 (0.51 – 0.90)**	**0.73 (0.54 – 0.99)**
High PA (≥4 d/w)	**0.67 (0.49 – 0.91)**	0.88 (0.63 – 1.24)	**0.53 (0.39 – 0.72)**	**0.63 (0.46 – 0.86)**
Boys				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	**0.54 (0.32 – 0.90)**	**0.56 (0.31 – 0.99)**	0.78 (0.49 – 1.23)	0.89 (0.53 – 1.49)
High PA (≥4 d/w)	**0.58 (0.56 – 0.91)**	0.70 (0.41 – 1.18)	**0.38 (0.23 – 0.62)**	**0.46 (0.27 – 0.79)**
	OR (OR, 95% CI) for low self-esteem (RSE)†			
Girls				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	**0.63 (0.48 – 0.82)**	**0.65 (0.49 – 0.87)**	**0.68 (0.30 – 0.93)**	**0.72 (0.52 – 0.99)**
High PA (≥4 d/w)	**0.53 (0.40 – 0.70)**	**0.59 (0.44 – 0.80)**	**0.43 (0.31 – 0.61)**	**0.49 (0.34 – 0.70)**
Boys				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	**0.37 (0.24 – 0.58)**	**0.32 (0.20 – 0.53)**	0.66 (0.38 – 1.15)	0.67 (0.37 – 1.20)
High PA (≥4 d/w)	**0.31 (0.20 – 0.48)**	**0.33 (0.21 – 0.52)**	**0.41 (0.24 – 0.71)**	**0.44 (0.25 – 0.79)**
	OR (OR, 95% CI) for low life satisfaction			
Girls				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	**0.60 (0.48 – 0.76)**	**0.59 (0.45 – 0.76)**	**0.66 (0.51 – 0.85)**	**0.68 (0.52 – 0.89)**
High PA (≥4 d/w)	**0.43 (0.34 – 0.55)**	**0.49 (0.37 – 0.63)**	**0.45 (0.34 – 0.59)**	**0.51 (0.38 – 0.69)**
Boys				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	**0.67 (0.51 – 0.90)**	**0.65 (0.47 – 0.90)**	0.76 (0.53 – 1.08)	0.73 (0.50 – 1.08)
High PA (≥4 d/w)	**0.42 (0.32 – 0.56)**	**0.44 (0.32 – 0.60)**	**0.44 (0.31 – 0.62)**	**0.43 (0.30 – 0.63)**

OR = odds ratio, CI = confidence interval, Bold: statistically significant associations, $p<0.05$.
* SCL5 ≥2 (range 0-4), † RSE <10 (range 4-16)
[a] Adjusted for age, puberty score (PDS), socioeconomic status, prior physical violence, prior bullying, prior sexual abuse

Table 4 Associations between sport participation and mental health problems (psychological distress, low self-esteem, and low life satisfaction) among girls and boys in junior and senior high school.

	Outcome			
	OR (OR, 95% CI) for psychological distress*			
	Junior high school		Senior high school	
Sport participation	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]
Girls				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	1.06 (0.70 – 1.60)	1.09 (0.68 – 1.73)	0.87 (0.61 – 1.22)	0.93 (0.64 – 1.35)
Team sports	0.78 (0.53 – 1.14)	1.02 (0.66 – 1.56)	**0.56 (0.40 – 0.78)**	**0.70 (0.49 – 1.00)**
Boys				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	1.04 (0.56 – 1.95)	1.04 (0.52 – 2.09)	0.85 (0.49 – 1.49)	0.98 (0.51 – 1.88)
Team sports	**0.55 (0.31 – 0.99)**	0.60 (0.31 – 1.15)	**0.57 (0.34 – 0.96)**	0.93 (0.50 – 1.70)
	OR (OR, 95% CI) for low self-esteem†			
Girls				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	**0.52 (0.37 – 0.75)**	**0.55 (0.37 – 0.81)**	0.77 (0.53 – 1.11)	0.81 (0.55 – 1.20)
Team sports	**0.42 (0.30 – 0.57)**	**0.45 (0.32 – 0.64)**	**0.50 (0.35 – 0.71)**	**0.57 (0.39 – 0.84)**
Boys				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	1.11 (0.62 – 1.99)	1.43 (0.73 – 2.79)	**0.42 (0.22 – 0.82)**	**0.37 (0.18 – 0.76)**
Team sports	**0.53 (0.30 – 0.92)**	0.72 (0.38 – 1.36)	**0.47 (0.27 – 0.81)**	0.57 (0.32 – 1.03)
	OR (OR, 95% CI) for low life satisfaction			
Girls				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	**0.70 (0.51 – 0.96)**	0.71 (0.50 – 1.00)	**0.66 (0.48 – 0.91)**	**0.65 (0.46 – 0.91)**
Team sports	**0.46 (0.34 – 0.61)**	**0.51 (0.37 – 0.70)**	**0.48 (0.36 – 0.65)**	**0.55 (0.40 – 0.76)**
Boys				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	1.00 (0.68 – 1.46)	0.99 (0.65 – 1.52)	0.84 (0.55 – 1.29)	0.80 (0.50 – 1.28)
Team sports	**0.56 (0.39 – 0.79)**	**0.63 (0.43 – 0.93)**	**0.62 (0.42 – 0.92)**	0.72 (0.47 – 1.12)

OR = odds ratio, CI = confidence interval, Bold: statistically significant associations, $p<0.05$.
* SCL5 ≥ 2 (range 0-4), † RSE <10 (range 4-16)
[a] Adjusted for age, puberty score (PDS), socioeconomic status, prior physical violence, prior bullying, prior sexual abuse

Discussion

In this population-based sample of adolescents, PA levels and participation rates in sports were lower among girls, and lower among senior high school students compared to junior high school students. Our results showed associations between higher levels of PA and reduced odds of mental health problems throughout adolescence, particularly in senior high school students. Further, team sport participation was associated with mental health benefits, especially for girls.

Strengths and limitations

The main strengths of our study include the large sample size of adolescents from an unselected general population, a high participation rate (73%), and the information including frequency of participation in sports. To our knowledge, such comprehensive information about sport participation in relation to gender and age differences has not previously been presented. This information enabled us to examine the relationship between sport participation and mental health outcomes, including the aspect of various types of sports, in contrast to most studies on this topic which mainly focus on general PA. We used validated measures of mental health outcomes. Another strength is that we were able to adjust for a variety of possible confounders, as well as including interpersonal violence as important risk factors for mental health problems among adolescents.

The main limitation of this study is the cross-sectional study design, and the resultant inability to demonstrate the direction of the association. Further, as measures were self-reported, the included variables are susceptible to information bias. Although the response rate in Young-HUNT3 was high, the lower response among senior high school students compared to junior high school students may represent a selection bias. In Norway, most

adolescents start senior high school the year they turn 16. Differences in school systems in other countries, as well as differences related to opportunities for engagement in sports and the organization of various youth sports may limit the generalizability of the results from this study.

Our results according to previous findings, and interpretation of findings

The findings from this study confirmed the gender differences in PA levels found in other population-based studies, with girls being less physically active than boys [11-13]. Also in line with reports from other studies, fewer girls were involved in sports [7 13 14 25]. The lower levels of PA and sport participation found among senior high school students confirms findings from previous studies reporting a decline in PA during adolescence [10 11 26 27], especially between the ages of 15 and 16 years [11]. In this study, lower participation rates among senior high school students compared to junior high school students were most evident in team sports, indicating a need for efforts to reduce drop out from these types of sports. Drop out from sports for adolescents at this age may be related, in part, to the difficulty of meeting the increasing demands of participation in both school and sport [7 28]. However, a systematic review of factors associated with drop out from organized sports, reported that lack of enjoyment and perceptions of competence are the two most dominant factors related to drop out from sports among adolescents [28].

The current findings are in line with previous studies reporting a postive relationship between adolescents' PA and mental health, including lower likelihood of depressive symptoms [1 11 13 29 30], greater well-being [13], and better self-esteem [1 30], and with longitudinal studies indicating that PA may protect against the development of depression [31 32]. PA may also be helpful for adolescents struggling with mental health problems [33 34]. Regarding

engagement in sports, the results of the present study are also in accordance with the literature indicating a positive relationship between sport participation and mental health [9 13 35-37].

The findings from this study make several contributions to the body of research on the impact of PA and sports on mental health among adolescents. Firstly, age differences were revealed in these relationships, as a high PA level was associated with reduced psychological distress in high school students only. Secondly, this study shows that the potential beneficial effects related to mental health vary across types of sport. Participation in team sports, compared to no participation, was more strongly related to beneficial mental health outcomes than individual sports compared to no participation, especially in high school girls. Other studies have reported that organized sports had a greater impact on depressive symptoms among girls than boys [11], and that team sports may confer mental health benefits for girls in particular [13]. A systematic review of the psychological and social benefits of sport participation argued that team sports seem to be associated with more beneficial outcomes compared to individual sports due to the social aspect of being part of a team [9]. In a recent study of a large representative sample of European adolescents, lower levels of anxiety and depression and higher levels of well-being were found among team sport participants [13]. Team sport participation during adolescence has also been shown to be associated with lower levels of depressive symptoms in early adulthood [36 38]. In line with this, our findings highlight that type of sport, including the social aspect of participation, should be considered when examining the impact of sports on mental health among adolescents.

Overall, adolescents with a high PA and team sport participation had lower odds of having low self-esteem than of having psychological distress. These results are in accordance with findings from a review study showing that, of the several mental health outcomes associated with PA in young people, the strongest association was with self-esteem [1]. It may

be that experiences of low self-esteem occur earlier than symptoms of anxiety and depression and that low self-esteem may trigger poor coping behavior and risk behavior that subsequently increases the likelihood of mental disorders [39]. A Cochrane review reports that exercise interventions have positive short-term effects on self-esteem that may help to prevent the development of psychological and behavioral problems [40].

This study contributes to our understanding of the implications lower levels of PA may have on mental health in different phases of adolescence. Regardless of the direction of the association between PA and mental health, our findings indicate that inactive adolescents may carry a "double health burden", with both physical and mental health challenges. To help more adolescents increase or maintain their levels of PA, interventions could include facilitation of a wider variety of sports activities, and at different skill levels, to reach and engage more adolescents. As lack of enjoyment has previously been found to be the most dominant factor related to drop out from sports, increased focus on the joy of sports may be important in order to reduce drop-out rates during adolescence. In efforts to reduce mental health problems, our results suggest that girls in particular should be a target group for promotion of team sport participation.

Conclusion and implications

This study identified gender and age differences in PA and sport participation across adolescent age-groups, with the lowest engagement in PA and sports found among girls in senior high school. Our results indicate that a high PA level and sport participation have a positive impact on various dimensions of mental health throughout adolescence, highlighting the importance of continuing with sports in the late teens. The findings underline a need for interventions aimed at maintaining or increasing PA and sport participation, especially for girls around the transition to senior high school. Initiatives to help adolescents continue in

team sports may be particularly advantageous. Future studies should examine the effect of interventions for encouraging and increasing PA and sport participation among adolescents, as well as their potential impact on mental health problems.

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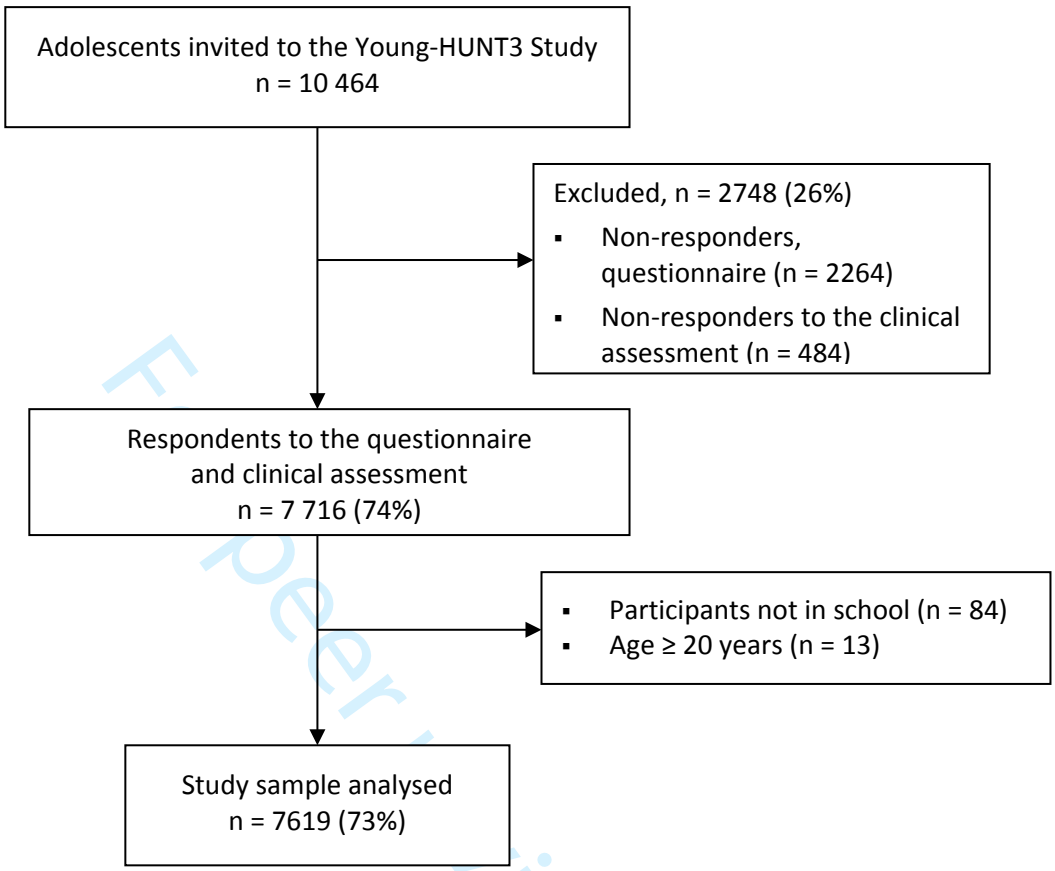
Appendix. Flow chart of the study sample.



Contributors: MHG processed, analysed and interpreted the data and drafted the initial manuscript. SØS, KS and JAZ were involved in the conception and design of the manuscript, as well as data interpretation and critical review and revision of the manucript. MCS supervised the statistical analyses. MSC and MBJ were involved in data interpretation, critical review and revision of the manucript. All authors have read and approved the final manuscript.

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Data sharing statement: The data set analysed belongs to a third party, the Nord-Trøndelag Health Study (HUNT Study). The authors of the current manuscript have been given permission to analyse the data after obtaining the necessary Norwegian permits. Research

groups wishing to analyse data from the HUNT study may apply to the HUNT organization to get access to the data (https://www.ntnu.no/hunt/datatilgang). HUNT databank online provides a complete overview of the research variables, as well as metadata (https://hunt-db.medisin.ntnu.no/hunt-db/#/survey/YH3). The general health questionnaire used in the study is accessible from the HUNT Bio-And-Databank (http://www.ntnu.edu/hunt/data/que).

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	2, 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-8
Bias	9	Describe any efforts to address potential sources of bias	7-8
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	8-9
		(*c*) Explain how missing data were addressed	9
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5, 24
		(b) Give reasons for non-participation at each stage	5, 24
		(c) Consider use of a flow diagram	24
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10-11
		(b) Indicate number of participants with missing data for each variable of interest	11
Outcome data	15*	Report numbers of outcome events or summary measures	14
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	15-16
		(*b*) Report category boundaries when continuous variables were categorized	15-16
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18-20
Generalisability	21	Discuss the generalisability (external validity) of the study results	17-18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	25

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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

BMJ Open

Physical activity and sport participation among adolescents: associations with mental health in different age groups. Results from the Young-HUNT Study, a cross sectional survey

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Physical activity and sport participation among adolescents: associations with mental health in different age groups. Results from the Young-HUNT Study, a cross sectional survey

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Abstract

Objectives: Knowledge of how physical activity (PA) and sport participation are related to mental health throughout adolescence is scarce. Our objective was to describe PA levels and sport participation in a population-based sample of adolescents, and to explore how they relate to mental health in different age groups.

Design: A population-based cross-sectional study.

Setting and participants: The adolescent part of the Nord-Trøndelag Health Study (Young-HUNT3), a Norwegian population-based health survey conducted from 2006-2008. Of 10464 invited participants (age13-19 years), 7619 (73%) participated, of whom 3785 (50%) were boys.

Outcome measures: Mental health outcomes included psychological distress assessed using a short version of the Hopkins Symptom Check List (SCL-5), self-esteem assessed using a short version of The Rosenberg Self-Esteem Scale (RSES) and life satisfaction assessed with a single-item satisfaction with life measure.

Method: Logistic regression models were used to estimate the likelihood of psychological distress, low self-esteem, and low life satisfaction, according to self-reported PA level and type of sport participation, stratified by gender and school level (junior vs senior high school).

Results: Fewer senior high school students participated in team sports compared to junior high school students (p<0.001). Physically active adolescents and participants in team sports had higher self-esteem and life satisfaction. A high PA level, compared to a low PA level, was associated with reduced odds of psychological distress among senior high school students (Odds ratio [OR] = 0.63, 95% confidence interval [CI] [0.46-0.86] for girls and OR = 0.46, 95% CI [0.27-0.79] for boys). Team sport participation was associated with reduced odds of psychological distress in senior high school girls.

Conclusion: A high PA level was favorably associated with various dimensions of mental health, especially for adolescents in senior high school. Team sport participation may have a positive impact on mental health and should therefore be encouraged.

Strengths and limitations of this study

- Large population-based sample of adolescents with a high participation rate.
- Comprehensive information about sport participation and validated measures of mental health across adolescent age groups.
- Stratified analysis that takes potential age and gender differences during adolescence into account, and adjustments for possible confounders including exposure to interpersonal violence (physical violence, bullying, sexual abuse).
- The main limitation of this study is the cross-sectional study design.
- Measures of PA were self-reported.

Introduction

Physical activity (PA) and psychological well-being are essential to healthy development and quality of life in adolescence [1-3]. Health behaviours, including the habit of engaging in regular PA, are often established during this period [4 5], paving the way for long-term health prospects.

Maintenance of PA throughout adolescence is of major importance in a public health perspective. Engaging in PA and sports during adolescence is associated with the development of lifelong PA [6-8] and psychological well-being [1 9]. Yet adolescents tend to be less physically active with increasing age [10]. The most dramatic decrease in PA is found to occur between the ages of 15 and 16, around the transition from junior to senior high school [11]. Although few adolescents are satisfying the recommended 60 minutes of moderate to vigorous PA per day worldwide [12 13], sport participation is found to be high in some population-based studies [6 14]. However, information about participation rates in various type of sports throughout adolescence is lacking.

Mental health problems are another major challenge among adolescents; currently the leading cause of health-related disability within this age group, affecting up to 20% of adolescents worldwide [15 16]. Prevalence rates of psychological distress, such as anxiety and depression, increase with age, especially from the mid-teens (14-16 years) [11 17]. Poor mental health also tends to carry over into adulthood [17 18], highlighting the importance of preventive efforts during adolescence. Currently the evidence indicates that PA may have a positive impact on anxiety, depression and self-esteem among adolescents, although our knowledge is limited [1]. Studies commonly assess these relationships without considering different developmental stages during adolescence. Further, the need for PA measures which account for various types of sports/activities has been emphasized [1]. No large population-based studies have evaluated PA levels and type of sport participation in relation to mental health among girls and boys in different adolescent age groups. Identification of these relationships could have implications for preventive

programs and may contribute to more accurate strategies for increasing engagement in PA and improving mental health among adolescents.

The aim of this study was to describe PA levels and the frequency of sport participation in a large population-based sample of adolescents stratified by age group and gender. Further, to explore associations between PA level, type of sport participation, and mental health, including psychological distress, self-esteem, and life satisfaction. Based on our knowledge and the literature, we anticipated that the associations between PA, sport participation and mental health measures would differ between boys and girls across adolescence. We hypothesised that a high level of PA and participation in sports would be associated with lower levels of psychological distress, higher self-esteem and greater life satisfaction, particularly among high school students and participants in team sports.

Methods

Study sample

From 2006-2008 all adolescent residents (age 13-19 years) of the Nord-Trøndelag county in Norway (N=10464) were invited to participate in the third wave of the population-based Nord-Trøndelag Health Study (Young-HUNT3). The attendees completed a comprehensive health-related questionnaire during school hours. Of those invited, 7716 (74%) adolescents responded to the questionnaire and attended a clinical examination. The response rate was 82% among junior high school students and 69% among senior high school students. Participants not enrolled in school (N=84) and participants ≥20 years of age (N=13) were excluded from the analyses in this study. Thus, the study sample comprised 7619 participants (73%) (Appendix), of whom 4615 (61%) went to junior high school. All participants in senior high school were ≥16 years old.

Exposure variables

Leisure time PA level was assessed by a validated question on frequency of PA from the World Health Organization Health Behavior in Schoolchildren (WHO HBSC) Survey Questionnaire [19] [20]: Outside school hours: "How often do you usually exercise in your free time so much that you get out of breath or sweat?". The level of intensity during exercise where you breathe heavily and/or sweat refers to moderate to vigorous activity. Response alternatives were: every day, 4-6 days/week, 2-3 days/week, 1 day/week, less than every week, less than every month, and never. Responses were categorized into three levels of PA: ''Low PA'' (≤1 days/week) (reference group), ''moderate PA'' (2-3 days/week), and ''high PA'' (≥4 days/week).

Type and frequency of sport participation was assessed by the question: "How often have you participated in the following activities/sports in the last 12 months?"; endurance sports (e.g. cross-country skiing, swimming, running), team sports (e.g. soccer, volleyball, handball), strength sports (e.g. weightlifting, bodybuilding), technical sports (e.g. track and field, alpine skiing, snowboard) , aesthetic sports (e.g. dance, gymnastics), martial arts (e.g. judo, karate, boxing), extreme sports (e.g. rafting, rock climbing, paragliding), jogging/walking, and other. Jogging/walking was not defined as an organized sport, and responses to this variable were not included as part of the sport participation exposure. Four alternatives were given for describing the frequency of participation in each of the sport categories: never, less than once a week, once a week, several times a week. A frequency of "at least once a week" was defined as active participation. Furthermore, adolescents were classified by their participation in sports into team sports (e.g. soccer, volleyball, handball) or individual sports (all other sports). The reference group consisted of those with no or infrequent participation in all the sport categories, as well as those who reported a low level of PA. The groups were mutually exclusive.

Outcome variables - Mental health

Psychological distress was assessed using a validated short version of the Hopkins Symptom Check List (SCL-5) [21 22], including the phrases: "During the last 14 days: I have been constantly afraid and anxious; I have felt tense or uneasy; I have felt hopeless about the future; I have felt dejected or sad; I have worried too much about various things". Responses were scored according to four response alternatives ranging from "not at all bothered" (1) to "extremely bothered" (4). A mean score was calculated, and a cut-off for symptoms of anxiety and depression was set at a mean score above two [21]. The five-item version (SCL-5) has shown high correlation with the 25-item SCL-25 (r = 0.92) [22] and good internal consistency (Cronbach's alpha 0.87) [21].

Self-esteem/feelings of self-worth was measured using a short version of the Rosenberg Self-Esteem Scale (RSES) (original 10 items) [23], including four statements: "I have a positive attitude toward myself", "I feel rather useless at times", "I feel that I don't have much to be proud of", and "I feel that I am a valuable person, at least equal to other people". Response alternatives were measured on a 4-point scale ranging from ''I strongly agree'' (1) to ''I strongly disagree'' (4). For the first and last items the scores were inversed. A mean score was calculated (range 4-16), with higher scores indicating higher levels of self-esteem. A cut-off was set at a mean score of 10 (midpoint of the scale) to separate low and high self-esteem, corresponding to the recommended cut-off at 25 on the original 10-item RSES scale (range 10-40) [24]. The four-item version of the RSES is found to correlate at 0.95 with the full scale and to explain 90% of the full-scale variance, and has good internal consistency (Cronbach's alpha 0.80) [25].

Life satisfaction was measured with the question: "Thinking about your life at the moment, would you say that you by and large are satisfied with life, or are you mostly dissatisfied?" Response alternatives were measured on a 7-point scale ranging from "very satisfied" (1) to "very dissatisfied" (7), and were coded into a dichotomous outcome variable where adolescents who responded 1-3 were classified as "high life satisfaction", and those who

responded 4-7 were classified as "low life satisfaction". A single-item life satisfaction measure is shown to perform almost as well as the multiple-item Satisfaction with Life Scale (SWLS) [26 27].

Potential confounders

Data on gender and age were obtained from the Norwegian National Population Registry. Socioeconomic status was based on participants' reports of perceived family economy. Pubertal development was assessed by self-reported pubertal status using the validated Pubertal Development Scale (PDS) [28]. Participants were asked to rate their own growth and to assess pubic hair growth. Further, boys were asked to assess changes in voice and facial hair growth, while girls were asked about age at menarche and breast development. Pubertal changes were reported on scales ranging from 1 (has not begun) to 4 (development completed). Menarche was dichotomized into yes (coded 4) and no (coded 1). The items were summed up and an average PDS score was calculated.

Exposure to interpersonal violence was assessed with questions derived from The University of California at Los Angeles Post-traumatic Stress Disorder Reaction Index (UCLA PTSD Reaction Index) [29]: "Have you ever experienced any of these events?" (no or yes): 1) Been subjected to violence (beaten or injured), 2) Been subjected to unpleasant/disagreeable sexual acts by someone approximately your own age, 3) Been subjected to unpleasant/disagreeable sexual acts by an adult, and 4) Been threatened or physically harassed by fellow students at school over a period of time. Responses were categorized as "prior violence", "prior sexual abuse" (by peer or adult), and "prior bullying" [30].

Statistical analyses

Categorical variables were described with counts and percentages, and continuous variables with mean and standard deviation (SD). Possible associations between gender and age distribution were assessed with Chi-square tests.

The associations between 1) PA level and 2) type of sport participation and the mental health outcomes were evaluated using multiple logistic regression models. The results are expressed as odds ratios (OR) with 95% confidence intervals (CI). Analyses were stratified by gender and school level (junior and senior high school). To adjust for potential confounding, age, puberty development (PDS), socio-economic status, prior violence, sexual abuse (by peer or adult), and bullying were all included in the multiple models. All tests were two-sided, and the significance level was set to 5%. Analyses were performed using SPSS version 25 (SPSS Inc., Chicago, IL).

Due to missing data on pubertal development (PDS score) (13% in girls, 15% in boys), a model-based imputation for this variable was performed. Linear regression models stratified by gender were fitted with age and body mass index (BMI). Residuals for both models followed standard normal distribution and the model fit was very good. The missing values were replaced with the predicted values. The predicted variables and the original variables for both genders were highly correlated, r=0.75 and r=0.85 for boys and girls, respectively.

Ethics

The current study has been approved by the Regional Committee for Medical Research Ethics (2014/1228/REK Sør-Øst A). The Young-HUNT Studies have been approved by REK and the Data Inspectorate of Norway. Participation in the study was voluntary. Inclusion in Young-

HUNT was based on written consent from participants 16 years of age or older, and from the parents of those under 16 years of age, in accordance with Norwegian law.

Patient and Public Involvement

When preparing for the Young-HUNT3 survey, the HUNT research centre appointed reference groups consisting of student representatives (13-19 years), as well as representatives from the county school authorities and county doctors. Content of the questionnaires, clinical examination, implementation of results and protection of privacy have been discussed with these representatives. Results from the current study have been presented and discussed with the Youth Panel for Research at the Research and Communication Unit for Musculoskeletal Health (FORMI), Oslo University Hospital. The HUNT research centre has an active information policy and publishes annual newsletters for participants as well as regular reports on the HUNT web-site (https://www.ntnu.no/hunt/om).

Results

Characteristics of the study sample

In total, 3785 boys and 3834 girls were included in the analyses. Characteristics of the study sample are summarized in Table 1. The mean age was 15.8 years (SD 1.7). About 10% reported living in families with an economy below average, and reports of exposure to interpersonal violence was higher among senior as compared to junior high school students, with physical violence being more common in boys, sexual violence more common in girls, and bullying more evenly distributed between the sexes. Girls reported more mental health problems than boys, with the highest levels of psychological distress found among girls in high school (Table 1).

Table 1 Characteristics of the study sample (n =7619)

	Girls (%)		Boys (%)	
Characteristics	**Junior high N = 2298**	**Senior high N = 1536**	**Junior high N = 2317**	**Senior high N = 1468**
Age, mean (SD)	14.6 (0.89)	17.6 (0.86)	14.6 (0.89)	17.5 (0.84)
Socioeconomic status; family economy, n (%)				
Above average	297 (12.9)	264 (17.2)	402 (17.4)	319 (21.7)
Average	1644 (71.5)	1077 (70.1)	1521 (65.6)	939 (64.0)
Below average	204 (8.9)	144 (9.4)	141 (6.1)	136 (9.3)
Missing	153 (6.7)	253 (10.9)	253 (10.9)	74 (5.0)
Puberty (PDS score), mean (SD)	2.90 (0.68)	3.49 (0.51)	2.56 (0.61)	3.34 (0.47)
Missing	10 (0.4)	5 (0.3)	-	1 (0.0)
Interpersonal violence, n (%)				
Physical violence	122 (5.3)	138 (9.0)	200 (8.6)	246 (16.8)
Missing	96 (4.2)	34 (2.2)	167 (7.2)	65 (4.4)
Sexual abuse	123 (5.4)	169 (11.0)	50 (2.2)	44 (3.0)
Missing	103 (4.5)	32 (2.1)	170 (7.3)	58 (4.0)
Bullying	140 (6.1)	129 (8.4)	183 (7.9)	117 (8.0)
Missing	107 (4.7)	32 (2.1)	170 (7.3)	58 (4.0)
Mental health outcomes				
Psychological distress (SCL5)*, n (%)				
SCL5 ≥2	350 (15.2)	362 (23.6)	111 (4.8)	110 (7.5)
SCL5 <2	1892 (82.3)	1138 (74.1)	2093 (90.3)	1302 (88.7)
Missing	56 (2.4)	36 (2.3)	113 (4.9)	56 (3.8)
Self-esteem (RSE)†, n (%)				
RSE <10	660 (28.7)	442 (28.8)	304 (13.1)	192 (13.1)
RSE ≥10	1499 (65.2)	1029 (67.0)	1847 (79.7)	1199 (81.7)
Missing	139 (6.0)	65 (4.2)	166 (7.2)	77 (5.2)
Life satisfaction, n (%)				
Low life satisfaction	722 (31.4)	469 (30.5)	373 (16.1)	223 (15.2)
High life satisfaction	1525 (66.4)	1050 (68.4)	1872 (80.8)	1212 (82.6)
Missing	51 (2.2)	17 (1.1)	72 (3.1)	33 (2.2)

PDS = Pubertal Development Scale
* Range 1-4, †Range 4-16

PA level and sport participation

More boys reported a high level of PA (45.2%) compared to girls (35.4%) ($p < .001$). For both genders, junior high school students reported significantly higher levels of PA than senior high school students (Table 2). Of the various sports, team sports were most commonly reported by both girls and boys, with almost two thirds of the adolescents participating in such sports at least once a week (Table 2). For both genders, participation in team and technical sports was less common among senior high school students as compared to junior high school students ($p < .001$). In contrast, a significantly higher proportion of both girls and boys in senior high school were engaged in strength sports compared to those in junior high school. Significantly, more girls than boys participated in aesthetic sports, while a higher proportion of boys participated in strength sports and extreme sports, in both age groups (Table 2).

Table 2 Physical activity (PA) level and sport participation rates in relation to gender and school level

	Girls (%)			Boys (%)		
	Junior high	**Senior high**	***p*-value**	**Junior high**	**Senior high**	***p*-value**
PA level						
High PA	38.4	32.4		46.5	43.8	
Moderate PA	39.9	34.3		33.1	28.0	
Low PA	20.2	31.6	**<0.001***	18.5	27.2	**<0.001***
Missing	1.5	1.6		1.9	1.0	
Sport participation (≥1 day/week)						
Team sports	**64.7**	**49.9**	**<0.001**	**65.8**	**56.7**	**<0.001**
Endurance sports	46.0	45.5	0.63	51.4	49.4	0.06
Aesthetic sports	25.9	27.3	0.43	6.0	5.2	0.25
Strength sports	**20.5**	**29.7**	**<0.001**	**33.8**	**47.6**	**<0.001**
Martial arts	3.5	4.4	0.17	7.6	7.6	0.85
Technical sports	**28.0**	**16.7**	**<0.001**	**26.8**	**20.8**	**<0.001**
Extreme sports	1.0	0.8	0.71	4.6	4.7	0.99

Bold: statistically significant, p<0.05, * chi-square test for trend
Low PA = ≤1 day/week, moderate PA = 2-3 days/week, high PA = ≥4 days/week).

PA and mental health

A high level of PA, compared to a low level of PA, was significantly associated with reduced odds of low self-esteem and low life satisfaction among all students (Table 3). In senior high school students, a high level of PA was significantly associated with reduced odds of psychological distress (OR = 0.63, 95% CI [0.46-0.86] for girls and OR = 0.46, 95% CI [0.27-0.79] for boys).

Sport participation and mental health

Participation in team sports, compared with no/infrequent sport participation, was significantly associated with reduced odds of low self-esteem for girls, both in junior high school (OR = 0.45, 95% [0.32-0.64]) and senior high school (OR = 0.57, 95% CI [0.39-0.84]). A similar non-significant trend was observed in boys (Table 4). Participation in individual sports was significantly associated with reduced odds of low self-esteem among senior high school boys (OR = 0.37, 95% CI [0.18-0.76]).

Participation in team sports was associated with reduced odds of low life satisfaction, among all girls and among junior high school boys (Table 4). Among girls in senior high school, team sport participation was also significantly associated with reduced odds of psychological distress (OR = 0.70, 95% CI [0.49 – 1.00]). In boys and junior high school girls, no statistically significant associations between sport participation and psychological distress were revealed in the adjusted models (Table 4).

Table 3 Associations between levels of physical activity and mental health problems (psychological distress, low self-esteem, and low life satisfaction) among girls and boys in junior and senior high school.

	Outcome			
	OR (OR, 95% CI) for psychological distress*			
	Junior high school		**Senior high school**	
Physical activity (PA) level	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]
Girls				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	0.80 (0.59 – 1.07)	0.86 (0.62 – 1.21)	**0.68 (0.51 – 0.90)**	**0.73 (0.54 – 0.99)**
High PA (≥4 d/w)	**0.67 (0.49 – 0.91)**	0.88 (0.63 – 1.24)	**0.53 (0.39 – 0.72)**	**0.63 (0.46 – 0.86)**
Boys				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	**0.54 (0.32 – 0.90)**	**0.56 (0.31 – 0.99)**	0.78 (0.49 – 1.23)	0.89 (0.53 – 1.49)
High PA (≥4 d/w)	**0.58 (0.56 – 0.91)**	0.70 (0.41 – 1.18)	**0.38 (0.23 – 0.62)**	**0.46 (0.27 – 0.79)**
	OR (OR, 95% CI) for low self-esteem (RSE)†			
Girls				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	**0.63 (0.48 – 0.82)**	**0.65 (0.49 – 0.87)**	**0.68 (0.30 – 0.93)**	**0.72 (0.52 – 0.99)**
High PA (≥4 d/w)	**0.53 (0.40 – 0.70)**	**0.59 (0.44 – 0.80)**	**0.43 (0.31 – 0.61)**	**0.49 (0.34 – 0.70)**
Boys				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	**0.37 (0.24 – 0.58)**	**0.32 (0.20 – 0.53)**	0.66 (0.38 – 1.15)	0.67 (0.37 – 1.20)
High PA (≥4 d/w)	**0.31 (0.20 – 0.48)**	**0.33 (0.21 – 0.52)**	**0.41 (0.24 – 0.71)**	**0.44 (0.25 – 0.79)**
	OR (OR, 95% CI) for low life satisfaction			
Girls				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	**0.60 (0.48 – 0.76)**	**0.59 (0.45 – 0.76)**	**0.66 (0.51 – 0.85)**	**0.68 (0.52 – 0.89)**
High PA (≥4 d/w)	**0.43 (0.34 – 0.55)**	**0.49 (0.37 – 0.63)**	**0.45 (0.34 – 0.59)**	**0.51 (0.38 – 0.69)**
Boys				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	**0.67 (0.51 – 0.90)**	**0.65 (0.47 – 0.90)**	0.76 (0.53 – 1.08)	0.73 (0.50 – 1.08)
High PA (≥4 d/w)	**0.42 (0.32 – 0.56)**	**0.44 (0.32 – 0.60)**	**0.44 (0.31 – 0.62)**	**0.43 (0.30 – 0.63)**

OR = odds ratio, CI = confidence interval, Bold: statistically significant associations, $p<0.05$.
* SCL5 ≥2 (range 0-4), † RSE <10 (range 4-16)
[a] Adjusted for age, puberty score (PDS), socioeconomic status, prior physical violence, prior bullying, prior sexual abuse

Table 4 Associations between sport participation and mental health problems (psychological distress, low self-esteem, and low life satisfaction) among girls and boys in junior and senior high school.

	Outcome			
	OR (OR, 95% CI) for psychological distress*			
	Junior high school		Senior high school	
Sport participation	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]
Girls				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	1.06 (0.70 – 1.60)	1.09 (0.68 – 1.73)	0.87 (0.61 – 1.22)	0.93 (0.64 – 1.35)
Team sports	0.78 (0.53 – 1.14)	1.02 (0.66 – 1.56)	**0.56 (0.40 – 0.78)**	**0.70 (0.49 – 1.00)**
Boys				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	1.04 (0.56 – 1.95)	1.04 (0.52 – 2.09)	0.85 (0.49 – 1.49)	0.98 (0.51 – 1.88)
Team sports	**0.55 (0.31 – 0.99)**	0.60 (0.31 – 1.15)	**0.57 (0.34 – 0.96)**	0.93 (0.50 – 1.70)
	OR (OR, 95% CI) for low self-esteem†			
Girls				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	**0.52 (0.37 – 0.75)**	**0.55 (0.37 – 0.81)**	0.77 (0.53 – 1.11)	0.81 (0.55 – 1.20)
Team sports	**0.42 (0.30 – 0.57)**	**0.45 (0.32 – 0.64)**	**0.50 (0.35 – 0.71)**	**0.57 (0.39 – 0.84)**
Boys				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	1.11 (0.62 – 1.99)	1.43 (0.73 – 2.79)	**0.42 (0.22 – 0.82)**	**0.37 (0.18 – 0.76)**
Team sports	**0.53 (0.30 – 0.92)**	0.72 (0.38 – 1.36)	**0.47 (0.27 – 0.81)**	0.57 (0.32 – 1.03)
	OR (OR, 95% CI) for low life satisfaction			
Girls				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	**0.70 (0.51 – 0.96)**	0.71 (0.50 – 1.00)	**0.66 (0.48 – 0.91)**	**0.65 (0.46 – 0.91)**
Team sports	**0.46 (0.34 – 0.61)**	**0.51 (0.37 – 0.70)**	**0.48 (0.36 – 0.65)**	**0.55 (0.40 – 0.76)**
Boys				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	1.00 (0.68 – 1.46)	0.99 (0.65 – 1.52)	0.84 (0.55 – 1.29)	0.80 (0.50 – 1.28)
Team sports	**0.56 (0.39 – 0.79)**	**0.63 (0.43 – 0.93)**	**0.62 (0.42 – 0.92)**	0.72 (0.47 – 1.12)

OR = odds ratio, CI = confidence interval, Bold: statistically significant associations, $p<0.05$.
* SCL5 ≥ 2 (range 0-4), † RSE <10 (range 4-16)
[a] Adjusted for age, puberty score (PDS), socioeconomic status, prior physical violence, prior bullying, prior sexual abuse

Discussion

In this population-based sample of adolescents, PA levels and participation rates in sports were lower among girls, and lower among senior high school students compared to junior high school students. Our results showed that higher levels of PA were favourably associated with self-esteem and life satisfaction throughout adolescence, as well as with reduced likelihood of psychological distress in senior high school students. Further, team sport participation was associated with mental health benefits, especially for girls.

Strengths and limitations

The main strengths of our study include the large sample size of adolescents from an unselected general population, a high participation rate (73%), and the information including frequency of participation in sports. To our knowledge, such comprehensive information about sport participation in relation to gender and age differences has not previously been presented. This information enabled us to examine the relationship between sport participation and mental health outcomes, including the aspect of various types of sports, in contrast to most studies on this topic which mainly focus on general PA. We used validated measures of mental health outcomes. Another strength is that we were able to adjust for a variety of possible confounders, as well as including exposures to interpersonal violence as these exposures may have an impact on both PA behaviours and mental health [31-33].

The main limitation of this study is the cross-sectional study design, and the resultant inability to demonstrate the direction of the association. Further, as measures were self-reported, the included variables are susceptible to information bias. We have used a single item measure to assess PA, and the variable used to describe sport participation exposure provides a crude measure of frequency of participation. However, the WHO HBSC question of PA used in this

study has been found to hold acceptable reliability and validity in adolescent samples [19 20]. It should be noted that a proportion of the "High PA" group in this study may not fulfil the recommended levels of daily PA according to the WHO guidelines [34], as this group includes all those who played sports or exercised at least 4 days/week. Measures of psychological distress (SCL-5) and self-esteem (RSES) were shortened versions of the original instruments, however, the measurement precision of these versions is found to be high and sufficient for use in population-based studies [21 22 25]. Furthermore, dichotomization of the mental health outcomes makes them prone to misclassification. However, the cut-off values to distinguish those with high vs low degree of psychological distress (SCL-5) and low self-esteem (RSES) have both been shown to be clinically relevant cut-points [21 24]. In contrast to psychological distress, low self-esteem and low life satisfaction were not more prevalent in the older age group, reflecting the measurement of different phenomena. Psychological distress is found to function as a proxy measure of symptoms of anxiety and depression [21 22], while self-esteem and life satisfaction are more closely related to subjective well-being [26 35] which may be more stable traits.

Although the response rate in Young-HUNT3 was high, the lower response among senior high school students compared to junior high school students may represent a selection bias. In Norway, most adolescents start senior high school the year they turn 16. Differences in school systems in other countries, as well as differences related to opportunities for engagement in sports and the organization of various youth sports may limit the generalizability of the results from this study. Norwegian society is rooted in egalitarian ideals, with "Sport for All" as a high priority and policy aim [36]; this may be part of the reason why sport participation found in this study is high by international standards. Lastly, the results of this study should be interpreted with caution due to multiple testing, and replication of results is warranted.

Our results according to previous findings, and interpretation of findings

The findings from this study confirmed the gender differences in PA levels found in other population-based studies, with girls being less physically active than boys [11-13]. Also in line with reports from other studies, fewer girls were involved in sports [7 13 14 37]. The lower levels of PA and sport participation found among senior high school students confirms findings from previous studies reporting a decline in PA during adolescence [10 11 38 39], especially between the ages of 15 and 16 years [11]. Drop-out from sports for adolescents at this age may be related, in part, to the difficulty of meeting the increasing demands of participation in both school and sport [7 40]. However, a systematic review of factors associated with drop-out from organized sports, reported that lack of enjoyment and perceptions of competence are the two most dominant factors related to drop-out from sports among adolescents [40].

The current findings are in line with previous studies reporting associations between adolescents' PA and mental health, including lower likelihood of depressive symptoms [1 11 13 41 42], as well as greater well-being [13] and higher self-esteem among those who are physically active [1 42]. Longitudinal studies also indicate that PA may protect against the development of depression [43 44]. Furthermore, PA may be a helpful intervention for adolescents struggling with depressive symptoms [45 46]. Regarding engagement in sports, the results of the present study are in accordance with the literature indicating a positive relationship between sport participation and mental health [9 13 47-49].

The findings from this study make several contributions to the body of research on the impact of PA and sports on mental health among adolescents. Firstly, age differences were revealed in these relationships, as a high PA level was associated with reduced psychological distress in high school students only. Explanations for why PA and sport participation may be of greater importance in reducing psychological distress among older adolescents could relate to how peer support and interaction play an increasingly important role during adolescence [50]. Thus,

social and physical activities with peers may be particularly beneficial for older adolescents, helping to distract them from depressive thoughts and to reduce the sense of isolation.

Secondly, this study shows that the potential beneficial effects related to mental health vary across various types of sport. Participation in team sports, compared to no participation, was more strongly related to beneficial mental health outcomes than individual sports compared to no participation, especially in high school girls. Other studies have reported that organized sports had a greater impact on depressive symptoms among girls than boys [11], and that team sports may confer mental health benefits for girls in particular [13]. A systematic review of the psychological and social benefits of sport participation argued that team sports seem to be associated with more beneficial outcomes compared to individual sports due to the social aspect of being part of a team [9]. In a recent study of a large representative sample of European adolescents, lower levels of anxiety and depression and higher levels of well-being were found among team sport participants [13]. Team sport participation during adolescence has also been shown to be associated with lower levels of depressive symptoms in early adulthood [48 51]. In line with this, our findings highlight that type of sport, including the social aspect of participation, should be considered when examining the impact of sports on mental health among adolescents.

Overall, adolescents with a high PA and team sport participation had lower odds of having low self-esteem than of having psychological distress. These results are in accordance with findings from a review study showing that, of the several mental health outcomes associated with PA in young people, the strongest association was with self-esteem [1]. It may be that experiences of low self-esteem occur earlier than symptoms of anxiety and depression and that low self-esteem may trigger poor coping behavior and risk behavior that subsequently increases the likelihood of mental disorders [52]. A Cochrane review reports that exercise interventions have positive short-term effects on self-esteem that may help prevent the development of psychological and behavioral problems [53].

This study contributes to our understanding of the implications lower levels of PA may have on mental health in different phases of adolescence. Regardless of the direction of the association between PA and mental health, inactive adolescents may carry a "double health burden", with both physical and mental health challenges. To help more adolescents increase or maintain their levels of PA, interventions could include facilitation of a wider variety of sports activities, and at different skill levels, to reach and engage more adolescents. As lack of enjoyment has previously been found to be the most dominant factor related to drop-out from sports [40], increased focus on the joy of sports may be important in order to reduce drop-out rates during adolescence. In efforts to reduce mental health problems, our results suggest that girls in particular should be a target group for promotion of team sport participation.

Conclusion and implications

This study identified gender and age differences in PA and sport participation across adolescent age-groups, with the lowest engagement in PA and sports found among girls in senior high school. Our results indicate that a high PA level and sport participation have a positive impact on various dimensions of mental health throughout adolescence, highlighting the importance of continuing with sports in the late teens. The findings underline a need for interventions aimed at maintaining or increasing PA and sport participation, especially for girls around the transition to senior high school. Initiatives to help adolescents continue in team sports may be particularly advantageous. Future studies should examine the effect of interventions for encouraging and increasing PA and sport participation among adolescents, as well as their potential mental health benefits.

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Data sharing statement: The data set analysed belongs to a third party, the Nord-Trøndelag Health Study (HUNT Study). The authors of the current manuscript have been given permission to analyse the data after obtaining the necessary Norwegian permits. Research groups that wish to analyse data from the HUNT study may apply to the HUNT organization to get access to the data

(https://www.ntnu.no/hunt/datatilgang). HUNT databank online provides a complete overview of the research variables, as well as metadata (https://hunt-db.medisin.ntnu.no/hunt-db/#/survey/YH3). The general health questionnaire used in the study is accessible from the HUNT Bio-And-Databank (http://www.ntnu.edu/hunt/data/que).

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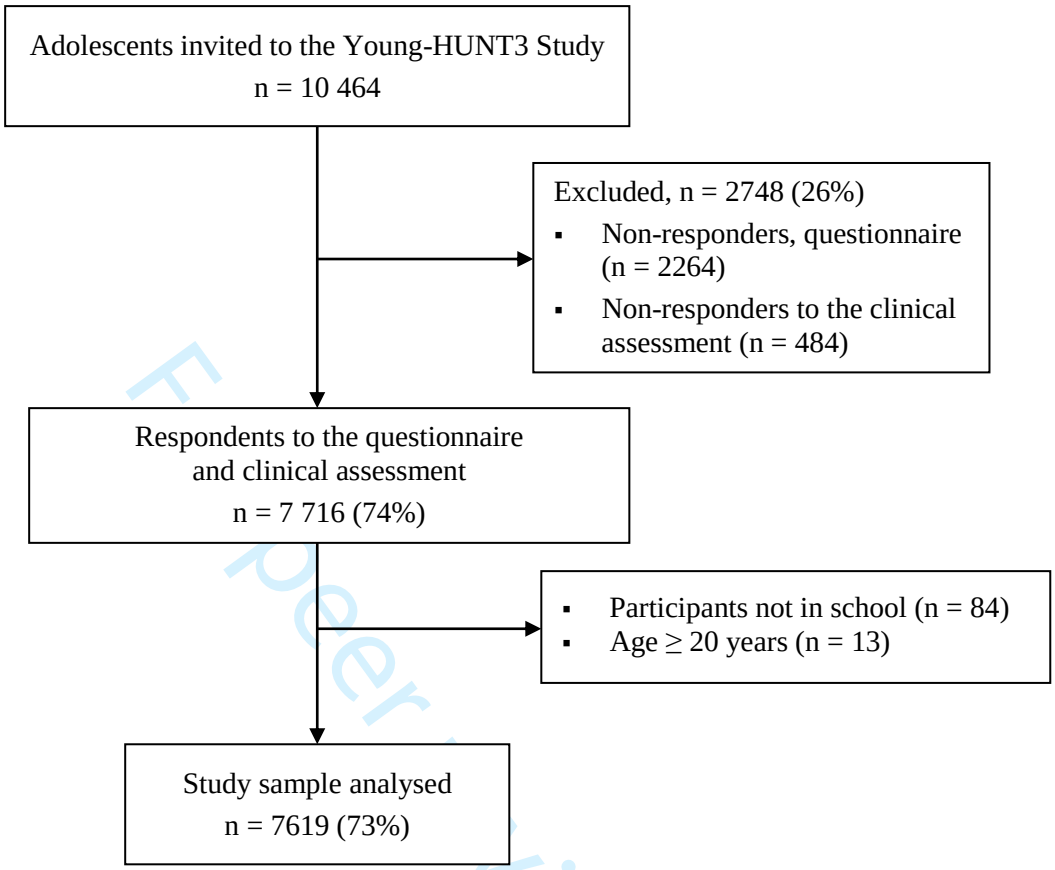
Appendix. Flow chart of the study sample.



STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	2, 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-8
Bias	9	Describe any efforts to address potential sources of bias	8-9
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	9
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5, 24
		(b) Give reasons for non-participation at each stage	5, Appendix
		(c) Consider use of a flow diagram	Appendix
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-12
		(b) Indicate number of participants with missing data for each variable of interest	12
Outcome data	15*	Report numbers of outcome events or summary measures	13, 15
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	16-17
		(*b*) Report category boundaries when continuous variables were categorized	16-17
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18-19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	20-22
Generalisability	21	Discuss the generalisability (external validity) of the study results	19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	27

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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

BMJ Open

Physical activity and sport participation among adolescents: associations with mental health in different age groups. Results from the Young-HUNT Study, a cross sectional survey

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Physical activity and sport participation among adolescents: associations with mental health in different age groups. Results from the Young-HUNT Study, a cross sectional survey

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Abstract

Objectives: Knowledge of how physical activity (PA) and sport participation are related to mental health throughout adolescence is scarce. Our objective was to describe PA levels and sport participation in a population-based sample of adolescents, and to explore how they relate to mental health in different age groups.

Design: A population-based cross-sectional study.

Setting and participants: The adolescent part of the Nord-Trøndelag Health Study (Young-HUNT3), a Norwegian population-based health survey conducted from 2006-2008. Of 10464 invited participants (age13-19 years), 7619 (73%) participated, of whom 3785 (50%) were boys.

Outcome measures: Mental health outcomes included psychological distress assessed using a short version of the Hopkins Symptom Check List (SCL-5), self-esteem assessed using a short version of The Rosenberg Self-Esteem Scale (RSES) and life satisfaction assessed with a single-item satisfaction with life measure.

Method: Logistic regression models were used to estimate the likelihood of psychological distress, low self-esteem, and low life satisfaction, according to self-reported PA level and type of sport participation, stratified by gender and school level (junior vs senior high school).

Results: Fewer senior high school students participated in team sports compared to junior high school students (p<0.001). Physically active adolescents and participants in team sports had higher self-esteem and life satisfaction. A high PA level, compared to a low PA level, was associated with reduced odds of psychological distress among senior high school students (Odds ratio [OR] = 0.63, 95% confidence interval [CI] [0.46-0.86] for girls and OR = 0.46, 95% CI [0.27-0.79] for boys). Team sport participation was associated with reduced odds of psychological distress in senior high school girls.

Conclusion: A high PA level was favorably associated with various dimensions of mental health, especially for adolescents in senior high school. Team sport participation may have a positive impact on mental health and should therefore be encouraged.

Strengths and limitations of this study

- Large population-based sample of adolescents with a high participation rate.
- Comprehensive information about sport participation and validated measures of mental health across adolescent age groups.
- Stratified analysis that takes potential age and gender differences during adolescence into account, and adjustments for possible confounders including exposure to interpersonal violence (physical violence, bullying, sexual abuse).
- The main limitation of this study is the cross-sectional study design.
- Measures of PA were self-reported.

Introduction

Physical activity (PA) and psychological well-being are essential to healthy development and quality of life in adolescence [1-3]. Health behaviours, including the habit of engaging in regular PA, are often established during this period [4 5], paving the way for long-term health prospects.

Maintenance of PA throughout adolescence is of major importance in a public health perspective. Engaging in PA and sports during adolescence is associated with the development of lifelong PA [6-8] and psychological well-being [1 9]. Yet adolescents tend to be less physically active with increasing age [10]. The most dramatic decrease in PA is found to occur between the ages of 15 and 16, around the transition from junior to senior high school [11]. Although few adolescents are satisfying the recommended 60 minutes of moderate to vigorous PA per day worldwide [12 13], sport participation is found to be high in some population-based studies [6 14]. However, information about participation rates in various type of sports throughout adolescence is lacking.

Mental health problems are another major challenge among adolescents; currently the leading cause of health-related disability within this age group, affecting up to 20% of adolescents worldwide [15 16]. Prevalence rates of psychological distress, such as anxiety and depression, increase with age, especially from the mid-teens (14-16 years) [11 17]. Poor mental health also tends to carry over into adulthood [17 18], highlighting the importance of preventive efforts during adolescence. Currently the evidence indicates that PA may have a positive impact on anxiety, depression and self-esteem among adolescents, although our knowledge is limited [1]. Studies commonly assess these relationships without considering different developmental stages during adolescence. Further, the need for PA measures which account for various types of sports/activities has been emphasized [1]. No large population-based studies have evaluated PA levels and type of sport participation in relation to mental health among girls and boys in different adolescent age groups. Identification of these relationships could have implications for preventive

programs and may contribute to more accurate strategies for increasing engagement in PA and improving mental health among adolescents.

The aim of this study was to describe PA levels and the frequency of sport participation in a large population-based sample of adolescents stratified by age group (junior vs senior high school students) and gender. Further, to explore associations between PA level, type of sport participation, and mental health, including psychological distress, self-esteem, and life satisfaction, among boys and girls across adolescent age groups. As early adolescent stage versus mid-late adolescence is characterized by a major shift in psychosocial development tasks, where peer relationships become more salient [19 20], the social benefits of sports participation may be of greater importance with increasing age through adolescence. We therefore hypothesised that a high level of PA and participation in sports would be associated with lower levels of psychological distress, higher self-esteem, and greater life satisfaction, particularly among high school students and participants in team sports.

Methods

Study sample

From 2006-2008 all adolescent residents (age 13-19 years) of the Nord-Trøndelag county in Norway (N=10464) were invited to participate in the third wave of the population-based Nord-Trøndelag Health Study (Young-HUNT3). The attendees completed a comprehensive health-related questionnaire during school hours. Of those invited, 7716 (74%) adolescents responded to the questionnaire and attended a clinical examination. The response rate was 82% among junior high school students and 69% among senior high school students. Participants not enrolled in school (N=84) and participants ≥20 years of age (N=13) were excluded from the analyses in this study. Thus, the study sample comprised 7619 participants (73%) (Appendix), of whom 4615 (61%) went to junior high school. All participants in senior high school were ≥16 years old.

Exposure variables

Leisure time PA level was assessed by a validated question on frequency of PA from the World Health Organization Health Behavior in Schoolchildren (WHO HBSC) Survey Questionnaire [21 22]: Outside school hours: "How often do you usually exercise in your free time so much that you get out of breath or sweat?". The level of intensity during exercise where you breathe heavily and/or sweat refers to moderate to vigorous activity. Response alternatives were: every day, 4-6 days/week, 2-3 days/week, 1 day/week, less than every week, less than every month, and never. Responses were categorized into three levels of PA: ''Low PA'' (≤1 days/week) (reference group), ''moderate PA'' (2-3 days/week), and ''high PA'' (≥4 days/week).

Type and frequency of sport participation was assessed by the question: "How often have you participated in the following activities/sports in the last 12 months?"; endurance sports (e.g. cross-country skiing, swimming, running), team sports (e.g. soccer, volleyball, handball), strength sports (e.g. weightlifting, bodybuilding), technical sports (e.g. track and field, alpine

skiing, snowboard), aesthetic sports (e.g. dance, gymnastics), martial arts (e.g. judo, karate, boxing), extreme sports (e.g. rafting, rock climbing, paragliding), jogging/walking, and other. Four alternatives were given for describing the frequency of participation in each of the sport categories: never, less than once a week, once a week, several times a week. A frequency of "at least once a week" was defined as active participation. Furthermore, adolescents were classified by their participation in sports into team sports (e.g. soccer, volleyball, handball) or individual sports (all other sports). The reference group consisted of those with no or infrequent participation in all the sport categories, as well as those who reported a low level of PA. The groups were mutually exclusive. Responses to "jogging/walking" were not defined as separate sport activities/participation, as they may also be performed in non-sport contexts. The activity "jogging/walking" was, however, included in all exposure categories; "jogging/walking" at least once a week was reported among 61% of those participating in individual sports, among 71% of those participating in team sports, and among 33% of those with no/infrequent sport participation or low PA level.

Outcome variables - Mental health

Psychological distress was assessed using a validated short version of the Hopkins Symptom Check List (SCL-5) [23 24], including the phrases: "During the last 14 days: I have been constantly afraid and anxious; I have felt tense or uneasy; I have felt hopeless about the future; I have felt dejected or sad; I have worried too much about various things". Responses were scored according to four response alternatives ranging from "not at all bothered" (1) to "extremely bothered" (4). A mean score was calculated, and a cut-off for symptoms of anxiety and depression was set at a mean score above two [23]. The five-item version (SCL-5) has shown high correlation with the 25-item SCL-25 (r = 0.92) [24] and good internal consistency (Cronbach's alpha 0.87) [23].

Self-esteem/feelings of self-worth was measured using a short version of the Rosenberg Self-Esteem Scale (RSES) (original 10 items) [25], including four statements: "I have a positive attitude toward myself", "I feel rather useless at times", "I feel that I don't have much to be proud of", and "I feel that I am a valuable person, at least equal to other people". Response alternatives were measured on a 4-point scale ranging from ''I strongly agree'' (1) to ''I strongly disagree'' (4). For the first and last items the scores were inversed. A mean score was calculated (range 4-16), with higher scores indicating higher levels of self-esteem. A cut-off was set at a mean score of 10 (midpoint of the scale) to separate low and high self-esteem, corresponding to the recommended cut-off at 25 on the original 10-item RSES scale (range 10-40) [26]. The four-item version of the RSES is found to correlate at 0.95 with the full scale and to explain 0.90% of the full-scale variance, and has good internal consistency (Cronbach's alpha 0.80) [27].

Life satisfaction was measured with the question: "Thinking about your life at the moment, would you say that you by and large are satisfied with life, or are you mostly dissatisfied?" Response alternatives were measured on a 7-point scale ranging from "very satisfied" (1) to "very dissatisfied" (7), and were coded into a dichotomous outcome variable where adolescents who responded 1-3 were classified as "high life satisfaction", and those who responded 4-7 were classified as "low life satisfaction". A single-item life satisfaction measure is shown to perform almost as well as the multiple-item Satisfaction with Life Scale (SWLS) [28 29].

Potential confounders

Data on gender and age were obtained from the Norwegian National Population Registry. Socioeconomic status was based on participants' reports of perceived family economy. Pubertal development was assessed by self-reported pubertal status using the validated Pubertal Development Scale (PDS) [30]. Participants were asked to rate their own growth and to assess pubic hair growth. Further, boys were asked to assess changes in voice and facial hair growth, while

girls were asked about age at menarche and breast development. Pubertal changes were reported on scales ranging from 1 (has not begun) to 4 (development completed). Menarche was dichotomized into yes (coded 4) and no (coded 1). The items were summed up and an average PDS score was calculated.

Exposure to interpersonal violence was assessed with questions derived from The University of California at Los Angeles Post-traumatic Stress Disorder Reaction Index (UCLA PTSD Reaction Index) [31]: "Have you ever experienced any of these events?" (no or yes): 1) Been subjected to violence (beaten or injured), 2) Been subjected to unpleasant/disagreeable sexual acts by someone approximately your own age, 3) Been subjected to unpleasant/disagreeable sexual acts by an adult, and 4) Been threatened or physically harassed by fellow students at school over a period of time. Responses were categorized as "prior violence", "prior sexual abuse" (by peer or adult), and "prior bullying" [32].

Statistical analyses

Categorical variables were described with counts and percentages, and continuous variables with mean and standard deviation (SD). Possible associations between gender and age distribution were assessed with Chi-square tests.

The associations between 1) PA level and 2) type of sport participation and the mental health outcomes were evaluated using multiple logistic regression models. The results are expressed as odds ratios (OR) with 95% confidence intervals (CI). Analyses were stratified by gender and school level (junior and senior high school). To adjust for potential confounding, age, puberty development (PDS), socio-economic status, prior violence, sexual abuse (by peer or adult), and bullying were all included in the multiple models. All tests were two-sided, and the significance level was set to 5%. Analyses were performed using SPSS version 25 (SPSS Inc., Chicago, IL).

Due to missing data on pubertal development (PDS score) (13% in girls, 15% in boys), a model-based imputation for this variable was performed. Linear regression models stratified by gender were fitted with age and body mass index (BMI). Residuals for both models followed standard normal distribution and the model fit was very good. The missing values were replaced with the predicted values. The predicted variables and the original variables for both genders were highly correlated, r=0.75 and r=0.85 for boys and girls, respectively.

Ethics

The current study has been approved by the Regional Committee for Medical Research Ethics (2014/1228/REK Sør-Øst A). The Young-HUNT Studies have been approved by REK and the Data Inspectorate of Norway. Participation in the study was voluntary. Inclusion in Young-HUNT was based on written consent from participants 16 years of age or older, and from the parents of those under 16 years of age, in accordance with Norwegian law.

Patient and Public Involvement

When preparing for the Young-HUNT3 survey, the HUNT research centre appointed reference groups consisting of student representatives (13-19 years), as well as representatives from the county school authorities and county doctors. Content of the questionnaires, clinical examination, implementation of results and protection of privacy have been discussed with these representatives. Results from the current study have been presented and discussed with the Youth Panel for Research at the Research and Communication Unit for Musculoskeletal Health (FORMI), Oslo University Hospital. The HUNT research centre has an active information policy and publishes annual newsletters for participants as well as regular reports on the HUNT web-site (https://www.ntnu.no/hunt/om).

Results

Characteristics of the study sample

In total, 3785 boys and 3834 girls were included in the analyses. Characteristics of the study sample are summarized in Table 1. The mean age was 15.8 years (SD 1.7). About 10% reported living in families with an economy below average, and reports of exposure to interpersonal violence was higher among senior as compared to junior high school students, with physical violence being more common in boys, sexual violence more common in girls, and bullying more evenly distributed between the sexes. Girls reported more mental health problems than boys, with the highest levels of psychological distress found among girls in high school (Table 1).

Table 1 Characteristics of the study sample (n =7619)

	Girls (%)		Boys (%)	
Characteristics	**Junior high N = 2298**	**Senior high N = 1536**	**Junior high N = 2317**	**Senior high N = 1468**
Age, mean (SD)	14.6 (0.89)	17.6 (0.86)	14.6 (0.89)	17.5 (0.84)
Socioeconomic status; family economy, n (%)				
Above average	297 (12.9)	264 (17.2)	402 (17.4)	319 (21.7)
Average	1644 (71.5)	1077 (70.1)	1521 (65.6)	939 (64.0)
Below average	204 (8.9)	144 (9.4)	141 (6.1)	136 (9.3)
Missing	153 (6.7)	253 (10.9)	253 (10.9)	74 (5.0)
Puberty (PDS score), mean (SD)	2.90 (0.68)	3.49 (0.51)	2.56 (0.61)	3.34 (0.47)
Missing	10 (0.4)	5 (0.3)	-	1 (0.0)
Interpersonal violence, n (%)				
Physical violence	122 (5.3)	138 (9.0)	200 (8.6)	246 (16.8)
Missing	96 (4.2)	34 (2.2)	167 (7.2)	65 (4.4)
Sexual abuse	123 (5.4)	169 (11.0)	50 (2.2)	44 (3.0)
Missing	103 (4.5)	32 (2.1)	170 (7.3)	58 (4.0)
Bullying	140 (6.1)	129 (8.4)	183 (7.9)	117 (8.0)
Missing	107 (4.7)	32 (2.1)	170 (7.3)	58 (4.0)
Mental health outcomes				
Psychological distress (SCL5)*, n (%)				
SCL5 ≥2	350 (15.2)	362 (23.6)	111 (4.8)	110 (7.5)
SCL5 <2	1892 (82.3)	1138 (74.1)	2093 (90.3)	1302 (88.7)
Missing	56 (2.4)	36 (2.3)	113 (4.9)	56 (3.8)
Self-esteem (RSE)†, n (%)				
RSE <10	660 (28.7)	442 (28.8)	304 (13.1)	192 (13.1)
RSE ≥10	1499 (65.2)	1029 (67.0)	1847 (79.7)	1199 (81.7)
Missing	139 (6.0)	65 (4.2)	166 (7.2)	77 (5.2)
Life satisfaction, n (%)				
Low life satisfaction	722 (31.4)	469 (30.5)	373 (16.1)	223 (15.2)
High life satisfaction	1525 (66.4)	1050 (68.4)	1872 (80.8)	1212 (82.6)
Missing	51 (2.2)	17 (1.1)	72 (3.1)	33 (2.2)

PDS = Pubertal Development Scale
* Range 1-4, †Range 4-16

PA level and sport participation

More boys reported a high level of PA (45.2%) compared to girls (35.4%) ($p < .001$). For both genders, junior high school students reported significantly higher levels of PA than senior high school students (Table 2). Of the various sports, team sports were most commonly reported by both girls and boys, with almost two thirds of the adolescents participating in such sports at least once a week (Table 2). For both genders, participation in team and technical sports was less common among senior high school students as compared to junior high school students ($p < .001$). In contrast, a significantly higher proportion of both girls and boys in senior high school were engaged in strength sports compared to those in junior high school. Significantly, more girls than boys participated in aesthetic sports, while a higher proportion of boys participated in strength sports and extreme sports, in both age groups (Table 2).

Table 2 Physical activity (PA) level and sport participation rates in relation to gender and school level

	Girls (%)			Boys (%)		
	Junior high	**Senior high**	***p*-value**	**Junior high**	**Senior high**	***p*-value**
PA level						
High PA	38.4	32.4		46.5	43.8	
Moderate PA	39.9	34.3		33.1	28.0	
Low PA	20.2	31.6	**<0.001***	18.5	27.2	**<0.001***
Missing	1.5	1.6		1.9	1.0	
Sport participation (≥1 day/week)						
Team sports	**64.7**	**49.9**	**<0.001**	**65.8**	**56.7**	**<0.001**
Endurance sports	46.0	45.5	0.63	51.4	49.4	0.06
Aesthetic sports	25.9	27.3	0.43	6.0	5.2	0.25
Strength sports	**20.5**	**29.7**	**<0.001**	**33.8**	**47.6**	**<0.001**
Martial arts	3.5	4.4	0.17	7.6	7.6	0.85
Technical sports	**28.0**	**16.7**	**<0.001**	**26.8**	**20.8**	**<0.001**
Extreme sports	1.0	0.8	0.71	4.6	4.7	0.99

Bold: statistically significant, p<0.05, * chi-square test for trend
Low PA = ≤1 day/week, moderate PA = 2-3 days/week, high PA = ≥4 days/week).

PA and mental health

A high level of PA, compared to a low level of PA, was significantly associated with reduced odds of low self-esteem and low life satisfaction among all students (Table 3). In senior high school students, a high level of PA was significantly associated with reduced odds of psychological distress (OR = 0.63, 95% CI [0.46-0.86] for girls and OR = 0.46, 95% CI [0.27-0.79] for boys).

Sport participation and mental health

Participation in team sports, compared with no/infrequent sport participation, was significantly associated with reduced odds of low self-esteem for girls, both in junior high school (OR = 0.45, 95% [0.32-0.64]) and senior high school (OR = 0.57, 95% CI [0.39-0.84]). A similar non-significant trend was observed in boys (Table 4). Participation in individual sports was significantly associated with reduced odds of low self-esteem among senior high school boys (OR = 0.37, 95% CI [0.18-0.76]).

Participation in team sports was associated with reduced odds of low life satisfaction, among all girls and among junior high school boys (Table 4). Among girls in senior high school, team sport participation was also significantly associated with reduced odds of psychological distress (OR = 0.70, 95% CI [0.49 – 1.00]). In boys and junior high school girls, no statistically significant associations between sport participation and psychological distress were revealed in the adjusted models (Table 4).

Table 3 Associations between levels of physical activity and mental health problems (psychological distress, low self-esteem, and low life satisfaction) among girls and boys in junior and senior high school.

	Outcome			
	OR (OR, 95% CI) for psychological distress*			
	Junior high school		**Senior high school**	
Physical activity (PA) level	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]
Girls				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	0.80 (0.59 – 1.07)	0.86 (0.62 – 1.21)	**0.68 (0.51 – 0.90)**	**0.73 (0.54 – 0.99)**
High PA (≥4 d/w)	**0.67 (0.49 – 0.91)**	0.88 (0.63 – 1.24)	**0.53 (0.39 – 0.72)**	**0.63 (0.46 – 0.86)**
Boys				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	**0.54 (0.32 – 0.90)**	**0.56 (0.31 – 0.99)**	0.78 (0.49 – 1.23)	0.89 (0.53 – 1.49)
High PA (≥4 d/w)	**0.58 (0.56 – 0.91)**	0.70 (0.41 – 1.18)	**0.38 (0.23 – 0.62)**	**0.46 (0.27 – 0.79)**
	OR (OR, 95% CI) for low self-esteem (RSE)†			
Girls				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	**0.63 (0.48 – 0.82)**	**0.65 (0.49 – 0.87)**	**0.68 (0.30 – 0.93)**	**0.72 (0.52 – 0.99)**
High PA (≥4 d/w)	**0.53 (0.40 – 0.70)**	**0.59 (0.44 – 0.80)**	**0.43 (0.31 – 0.61)**	**0.49 (0.34 – 0.70)**
Boys				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	**0.37 (0.24 – 0.58)**	**0.32 (0.20 – 0.53)**	0.66 (0.38 – 1.15)	0.67 (0.37 – 1.20)
High PA (≥4 d/w)	**0.31 (0.20 – 0.48)**	**0.33 (0.21 – 0.52)**	**0.41 (0.24 – 0.71)**	**0.44 (0.25 – 0.79)**
	OR (OR, 95% CI) for low life satisfaction			
Girls				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	**0.60 (0.48 – 0.76)**	**0.59 (0.45 – 0.76)**	**0.66 (0.51 – 0.85)**	**0.68 (0.52 – 0.89)**
High PA (≥4 d/w)	**0.43 (0.34 – 0.55)**	**0.49 (0.37 – 0.63)**	**0.45 (0.34 – 0.59)**	**0.51 (0.38 – 0.69)**
Boys				
Low PA	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/w)	**0.67 (0.51 – 0.90)**	**0.65 (0.47 – 0.90)**	0.76 (0.53 – 1.08)	0.73 (0.50 – 1.08)
High PA (≥4 d/w)	**0.42 (0.32 – 0.56)**	**0.44 (0.32 – 0.60)**	**0.44 (0.31 – 0.62)**	**0.43 (0.30 – 0.63)**

OR = odds ratio, CI = confidence interval, Bold: statistically significant associations, $p<0.05$.
* SCL5 ≥2 (range 0-4), † RSE <10 (range 4-16)
[a] Adjusted for age, puberty score (PDS), socioeconomic status, prior physical violence, prior bullying, prior sexual abuse

Table 4 Associations between sport participation and mental health problems (psychological distress, low self-esteem, and low life satisfaction) among girls and boys in junior and senior high school.

	Outcome			
	OR (OR, 95% CI) for psychological distress*			
	Junior high school		Senior high school	
Sport participation	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]
Girls				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	1.06 (0.70 – 1.60)	1.09 (0.68 – 1.73)	0.87 (0.61 – 1.22)	0.93 (0.64 – 1.35)
Team sports	0.78 (0.53 – 1.14)	1.02 (0.66 – 1.56)	**0.56 (0.40 – 0.78)**	**0.70 (0.49 – 1.00)**
Boys				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	1.04 (0.56 – 1.95)	1.04 (0.52 – 2.09)	0.85 (0.49 – 1.49)	0.98 (0.51 – 1.88)
Team sports	**0.55 (0.31 – 0.99)**	0.60 (0.31 – 1.15)	**0.57 (0.34 – 0.96)**	0.93 (0.50 – 1.70)
	OR (OR, 95% CI) for low self-esteem†			
Girls				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	**0.52 (0.37 – 0.75)**	**0.55 (0.37 – 0.81)**	0.77 (0.53 – 1.11)	0.81 (0.55 – 1.20)
Team sports	**0.42 (0.30 – 0.57)**	**0.45 (0.32 – 0.64)**	**0.50 (0.35 – 0.71)**	**0.57 (0.39 – 0.84)**
Boys				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	1.11 (0.62 – 1.99)	1.43 (0.73 – 2.79)	**0.42 (0.22 – 0.82)**	**0.37 (0.18 – 0.76)**
Team sports	**0.53 (0.30 – 0.92)**	0.72 (0.38 – 1.36)	**0.47 (0.27 – 0.81)**	0.57 (0.32 – 1.03)
	OR (OR, 95% CI) for low life satisfaction			
Girls				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	**0.70 (0.51 – 0.96)**	0.71 (0.50 – 1.00)	**0.66 (0.48 – 0.91)**	**0.65 (0.46 – 0.91)**
Team sports	**0.46 (0.34 – 0.61)**	**0.51 (0.37 – 0.70)**	**0.48 (0.36 – 0.65)**	**0.55 (0.40 – 0.76)**
Boys				
No sport	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Individual sports	1.00 (0.68 – 1.46)	0.99 (0.65 – 1.52)	0.84 (0.55 – 1.29)	0.80 (0.50 – 1.28)
Team sports	**0.56 (0.39 – 0.79)**	**0.63 (0.43 – 0.93)**	**0.62 (0.42 – 0.92)**	0.72 (0.47 – 1.12)

OR = odds ratio, CI = confidence interval, Bold: statistically significant associations, $p<0.05$.
* SCL5 ≥ 2 (range 0-4), † RSE <10 (range 4-16)
[a] Adjusted for age, puberty score (PDS), socioeconomic status, prior physical violence, prior bullying, prior sexual abuse

Discussion

In this population-based sample of adolescents, PA levels and participation rates in sports were lower among girls, and lower among senior high school students compared to junior high school students. Our results showed that higher levels of PA were favourably associated with self-esteem and life satisfaction throughout adolescence, as well as with reduced likelihood of psychological distress in senior high school students. Further, team sport participation was associated with mental health benefits, especially for girls.

Strengths and limitations

The main strengths of our study include the large sample size of adolescents from an unselected general population, a high participation rate (73%), and the information including frequency of participation in sports. To our knowledge, such comprehensive information about sport participation in relation to gender and age differences has not previously been presented. This information enabled us to examine the relationship between sport participation and mental health outcomes, including the aspect of various types of sports, in contrast to most studies on this topic which mainly focus on general PA. We used validated measures of mental health outcomes. Another strength is that we were able to adjust for a variety of possible confounders, as well as including exposures to interpersonal violence as these exposures may have an impact on both PA behaviours and mental health [33-35].

The main limitation of this study is the cross-sectional study design, and the resultant inability to demonstrate the direction of the association. Further, as measures were self-reported, the included variables are susceptible to information bias. We have used a single item measure to assess PA, and the variable used to describe sport participation exposure provides a crude measure of frequency of participation. However, the WHO HBSC question of PA used in this

study has been found to hold acceptable reliability and validity in adolescent samples [21 22]. It should be noted that a proportion of the "High PA" group in this study may not fulfil the recommended levels of daily PA according to the WHO guidelines [36], as this group includes all those who played sports or exercised at least 4 days/week. Although measures of psychological distress (SCL-5) and self-esteem (RSES) were shortened versions of the original instruments, the measurement precision of these versions is found to be high and sufficient for use in population-based studies [23 24 27]. Furthermore, dichotomization of the mental health outcomes makes them prone to misclassification. However, the cut-off values to distinguish those with high vs low degree of psychological distress (SCL-5) and low self-esteem (RSES) have both been shown to be clinically relevant cut-points [23 26]. In contrast to psychological distress, low self-esteem and low life satisfaction were not more prevalent in the older age group, reflecting the measurement of different phenomena. Psychological distress is found to function as a proxy measure of symptoms of anxiety and depression [23 24], while self-esteem and life satisfaction are more closely related to subjective well-being [28 37] which may be more stable traits.

Although the response rate in Young-HUNT3 was high, the lower response among senior high school students compared to junior high school students may represent a selection bias. In Norway, most adolescents start senior high school the year they turn 16. Differences in school systems in other countries, as well as differences related to opportunities for engagement in sports and the organization of various youth sports may limit the generalizability of the results from this study. Norwegian society is rooted in egalitarian ideals, with "Sport for All" as a high priority and policy aim [38]; this may be part of the reason why sport participation found in this study is high by international standards. Lastly, the results of this study should be interpreted with caution due to multiple testing, and replication of results is warranted.

Our results according to previous findings, and interpretation of findings

The findings from this study confirmed the gender differences in PA levels found in other population-based studies, with girls being less physically active than boys [11-13]. Also in line with reports from other studies, fewer girls were involved in sports [7 13 14 39]. The lower levels of PA and sport participation found among senior high school students confirms findings from previous studies reporting a decline in PA during adolescence [10 11 40 41], especially between the ages of 15 and 16 years [11]. Drop-out from sports for adolescents at this age may be related, in part, to the difficulty of meeting the increasing demands of participation in both school and sport [7 42]. However, a systematic review of factors associated with drop-out from organized sports, reported that lack of enjoyment and perceptions of competence are the two most dominant factors related to drop-out from sports among adolescents [42].

The current findings are in line with previous studies reporting associations between adolescents' PA and mental health, including lower likelihood of depressive symptoms [1 11 13 43 44], as well as greater well-being [13] and higher self-esteem among those who are physically active [1 44]. Longitudinal studies also indicate that PA may protect against the development of depression [45 46]. Furthermore, PA may be a helpful intervention for adolescents struggling with depressive symptoms [47 48]. Regarding engagement in sports, the results of the present study are in accordance with the literature indicating a positive relationship between sport participation and mental health [9 13 49-51].

The findings from this study make several contributions to the body of research on the impact of PA and sports on mental health among adolescents. Firstly, age differences were revealed in these relationships, as a high PA level was associated with reduced psychological distress in high school students only. Explanations for why PA and sport participation may be of greater importance in reducing psychological distress among older adolescents could relate to how peer support and interaction play an increasingly important role during adolescence [19 20.

Thus, social and physical activities with peers may be particularly beneficial for older adolescents, helping to distract them from depressive thoughts and to reduce the sense of isolation.

Secondly, this study shows that the potential beneficial effects related to mental health vary across various types of sport. Participation in team sports, compared to no participation, was more strongly related to beneficial mental health outcomes than individual sports compared to no participation, especially in high school girls. Other studies have reported that organized sports had a greater impact on depressive symptoms among girls than boys [11], and that team sports may confer mental health benefits for girls in particular [13]. A systematic review of the psychological and social benefits of sport participation argued that team sports seem to be associated with more beneficial outcomes compared to individual sports due to the social aspect of being part of a team [9]. In a recent study of a large representative sample of European adolescents, lower levels of anxiety and depression and higher levels of well-being were found among team sport participants [13]. Team sport participation during adolescence has also been shown to be associated with lower levels of depressive symptoms in early adulthood [50 52]. In line with this, our findings highlight that type of sport, including the social aspect of participation, should be considered when examining the impact of sports on mental health among adolescents.

Overall, adolescents with a high PA and team sport participation had lower odds of having low self-esteem than of having psychological distress. These results are in accordance with findings from a review study showing that, of the several mental health outcomes associated with PA in young people, the strongest association was with self-esteem [1]. It may be that experiences of low self-esteem occur earlier than symptoms of anxiety and depression and that low self-esteem may trigger poor coping behavior and risk behavior that subsequently increases the likelihood of mental disorders [53]. A Cochrane review reports that exercise interventions have

positive short-term effects on self-esteem that may help prevent the development of psychological and behavioral problems [54].

This study contributes to our understanding of the implications lower levels of PA may have on mental health in different phases of adolescence. Regardless of the direction of the association between PA and mental health, inactive adolescents may carry a "double health burden", with both physical and mental health challenges. To help more adolescents increase or maintain their levels of PA, interventions could include facilitation of a wider variety of sports activities, and at different skill levels, to reach and engage more adolescents. As lack of enjoyment has previously been found to be the most dominant factor related to drop-out from sports [40], increased focus on the joy of sports may be important in order to reduce drop-out rates during adolescence. In efforts to reduce mental health problems, our results suggest that girls in particular should be a target group for promotion of team sport participation.

Conclusion and implications

This study identified gender and age differences in PA and sport participation across adolescent age-groups, with the lowest engagement in PA and sports found among girls in senior high school. Our results indicate that a high PA level and sport participation have a positive impact on various dimensions of mental health throughout adolescence, highlighting the importance of continuing with sports in the late teens. The findings underline a need for interventions aimed at maintaining or increasing PA and sport participation, especially for girls around the transition to senior high school. Initiatives to help adolescents continue in team sports may be particularly advantageous. Future studies should examine the effect of interventions for encouraging and increasing PA and sport participation among adolescents, as well as their potential mental health benefits.

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Patient consent: Not required.

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Data sharing statement: The data set analysed belongs to a third party, the Nord-Trøndelag Health Study (HUNT Study). The authors of the current manuscript have been given permission to analyse the data after obtaining the necessary Norwegian permits. Research groups that wish to analyse data from the HUNT study may apply to the HUNT organization to get access to the data

(https://www.ntnu.no/hunt/datatilgang). HUNT databank online provides a complete overview of the research variables, as well as metadata (https://hunt-db.medisin.ntnu.no/hunt-db/#/survey/YH3). The general health questionnaire used in the study is accessible from the HUNT Bio-And-Databank (http://www.ntnu.edu/hunt/data/que).

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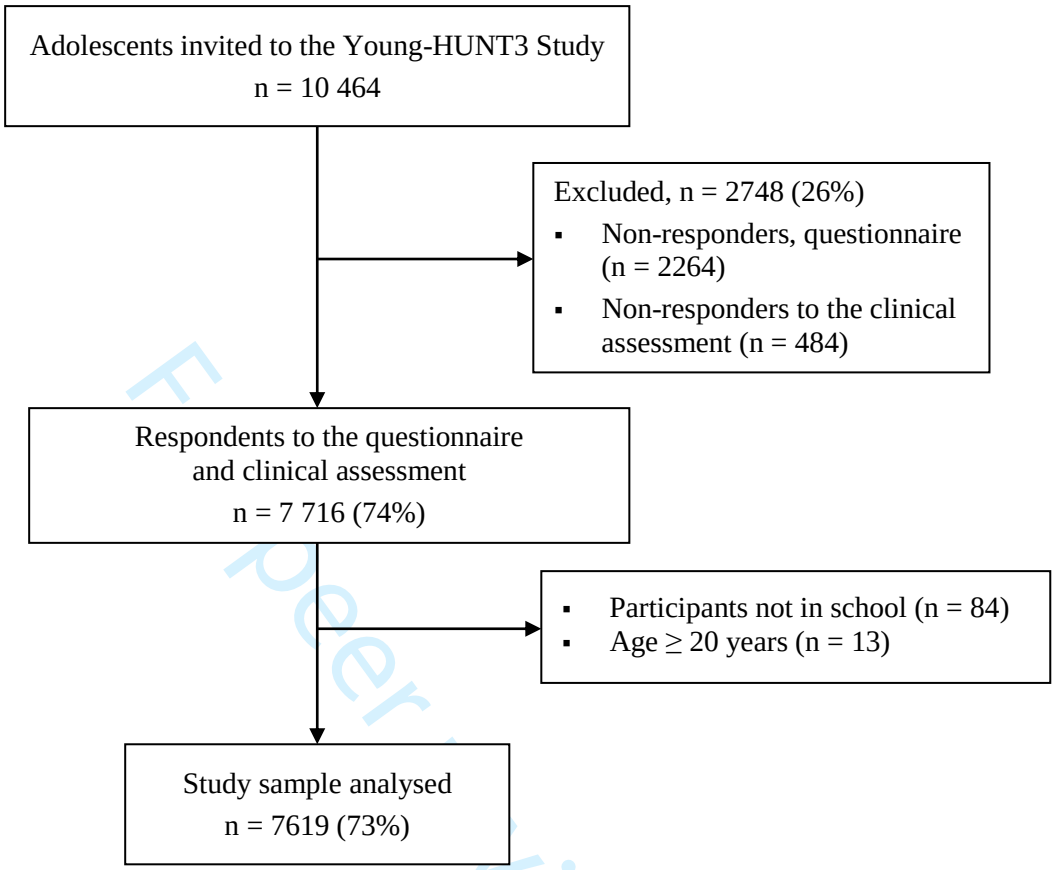
Appendix. Flow chart of the study sample.



STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	2, 6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-9
Bias	9	Describe any efforts to address potential sources of bias	8-9
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6, Appendix
		(b) Give reasons for non-participation at each stage	6, Appendix
		(c) Consider use of a flow diagram	Appendix
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-12
		(b) Indicate number of participants with missing data for each variable of interest	12
Outcome data	15*	Report numbers of outcome events or summary measures	13, 15
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	16-17
		(*b*) Report category boundaries when continuous variables were categorized	16-17
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18-19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	20-22
Generalisability	21	Discuss the generalisability (external validity) of the study results	19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	27

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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