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Relationship between health-related quality of life and physical fitness in Norwegian adolescents

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Abstract

Aims This cross-sectional study investigated the association between health-related quality of life (HRQoL), cardiorespiratory fitness (CRF) and muscular fitness in 14-year-old adolescents.

Methods Norwegian adolescents ($N = 1985$) carried out a 10-min running test to assess cardiorespiratory fitness and three different muscular fitness tests (handgrip, sit-ups, and standing broad jump) and answered the KIDSCREEN-27 questionnaire to provide HRQoL data. Linear-mixed effect models were applied to detect relationships among the variables.

Results Running-test results were positively associated with higher scores in the following KIDSCREEN domains: physical well-being, psychological well-being, autonomy and parent relationships, and school environment ($\beta = 0.01$–0.04; $p < .01$ for all). Performance in sit-ups test was positively associated with higher scores in three out of five KIDSCREEN domains: physical well-being ($\beta = 0.31$; $p < .001$), social support and peers ($\beta = 0.16$; $p = .023$), and school environment scores ($\beta = 0.19$; $p = .006$). An inverse association was found between the handgrip test results and the score on psychological well-being domain ($\beta = -0.10$; $p = .013$).

Conclusions The associations between HRQoL and physical fitness were trivial (abdominal strength and handgrip strength) to small (CRF) but confirmed that earlier findings from children also are applied to adolescents. Explosive strength in the lower body showed no association with HRQoL. Further research should investigate the direction of causality.

Trial registration Clinicaltrials.gov ID nr: NCT03817047. Registered 01/25/2019 'retrospectively registered'.

Keywords Youth · KIDSCREEN-27 · Cardiorespiratory fitness · Muscular fitness

Abbreviations

HRQoL	Health-related quality of life
PA	Physical activity
CRF	Cardiorespiratory fitness
SES	Socio-economic status
BMI	Body mass index

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Background

Quality of life is a broad ranging concept covering individuals` physical health, psychological state, level of independence, social relationships, personal beliefs, and their relationships to salient features of the environment [1]. Health-related quality of life (HRQoL) is one of several indicators of mental health and includes the subjective experience and opinion of one's own health status and lifestyle [2]. HRQoL among today's youth can be determined by their goals, expectations, norms, and concerns about their socio-economic status, as well as friends, family life, and school [2].

Previous studies indicate that children generally have better HRQoL than adolescents [3]. While boys and girls have similar HRQoL at a young age, girls' HRQoL declines more than boys' with increasing age, depending on the HRQoL domain [3]. Increased body weight also appears to negatively impact the overall HRQoL among children and

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adolescents, where physical and social functioning seem to be most affected [4].

Physical activity (PA) history together with individual characteristics, such as gender, age, weight status, physical fitness, and the constant intention to gain or maintain well-being, can facilitate or limit the changes in the quality of life of children and adolescents in a complex and dynamic way [5]. While the association between PA and HRQoL among healthy children and adolescents is well documented [6], as well as in obese populations [7], there is a gap of evidence when it comes to the association between physical fitness and HRQoL. Furthermore, considering the week-to-week variation of PA levels, physical fitness is of particular interest, as it represents the type, duration, intensity and frequency of PA that occurs over time [8].

Physical fitness is the capacity to perform PA and refers to a full range of physiological and psychological qualities [9], in which components such as cardiorespiratory fitness (CRF) and muscular fitness (MF) refer to health-related fitness. Physical fitness is in part genetically determined but can also be greatly influenced by environmental and behavioral factors [10]. Physical fitness, and particularly CRF, has been found to be a useful health marker in adolescence, as CRF has been positively associated with the ideal cardiovascular health profile in European adolescents [11]. Furthermore, Smith et al. [12] have found a positive association between MF, bone health and self-esteem, and an inverse association between MF, adiposity and cardiovascular disease, and metabolic risk factors among school-aged youth (4–19 years). To the best of our knowledge, there is no other study targeting the relationship between the overmentioned health markers and how adolescents perceive their own health status. Consequently, the examination of the relationship between physical fitness and HRQoL is needed from a health promotion point of view.

Earlier research among Spanish school children aged 8–11 years has reported a positive association between MF and HRQoL in boys, and CRF and HRQoL in girls [13]. Similarly, CRF in Norwegian 10-year-old children has been strongly, positively associated with all aspects of HRQoL [14]. The effect size for the associations between CRF and physical well-being was small to moderate for several HRQoL domains, such as psychological well-being, and autonomy and parents, while the association for social support and peers, and school environment domains were trivial [14]. Although an association between CRF and HRQoL was found among overweight adolescents [15], further research is needed with healthy adolescents as a target group. The study by Andersen et al. [14] shows that besides CRF, other variables such as explosive strength in the lower body, PA, abdominal adiposity, and handgrip strength correlate with domains of HRQoL. There is a knowledge gap when it comes to studies investigating the association between physical fitness and HRQoL among adolescents [10], especially in the general population. The main purpose of the present study was, therefore, to examine the association between CRF, MF, and HRQoL in 14-year-old adolescents in Norway.

Methods

Design and participants

The present study was part of a cluster-randomized controlled trial called School in Motion [16]. One hundred and three schools from four regions across southern Norway were asked to participate, of which 30 schools agreed. A total of 2733 8th graders were invited and 76% of these 13–14 years old adolescents agreed to participate and returned the written informed consent signed by the parents. The study used cross-sectional analysis of the baseline data from 1985 participants (Fig. 1).

Data collection was carried out during school hours in the school gymnasium and classroom and was conducted by trained test leaders following a given test protocol. The project was approved by the Norwegian Centre of Research Data and registered at clinicaltrials.gov with ID nr: NCT03817047.

Measurements

Health-related quality of life

HRQoL was measured by the KIDSCREEN-27 questionnaire [17], which contains 27 questions within five domains: physical well-being (5 items); psychological well-being (7 items); autonomy and parents (7 items); social support and peers (4 items); and school environment (4 items). Following standardized information about the procedure, the adolescents answered the questions on the KIDSCREEN-27 using a five-point Likert scale, which indicated either the frequency or intensity of a behavior or feeling. The questionnaire contains items such as *"Thinking about the last week… have you felt fit and well*, or *have your parents treated you fairly?"*. Test leaders were available to answer questions from the participants, if they had trouble understanding any of the questions. We used the methodology described in the developers' manual to obtain the T-scores, where mean ± standard deviation (SD) scores of 50 ± 10 define normality for children and adolescents aged 8–18 years across Europe [17]. A higher score indicates better HRQoL. Differences in HRQoL scores not higher than 2.0 points were considered trivial, 2.0–4.9 points considered small, 5.0–7.9 points considered moderate, and 8 points and over were considered to be large [17]. The KIDSCREEN-27 showed good

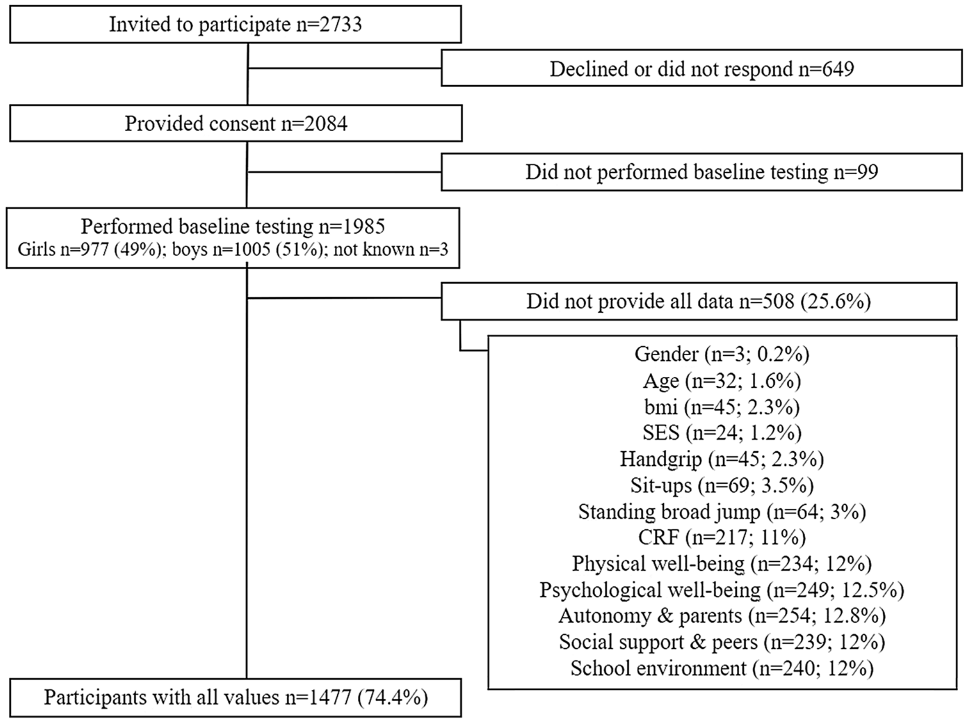

Fig. 1 Flow chart of recruitment and participation

psychometric properties for children and adolescents from 13 European countries [17], and for Norwegian children aged 10 using the Norwegian version [18].

Physical fitness

Cardiorespiratory fitness was assessed using an intermittent running field test [19]. According to the study of Andersen et al. [19], the association between performed distance in the intermittent running test and VO_2max measured on the treadmill have shown a correlation coefficient 0.60 among 14-year-old elite football players, while the reproducibility of the test has been considered good ($r = 0.84$). The adolescents ran back and forth between two lines 16 m apart, touching the floor behind the line in every turn. After 15 s, the test leader blew a whistle and the adolescents rested for 15 s before they once more ran for 15 s. This procedure lasted 10 min. An experienced test team counted the running distance, which was the outcome measure. The distance in meters was used as a proxy for CRF.

Muscular fitness was measured by three reliable and validated tests from the Eurofit test battery [20]. A hand dynamometer (Baseline Hydraulic Hand Dynamometer, Elmsford, NY, USA) measured upper body muscular strength (handgrip strength) in kilograms with the dominant hand [21]. Standing broad jump measures explosive strength in the lower body [21]. The jump was performed by standing behind a line with feet slightly apart and then jumping as far as possible by taking off with both feet and landing on both feet. The best of two jumps was registered in cm. Sit-ups test, mirroring adolescents' abdominal muscular endurance [20], measured by the number of the sit-ups completed within 30 s.

Anthropometry

Adolescents' weight was measured to the nearest 0.1 kg by a digital weight with external display (Seca 899, Hamburg, Germany). Height was measured to the nearest 1 cm by a portable stadiometer (Seca 123, Hamburg, Germany). The formula, weight (kg)/height (m^2) was used to calculate body mass index (BMI). Trained test leaders of the same gender as the adolescent conducted the measurements.

Socio-economic status

The adolescents' socio-economic status (SES) was based on parents' educational details registered at Statistics Norway. Education level was divided into four different levels (1: primary school, 2: upper secondary school, 3: university college /university ≤ 4 years, 4: university college /university > 4 years). Data from the parent or guardian with the highest education were used.

Statistical analysis

Statistical analyses were carried out using IBM SPSS Statistics 26 (IBM, Armnok, New York, USA).

Preliminary analysis

Descriptive data are presented as frequencies, mean, and SD where appropriate. Preliminary analyses included One-way ANOVA analysis between girls and boys, as well as among students with different SES background (see Online Appendix 3. for more details). Analyses detecting interaction effects, gender*physical fitness tests*KIDSCREEN domains showed only one out of twenty potential interactions as significant (see Online Appendix 1. for more details). Therefore, subsequent analyses included both genders together, while gender was included as covariate.

Main analysis

Linear-mixed effect models were first applied to detect the relationship between HRQoL, CRF, and muscular fitness on the complete-case group. School was included as random effect. In the Crude models, we entered KIDSCREEN domains as dependent variables, physical fitness tests as independent variables, and we adjusted for gender. In the subsequent fully adjusted model, we adjusted for gender, age, BMI, SES, and the other physical fitness variables (handgrip, sit-ups, standing broad jump, running test). We considered a p value of less than 0.05 as statistically significant.

Missing-value analysis

Out of 1985 participants, 25.6% ($n=508$; girls = 45%) had at least one missing value. We used chi-square test and one-way ANOVA to examine potential differences between participants with all values, called complete-case group ($n=1477$) and participants with missing values, called missing-value group ($n=508$). We used Little's MCAR test to assess whether missing values were missing completely at random (MCAR). The analysis did not support MCAR (590.512, DF = 362, $p<0.001$). Pattern analysis indicated likelihood that the data were missing at random (MAR). Our pattern showed a lot of missing data from the KIDCSREEN questionnaire. A potential explanation could be that the KIDSCREEN-27 was one part of an extensive questionnaire. Because of the size and the duration of the questionnaire, several participants may have quit before completion. The running test (CRF) also showed large portions of missing data. This was partly caused by participants who, for unknown reasons, did not want to perform the test. Moreover, data collection occurred during school time, and participants who were absent on the day of data collection (due to sickness, family reasons etc.), are missing physical fitness data. There may also be other reasons behind the missing data that are unknown to us. As a final measure to handle the missing data, we conducted multiple imputation on the dataset. In this procedure, five imputations were generated based on the scan of data regarding relevant variables (age, BMI, handgrip, sit-ups, standing broad jump, CRF, physical well-being T-score, psychological well-being T-score, autonomy and parents T-score, social support and peers T-score, school environment T-score). After multiple imputation, linear-mixed effect models were conducted on the pooled dataset again. A step-by step description of the missing-data handling can be found in Online Appendix 2.

Results

Descriptive results regarding the complete-case group and the missing-value group are presented in Table 1. There were significantly more boys ($n=279$), than girls ($n=226$) with missing data ($\chi 2=5.59$, $p<0.05$). For the variables BMI, sit-ups test and the social support and peers domain of KIDSCREEN, there were no significant differences between the missing-data group and complete-case group. The missing-value group performed 3% better (28 m) on the running test; performed 7% (2 kg) poorer on the handgrip test; and performed 2% (3.5 cm) poorer on the standing broad jump test, than the complete-case group. The complete-case group scored significantly higher on physical well-being, psychological well-being, autonomy and parents, and school environment domains, compared to the missing-data group ($p<0.05$ for all). Effect sizes are considered small, as Cohen's d values ranged from 0.04 to 0.30.

Table 2 shows the association between KIDSCREEN-27 scores, muscular fitness, and CRF. In the Crude analysis, we found significant positive associations between physical well-being and all of the physical fitness tests: handgrip strength (Coefficient (β) = 0.13, 95% confidence interval (CI) 0.06, 0.21; $p<0.001$); sit-ups ($\beta=0.78$, 95% CI 0.66, 0.90; $p<0.001$); standing broad jump ($\beta=0.11$, 95% CI 0.09, 0.13; $p<0.001$); and running distance ($\beta=0.05$, 95% CI 0.04, 0.05; $p<0.001$). When we adjusted for gender, age, SES, BMI, and the other physical fitness variables in the analysis, all associations were attenuated and only the association between physical well-being and sit-ups ($\beta=0.31$, 95% CI 0.18, 0.45; $p<0.001$), as well as running distance ($\beta=0.04$, 95% CI 0.03, 0.04; $p<0.001$) were still significant.

The second domain of KIDSCREEN-27, psychological well-being showed significant positive association with three out of four physical fitness variables after adjusting only for gender; sit-ups ($\beta=0.18$, 95% CI 0.06, 0.29; $p=0.002$); standing broad jump ($\beta=0.03$, 95% CI 0.01, 0.04; $p=0.004$); and the running distance ($\beta=0.01$, 95% CI 0.007, 0.02; $p<0.001$). The inverse association between psychological well-being and handgrip strength appeared to be strengthened from the Crude analysis to Model 1 ($\beta=-0.10$, 95% IC -0.18, − 0.02; $p=0.013$). Two associations turned

Table 1 Background characteristics, baseline physical fitness values, and KIDSCREEN domains' score for participants in the complete-case and the missing-value group

	Complete-case group ($n=1477$)	Missing-value group ($n=254$–484)
Background characteristics		
Gender	Girls $n=751$ (51%)	Girls $n=226$ (45%)*
Body Mass Index[a]	19.90 (±3.13)	20.03±3.31
Socio-economic status		
Lower secondary school or less	$n=82$ (5%)	$n=38$ (8%)
High school	$n=423$ (29%)	$n=148$ (31%)
Less than 4 years university education	$n=619$ (42%)	$n=201$ (41%)
4 years or more university education	$n=353$ (24%)	$n=97$ (20%)
Physical fitness[a]		
Handgrip strength (kg)**	30.56 (±7.00)	28.45 (±7.32)
Sit-ups (reps/30 s)	18.88 (±4.14)	19.31 (±4.02)
Standing broad jump (cm)**	172.19 (±26.00)	168.80 (±26.55)
Running distance (m)**	905.43 (±98.51)	933.96 (±112.69)
KIDSCREEN-27 domains (*T*-score)[a]		
Physical well-being**	46.11 (±9.54)	44.86 (±10.19)
Psychological well-being**	48.65 (±8.81)	47.12 (±9.76)
Autonomy & parents**	52.22 (±9.32)	50.72 (±9.80)
Social support & peers	49.21 (±8.78)	48.19 (±9.51)
School environment**	48.86 (±9.06)	47.02 (±9.49)

Values are reported as frequencies with percentage (%) and means with standard deviations (±SD)

[a]Cohen's d = 0.04–0.30

*Significant more boys, than girls with missing data ($\chi 2=5.59$, $p<.05$)

**Significant difference between complete-case group and missing-value group

up to be not significant in the fully adjusted model, while the association between psychological well-being and running distance was slightly attenuated ($\beta=0.01$, 95% IC 0.004, 0.02; $p=0.002$).

The autonomy and parents domain showed positive associations with the number of sit-ups ($\beta=0.17$, 95% IC 0.04, 0.29, p = 0.008) and running distance ($\beta=0.009$, 95% IC 0.004, 0.01; $p<0.001$). After adjustments in Model 1, the association between autonomy and parents and running distance was still significant ($\beta=0.01$, 95% IC 0.003, 0.02; $p=0.006$).

In the Crude analysis, we found a positive association between social support & peers and two physical fitness components; sit-ups ($\beta=0.19$, 95% IC 0.07, 0.30; $p=0.001$), running distance ($\beta=0.007$; 95% IC 0.002, 0.01; $p=0.006$). All these associations were attenuated in Model 1, where only the association between social support and peers and sit-ups remained significant ($\beta=0.16$, 95% IC 0.02, 0.29; $p=0.023$).

The school environment domain of KIDSCREEN-27 showed positive associations with the number of sit-ups ($\beta=0.32$, 95% IC 0.20, 0.44; $p<0.001$), standing broad jump ($\beta=0.02$, 95% IC 0.004, 0.04; $p=0.018$), and running distance ($\beta=0.01$, 95% IC 0.01, 0.02; $p<0.001$) in the Crude analysis. When adjusting for gender, age, SES, BMI, and the other physical fitness variables in the Model 1, the association became non-significant for standing broad jump. Associations slightly attenuated between school environment and sit-ups ($\beta=0.19$, 95% IC 0.06, 0.33; $p=0.006$) and between school environment and running distance ($\beta=0.01$, 95% IC 0.005, 0.02; $p=0.001$).

Discussion

The purpose of this study was to examine how HRQoL was associated with CRF and muscular fitness in 14-year-old Norwegian adolescents. The main findings were that higher scores for physical and psychological well-being, autonomy and parents, and school environment were associated with longer running distance. In addition, higher score for the physical well-being, social support and peers, and school environment domains were associated with better results in sit-ups, while a lower score for the psychological well-being domain was associated with greater handgrip strength.

Cardiorespiratory fitness and HRQoL

The present findings indicated that adolescents with high CRF were likely to report their own health status

Table 2 Linear mixed models with the KIDSCREEN-27 scores as the dependent variables in the complete-case group ($N = 1477$)

	Crude Coefficient (95% CI)	*p* value	Model 1 Coefficient (95% CI)	*p* value
Physical Well-Being				
Handgrip strength	0.13 (0.06, 0.21)	**< 0.001**	0.004 (− 0.08, 0.08)	0.933
Sit-ups	0.78 (0.66, 0.90)	**< 0.001**	0.31 (0.18, 0.45)	**< 0.001**
Standing broad jump	0.11 (0.09, 0.13)	**< 0.001**	0.01 (− 0.01, 0.04)	0.289
Running distance	0.05 (0.04, 0.05)	**< 0.001**	0.04 (0.03, 0.04)	**< 0.001**
Psychological Well-Being				
Handgrip strength	− 0.05 (− 0.12, 0.01)	0.122	− 0.10 (− 0.18, − 0.02)	**0.013**
Sit-ups	0.18 (0.06, 0.29)	**0.002**	0.05 (− 0.08, 0.19)	0.429
Standing broad jump	0.03 (0.01, 0.04)	**0.004**	0.01 (− 0.01, 0.04)	0.241
Running distance	0.01 (0.007, 0.02)	**< 0.001**	0.01 (0.004, 0.02)	**0.002**
Autonomy & Parents				
Handgrip strength	0.02 (− 0.05, 0.09)	0.643	0.02 (− 0.07, 0.11)	0.637
Sit-ups	0.17 (0.04, 0.29)	**0.008**	0.10 (− 0.05, 0.24)	0.187
Standing broad jump	0.01 (− 0.01, 0.03)	0.387	− 0.02 (− 0.05, 0.006)	0.137
Running distance	0.009 (0.004, 0.01)	**< 0.001**	0.01 (0.003, 0.02)	**0.006**
Social support & peers				
Handgrip strength	0.01 (− 0.06, 0.08)	0.733	− 0.04 (− 0.12, 0.05)	0.397
Sit-ups	0.19 (0.07, 0.30)	**0.001**	0.16 (0.02, 0.29)	**0.023**
Standing broad jump	0.02 (− 0.002, 0.04)	0.077	0.004 (− 0.02, 0.03)	0.742
Running distance	0.007 (0.002, 0.01)	**0.006**	0.005 (− 0.001, 0.01)	0.108
School Environment				
Handgrip strength	− 0.02 (− 0.08, 0.05)	0.665	− 0.06 (− 0.14, 0.03)	0.188
Sit-ups	0.32 (0.20, 0.44)	**< 0.001**	0.19 (0.06, 0.33)	**0.006**
Standing broad jump	0.02 (0.004, 0.04)	**0.018**	− 0.008 (− 0.03, 0.02)	0.518
Running distance	0.015 (0.01, 0.02)	**< 0.001**	0.01 (0.005, 0.02)	**0.001**

Note: *CI* confidence interval. School was included as random effect. Sign. value written with bold letter

Crude: adjusted for gender

Model 1: adjusted for gender, age, SES, BMI, and the other physical fitness variables in the table

as energetic, healthy, happy, and emotionally balanced. The fully adjusted model showed that a distance increase of 100 m in the running test is associated with a 4-point increase (small difference [22]) in physical well-being and one point increase (trivial difference [22]), in psychological well-being, autonomy and parents, and school environment. High-intensity PA is an important factor for high CRF [23], and the ability to work with relatively high intensity over time (i.e., high CRF) may induce adolescents' HRQoL positively, since they may able to better dispose the energy use among different duties as leisure time and peer activities, family chores, and schoolwork [10].

The present results are in line with previous findings by Andersen et al. [14] and Morales et al. [13]. In the present study, higher score in four out of five HRQoL domains was associated with higher CRF. In the study by Andersen et al. [14], all HRQoL domains were associated with CRF in both genders, while in the study by Morales et al. [13], eight out of 10 HRQoL domains were associated with CRF among girls only. Due to the changes in CRF from childhood to adolescence [24], the age differences could be a limitation of this comparison. Similarly, Riiser et al. [15] have captured the contribution of CRF on overall HRQoL among adolescents. However, these results and the present study are somewhat difficult to compare because of the different HRQoL measures and that Riiser et al. [15] studied an overweight and obese population. The results of the present study, therefore, complement the knowledge about the association between CRF and HRQoL in a healthy adolescent population.

Muscular fitness and HRQoL

The present findings showed that adolescents with low performance in sit-ups likely to report that they felt physically unwell, had low energy, felt disliked in peer groups and had negative feelings about school. Specifically, one-repetition increase in sit-ups within 30 s was associated with 0.3 point higher score in physical well-being, 0.16 point higher in social support and peers, and 0.19 point higher in school environment. One kg higher press in handgrip strength test was associated with 0.1 point lower score in psychological well-being. These are all considered to be trivial differences [22]. The applied muscular fitness measures show the ability to apply adequate muscle activity in different way such as strength (handgrip), endurance (sit-ups), and power (standing board jump). All these aspects of health-related fitness are essential in controlling motor tasks [25], which further may be important for a well-functioning embedded motor behavior in everyday life.

Due to different physical fitness tests and statistical procedures, the comparison with previous research regarding the association between HRQoL domains and muscular fitness is challenging. The study by Morales et al. [13] used an age- and gender-related muscular fitness index calculated as the sum of the standardized scores of handgrip strength test/weight and standing broad jump test. The Spanish study concluded that muscular fitness is a component of physical fitness that has a greater impact on the HRQoL of boys than of girls. Another study from Finland [26] also calculated a composite score from several physical fitness tests, such as bicycle ergometer test, grip strength, push-ups, sit-ups, and repeated squats. They concluded that higher physical fitness and leisure-time PA level promote certain dimensions of HRQoL, including general health, physical functioning, mental health, and vitality. The present study found no association between standing broad jump and HRQoL domains, while Andersen et al. [14] found a positive association between the explosive strength of the lower body and autonomy and parents score. There was no association between handgrip strength and HRQoL in the previous Norwegian study [14]. In the present study, however, there was an inverse association between handgrip strength and psychological well-being. We can only speculate when we attempt discuss why 14 year olds with stronger grips also displayed lower levels of psychological well-being. Age and maturity could explain the inverse association, given that 10 year olds did not display the same result [14]. These different results are related to handgrip strength call for consideration in future research.

Physical fitness

Generally, low-regression coefficients suggest that the associated physical fitness components are among many factors that may contribute to HRQoL among adolescents [2, 22]. Physical fitness is a set of attributes needed for everyday activities; thus, being physically fit increases the possibility to carry out those activities with vigor and ample energy [9].

On one hand, the contribution of genetic factors to physical fitness is unquestionable [8], and together with environmental factors accounts for a certain variation of observed fitness. On the other hand, performance on both the sit-ups test and the running test depends largely on participation in regular PA, which in turn gives us several explanations for these findings. First, the activities adolescents primarily engage in, like football or handball, require a certain level of CRF and at the same time, may enhance cognition and mental health via changes in the structural and functional composition of the central nervous system and central and peripheral biomarkers [5]. Second, adolescents with poor self-reported health status and poor physical fitness miss out the psychosocial benefits, such as positive physical self-perception and social interaction, of the regular PA [5]. Third, according to the behavioral hypothesis, school, leisure time, and family activities may emphasize self-regulation and coping skills that have subsequent implications for mental well-being [5]. Adolescents with high scores on items regarding parent relationships, peer relationships, and school environment may feel a satisfying independence and master coping with others during the abovementioned activities.

Finally, physical fitness varies from person to person and all person are fit to a lesser or greater a degree [9]. Additionally, physical fitness may vary within a person, such as one may have adequate CRF, but poor muscle strength in upper body. This individual variability may explain the inconsistent associations in our analyses. Physical fitness is essential for an individual's functioning which requires a certain level of PA over time [9].

Strengths and limitations

The major strength of the study was the large sample size from twenty-nine schools and four different regions of Norway, which in turn allows us to apply mixed model analysis. In addition, a complete battery of validated measurement tools was used, although the applied running test measured aerobic capacity in an indirect way. It is possible that the inclusion of pubertal development and morbidity could have influenced the results. Unfortunately, these variables were not measured in our study, which can be considered as a limitation. The high ratio of missing values is the most notable limitation of this study. Of course, we cannot fully determine how this affected the results. However, we applied a comprehensive strategy to handle the missing data, and this suggested an insignificant impact. For example, the differences between the complete-case and missing-data groups showed small effect sizes. There were also minimal differences when comparing results from the complete-case group and the pooled data from the multiple imputation procedure. The main limitation of the study was the cross-sectional design which prevents us from inferring a causal explanation.

Conclusions

The purpose of this study was to examine the association between health-related components of physical fitness and HRQoL in Norwegian adolescents. CRF was associated with physical and psychological well-being, autonomy and parents, and school environment domains of HRQoL. Sit-ups was associated with physical and psychological well-being, social support and peers, and school environment domains of HRQoL. Handgrip strength showed an inverse association with psychological well-being.

The findings suggest that improving physical fitness can contribute to adolescents' quality of life. The associations between HRQoL and physical fitness were trivial to small but confirmed that earlier findings from children also apply to adolescents. Results from the present study gives a better understanding of the association between the mental and physical components of well-being among adolescents. However, there is a further need for well-designed longitudinal studies, as well as randomized controlled trials before any causal claims can be made.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11136-022-03309-6.

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Data availability The datasets generated and/or analyzed during the current study are not publicly available as publications are planned but are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declare that they have no competing interests.

Ethical approval The project was reviewed by the Regional Committee for Medical and Health Research Ethics (REK) in Norway, which concluded that the study did not require full review by REK according to the Health Research Act of 2008. The study was approved by the Norwegian Centre for Research Data.

Consent to participate Written informed consent from the participants and their parents or caretakers was obtained prior to data collection.

Consent for publication Not applicable.

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