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Physical activity, physical fitness and self-rated health: cross-sectional and longitudinal associations in adolescents

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ABSTRACT

Objectives To evaluate the independent associations of physical activity and physical fitness with self-rated health in adolescents.

Methods Data from a 2-year observational study (2013–2015) were used (n=256, 58% girls, 13.7±0.3 years at baseline). Self-rated health was assessed with a questionnaire, physical activity by an accelerometer and a questionnaire, and physical fitness via the measurements included in the Finnish national Move! monitoring system for physical functional capacity and their z-score average (fitness index).

Results Self-reported physical activity had cross-sectional associations with self-rated health (girls β 0.213, p=0.006, β 0.221 boys p=0.021) while accelerometer-based moderate-to-vigorous physical activity did not. Higher self-reported physical activity at baseline was associated with higher self-rated health at follow-up in boys (β 0.289, p<0.001), but not in girls (β −0.056, p=0.430). Accelerometer-based moderate-to-vigorous physical activity had positive longitudinal associations with future self-rated health in boys, but some of these similar associations were negative in girls. Fitness index had a positive cross-sectional association with self-rated health in boys (β 0.282 or β 0.283, p=0.002), but not in girls (β 0.162 or β 0.161, p=0.051). Physical fitness was not longitudinally associated with self-rated health.

Conclusions Self-reported physical activity showed potential to explain current and future self-rated health better than accelerometer-based physical activity or physical fitness. We recommended to consider self-reported physical activity as an adequate metric of adolescent health in the population-level surveillance systems.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ A simple single-item self-rating of health from very good to poor is considered to give a powerful summary of an individual's overall health status.
⇒ Self-reported and device-measured physical activity, and physical fitness have previously shown positive associations with self-rated health in adolescents, indicating their potential to promote overall health.

WHAT THIS STUDY ADDS

⇒ Self-reported physical activity showed the most systematic positive associations with self-rated health and might explain current and future self-rated health better than accelerometer-based moderate-to-vigorous physical activity and physical fitness.
⇒ We found that the associations might differ between sexes and depend on the variables selected to indicate physical activity and fitness.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study confirms the meaningfulness of self-reported physical activity as an indicator of future health among adolescents and supports its inclusion in population-level surveillance systems.

INTRODUCTION

A simple single-item self-rating of health from very good to poor is considered to give a powerful summary of an individual's overall health status.[1] In adolescents, low rating of self-rated health is associated with increased prevalence of chronic health conditions,[2] but also with low socioeconomic status, unfavourable psychosomatic symptoms, smoking, alcohol consumption, physical inactivity, poor fitness and nutrition, and obesity.[2–4] Self-rated health in adolescents is considered to be an indicator of unhealthy behaviours and/or circumstances, even prior to the expression of chronic conditions.[5]

Typical adolescent health promotion strategies in sport and exercise medicine are the enhancement of physical activity (PA) and physical fitness (PF). PA is defined as any bodily movement produced by skeletal muscles that results in energy expenditure, and PF as a set of attributes that people have or achieve which relate to physical abilities.[6] Especially at young age, these are separate constructs and it is important to study them independently.[7] Self-reported and device-measured PA have previously shown positive associations with self-rated health,[8–10] with potential dose–response associations in adolescents.[11] Cross-sectional and longitudinal findings

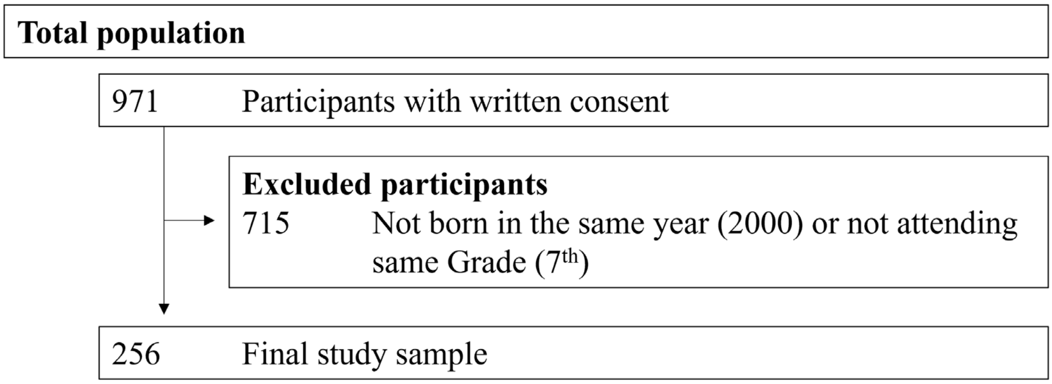

Figure 1 Flow chart of the study sample.

have shown low levels of cardiorespiratory,[12–14] and muscular fitness[15 16] to be associated with poorer self-rated health.

The main aim of this study was to examine if the associations of PA and PF with self-rated-health are independent from each other. The secondary aim of this study was to evaluate if the associations between accelerometer-based and self-reported PA with self-rated health are different.

PARTICIPANTS AND METHODS

Study design and participants

A total of 971 students from 9 Finnish schools from grades 4 to 7 provided written consent (signed by themselves and their main carer) to participate in a longitudinal observational study (2013–2015). Participation was voluntary and could be discontinued at any point during the research. A carefully selected subsample of adolescents all born in the same year and attending the 7th grade at baseline was used in this study (figure 1, n=256, 58% girls, 13.7±0.3 years). Data were collected at baseline during the spring semester 01/2013-05/2013 and at follow-up during the spring semester 01/2015-05/2015. The longitudinal measurements were performed annually during the same calendar week in each school.

Measurements

Anthropometrics

Stature was measured with an accuracy of 0.1 cm (Charder HM 200P scale). Body weight was measured in light clothing using a bioelectrical impedance analysis device with one decimal accuracy (InBody 720, Biospace).

Self-rated health

Self-rated health was measured by asking adolescent's perception of their current health with a question: 'What do you think about your health? It is…? Very good, good, fair or poor', using a scale of 4=very good, 3=good, 2=fair and 1=poor. Self-rated health surveys are reportedly reliable in adolescents.[17] The test–retest (2 weeks) reliability of our questionnaire was (Cohen's kappa) 0.52 (p<0.001) for boys and 0.53 (p<0.001) for girls.

Physical activity

Self-reported PA was measured by asking adolescent's perception of their current PA level with a question: 'Over the past 7 days, on how many days were you physically active for a total of at least 60 min per day?' (HBSC questionnaire).[18] The scale ranged from 0 (0 days) to 7 (7 days). Accelerometer-based PA data were collected using a hip-worn accelerometer (ActiGraph GT3X+, wGT3X+, Pensacola, Florida, USA) during a 7-day measurement period. Data were collected at 30 Hz and a 15 s epoch conversion was used for subsequent analysis. Evenson *et al* criteria were used to define moderate-to-vigorous PA (MVPA).[19] A valid data required at least 500 min of monitored data per day (between 7:00 and 23:00 hours),[20] including at least 2 weekdays and 1 weekend day. PA intensities were subsequently converted into a weighted mean value per day (eg, MVPA=[(average MVPA min/day of weekdays × 5+average MVPA min/day of weekend day × 2)/7]).

Physical fitness

Measurements were conducted on the school premises during the school day using the Finnish national Move!—monitoring system for physical functional capacity.[21 22] The measurements were conducted and scores recorded by trained staff. The measurements included the 20 m shuttle run test, push-up, curl-up, the 5-leaps test, throwing-catching combination test and flexibility. All measurements are described with further details and illustrations elsewhere.[7 22] Reliability estimates for all measurements are provided in the following text. We note that the criterion-related validity of the 20 m shuttle run test using the Eurofit protocol is reported to be r=0.68 (95% CI 0.52 to 0.84) in children.[23] However, the criterion-related validity of other measurements is unknown and constitutes a limitation.

Briefly, cardiorespiratory fitness was estimated using the 20 m shuttle run test. Running speed was increased by 1 min intervals until maximal voluntary exhaustion. Cardiorespiratory fitness was recorded as the number of completed laps. The 20 m shuttle run test has acceptable reliability (intraclass correlation coefficient (ICC) of 0.78—0.93) in children and adolescents.[24]

Upper body muscle strength was assessed via a push-up.[25] Boys performed push-ups with hands and toes and girls with hands and knees on the ground. Participants completed as many push-ups as possible during 1 min. The number of correctly performed repetitions was counted. ICC of repeated measurements in Finnish school children (11 and 14 years) is >0.80.[21]

Abdominal strength was assessed via a curl-up. The curl-up is a modified version of FitnessGram curl-up, with slightly faster cadence. The number of correctly performed repetitions was counted with a maximal number of repetitions limited to 75. ICC of repeated measurements in Finnish school children (11 and 14 years) is 0.67.[21]

Motor skills and leg muscle power were assessed via a 5-leaps test.[26] Each participant had two attempts to jump as far as they could with five consecutive leaps and the best score was recorded to 0.1 m accuracy. ICC of repeated measurements in Finnish school children (11 and 14 years) is 0.53–0.96.[21]

In the throwing-catching combination test (assessment of motor skills and upper limb muscle power), students threw a tennis ball from 7–10 m distance (distance was selected according to their age and sex) to a 1.5×1.5 m sized target area situated on the wall 0.9 m above the floor. Students had 20 attempts to throw the ball behind the marked line, hit the target area and catch the ball after one bounce. The number of correctly performed repetitions was counted. ICC of repeated measurements in Finnish school children is 0.69.[21]

Flexibility is a composite score comprised of four different multijoint flexibility measurements. Measurements included squat, lower back extension and left and right shoulder stretch. Each participant received 1 point out of each measurement that he/she performed according to the selected criteria. The maximum score in flexibility is 4 and the minimum 0. ICCs are 0.62—0.85 (ICC squat ICC: 0.62, lower back extension ICC: 0.81, shoulder stretch ICC: 0.82–0.85).[21]

Covariates

Body fat percentage

Body composition was measured in light clothing using a bioelectrical impedance analysis device (InBody 720, Biospace).

Pubertal status

Students self-assessed their biological maturity status with a questionnaire using line drawings of external primary and secondary sex characteristics using the five stages described by Tanner.[27] Pubertal status was defined by the developmental stage of pubic hair.

Subjective social status in the society

A ladder scale from 1 to 10 was used, where adolescents evaluate their family's position in the socioeconomic structure.[28 29]

Statistical analyses

Participant characteristics were calculated as means and SD. Differences between baseline and follow-up values were evaluated with a paired t-test for continuous variables and with McNemar and Wilcoxon signed-rank tests for categorical variables.

Because of the low prevalence of poor ratings of self-rated health in our sample, the adolescents were regrouped into three groups: very good, good and fair/poor. Cross-sectional differences in group mean values of PF, PA and selected covariates (body fat percentage, pubertal status, subjective social status in the society) were assessed with one-way analysis of variance (ANOVA) and further Tukey post hoc tests. All above-mentioned analyses were completed using the IBM SPSS Statistics (IBM, Released 2016. IBM SPSS Statistics for Windows, V.24.0, IBM).

Cross-lagged path analyses were used to assess cross-sectional and longitudinal associations between PA, PF and self-rated health. In the final models, the baseline values of overall fitness index (average of sex specific z-scores from all fitness measurements), MVPA or self-reported PA and self-rated health rating, were used to explain the follow-up values of the same variables, independent of baseline body fat percentage and pubertal status. Subjective social status in the society was excluded from the final model as no statistically significant associations were observed. Additionally to using the fitness index, analyses were also conducted for each fitness characteristic separately. Cross-lagged path analyses were conducted using the Mplus statistical package (seventh edition, Los Angeles, California, USA).[30] Further description of the statistical procedures is provided in online supplemental document 1. In addition, supplementary information is available on the sensitivity analyses where high rating of self-rated health was associated with lower prevalence of pain symptoms and sleep disorders, and unhealthy behaviour in our sample (online supplemental document 2). The level of significance was set at $p<0.05$.

Patient and public involvement

The participants were not involved in forming the research questions, outcome measures, design or other aspects of the study.

RESULTS

Participant characteristics are presented in table 1. The majority of the adolescents reported having good self-rated health (65.8% of girls and 60.7% of boys at

Table 1 Subject characteristics at baseline and follow-up

	Girls			Boys		
	Baseline 2013 n=149	Follow-up 2015 n=114	P value	Baseline 2013 n=107	Follow-up 2015 n=77	P value
Subject characteristics						
Age (years)	13.7 (0.3)	15.7 (0.3)	**<0.001**	13.7 (0.3)	15.7 (0.3)	**<0.001**
Stature (cm)	161.1 (7.1)	165.0 (6.7)	**<0.001**	165.2 (8.2)	175.9 (5.8)	**<0.001**
Body weight (kg)	50.1 (7.3)	58.6 (9.4)	**<0.001**	52.4 (10.3)	63.0 (9.6)	**<0.001**
BMI	19.6 (2.8)	21.5 (3.1)	**<0.001**	19.0 (2.6)	20.3 (2.6)	**<0.001**
Prevalence of overweight or obesity (%)[!]	11.4% (n=17)	10.1% (n=15)	0.125	12.1% (n=13)	9.3% (n=10)	1.000
Body fat %	21.2 (7.1)	25.0 (7.1)	**<0.001**	12.9 (6.5)	11.3 (5.0)	**0.001**
Society SSS[b]	3.8 (1.6)	3.8 (1.7)	0.660	3.4 (1.2)	3.2 (1.5)	0.291
Pubertal status						
Tanner stage I[a]	2.0% (n=3)	1.3% (n=2)	**<0.001**	1.9% (n=2)	2.8% (n=3)	**<0.001**
Tanner stage II[a]	18.8% (n=28)	8.1% (n=12)		25.2% (n=27)	4.7% (n=5)	
Tanner stage III[a]	50.3% (n=75)	28.9% (n=43)		24.3% (n=26)	23.4% (n=25)	
Tanner stage IV[a]	27.5% (n=41)	29.5% (n=44)		35.5% (n=38)	47.7% (n=51)	
Tanner stage V[a]	0.7% (n=1)	8.1% (n=12)		10.3% (n=11)	78.5% (n=84)	
Self-rated health						
Very good	23.5% (n=35)	22.8% (n=34)	0.330	30.8% (n=33)	37.4% (n=40)	0.117
Good	65.8% (n=98)	62.4% (n=93)		60.7% (n=65)	49.5% (n=53)	
Fair or poor	8.4% (n=12)	2.7% (n=4)		5.6% (n=6)	4.7% (n=5)	
Physical activity						
Accelerometer-based MVPA (min/day)	43.6 (17.7)	42.9 (17.7)	0.763	47.7 (18.2)	42.0 (17.3)	0.070
Self-reported PA (weekdays with PA>60 min, range 0–7)	5.5 (1.7)	5.2 (1.8)	0.062	6.3 (1.6)	5.7 (1.8)	**<0.001**
Physical fitness						
20 m shuttle run (laps)	42.1 (6.0)	42.3 (17.8)	0.879	53.1 (17.7)	59.7 (22.8)	**0.002**
Push-up (repetitions)	28.2 (14.0)	31.1 (12.7)	**0.009**	20.5 (11.4)	30.0 (15.4)	**<0.001**
Curl-up (repetitions)[c]	33.3 (18.2)	43.3 (22.8)	**<0.001**	42.8 (19.1)	56.1 (19.1)	**<0.001**
5-leaps (m)	8.5 (0.9)	8.8 (0.9)	**<0.001**	9.2 (1.1)	10.5 (1.3)	**<0.001**
TCCT (repetitions)[c]	12.6 (4.2)	14.4 (3.9)	**<0.001**	12.1 (4.7)	15.4 (4.1)	**<0.001**
Flexibility score[d]	3.5 (0.7)	3.5 (0.8)	0.913	3.3 (0.9)	3.3 (0.8)	0.525

Values are means and SD unless other mentioned. Statistically significant associations (p<0.05) are highlighted with bold.
[!]based on the International Obesity Task Force (IOTF) classification by Cole & Lobstein 2012.
[b]Subjectively evaluated social status of the family in the society.
[a]Self-assessed maturation status based on Tanner scale and pubic hair prevalence.
[c]Measurement instructions differed between sexes.
[d]Sum of four binary flexibility results.
BMI, body mass index; MVPA, moderate-to-vigorous PA; PA, physical activity; SRH, self-rated health; TCCT, throwing-catching combination test.

baseline). No changes were observed in self-rated health during the observational period.

Self-reported PA decreased in both sexes during the observational period but was statistically significant only in boys (from 5.5 to 5.2 weekdays with PA>60 min, p=0.062 girls and 6.3 to 5.7 weekdays with PA>60 min, p<0.001 boys). Accelerometer-based MVPA decreased in both sexes but did not reach statistical significance (from 43.6 to 42.9 min/day, p=0.763 girls and from 47.7 to 42.0 min/day, p=0.070 boys).

Performance in the PF measurements improved during the observational period in both sexes for push-ups (from 28.2 to 31.1 repetitions, p=0.009 girls and from 20.5 to 30.0 repetitions, p<0.001 boys), curl-ups (from 33.3 to 43.3 repetitions in girls and from 42.8 to 56.1 in boys, p<0.001 for both sexes), 5-leaps test (from 8.5 to 8.8 m in girls and from 9.2 to 10.5 m in boys, p<0.001 for both sexes), throwing-catching combination (from 12.6 to 14.4 repetitions in girls and from 12.1 to 15.4 repetitions in boys, p<0.001 for both sexes) and in the 20 m shuttle run in boys (from 53.1 to 59.7 laps, p=0.002) but not in girls (from 42.1 to 42.3 laps, p=0.879). No change was observed in the flexibility score (from 3.5 to 3.5, p=0.913 girls and 3.3 to 3.3, p=0.525 boys).

Cross-sectional associations between PA, PF and self-rated health

Tables 2 and 3 present group differences in PA, PF and covariates between self-rated health groups for girls and boys. Higher self-reported PA was observed in the very good group compared with the fair/poor group with statictical significance in boys (5.9 vs 4.6 weekdays with PA>60 min in girls, p=0.050 and 6.7 vs 4.8 weekdays with PA>60 min in boys, p=0.032). Analyses showed no significant difference between self-rated health groups in baseline device-based MVPA levels for either sex.

PF characteristics differed by self-rated health groups in both sexes: higher fitness index was observed in the very good, and good groups compared with the fair/poor group in girls (0.12 vs –0.46, p=0.022, 0.02 vs –0.46, p=0.048, respectively), and in boys in very good group compared with the good group (0.3 vs –0.1, p=0.022, tables 2 and 3). In the separate fitness characteristics, the very good and good self-rated health groups in girls had better leaping performance compared with fair/poor group (8.5 vs 7.7 m, p=0.028 and 8.4 vs 7.7 m, p=0.037, respectively). The very good group had better 20m shuttle run (47.3 vs 33.3 laps, p=0.037) and push-up performances (30.7 vs 17.9 repetitions, p=0.024) than the fair/poor group in girls. In boys, the very good group had better performance than the good group in the curl-up (49.6 vs 39.5 repetitions, p=0.042), 5-leaps (9.7 vs 9.1 m, p=0.015) and throwing-catching combination tests (14.0 vs 11.5 repetitions, p=0.027). Additionally, the very good group had a better throwing-catching combination test score than the fair/poor group (14.0 vs 8.0 repetitions, p=0.009). However, no differences in group means across self-rated health groups were observed in the curl-up, throwing-catching combination, and flexibility in girls, and in 20m shuttle run, push-up, and flexibility in boys.

The cross-sectional part of the cross-lagged path analysis showed higher self-reported PA levels to be associated with higher self-rated health in both sexes (standardised regression coefficient (β) 0.213, p=0.006 girls, 0.221, p=0.021 boys).

Table 2 Differences in physical activity, physical fitness and selected covariates between self-rated health groups analysed with one-way ANOVAs Tukey post hoc test in girls

	Very good self-rated health n=35	Good self-rated health n=98	Fair or poor self-rated health n=12
Girls	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Physical activity			
Accelerometer-based MVPA (min/day)	45.3 (15.2)	46.2 (21.1)	39.3 (18.5)
Self-reported PA (weekdays with PA>60 min)	5.9 (1.6)	5.4 (1.7)	4.6 (1.7)
Physical fitness			
Fitness index[a]	**0.12 (0.7)***	**0.02 (0.6)[#]**	–0.46 (0.7)
20 m shuttle run (laps)	**47.3 (18.9)***	42.1 (15.8)	33.3 (19.1)
Push-up (repetitions)	**30.7 (16.6)***	27.0 (13.5)	17.9 (14.8)
Curl-up (repetitions)	36.1 (16.8)	32.5 (18.8)	22.5 (10.8)
5-leaps (m)	**8.5 (0.9)***	**8.4 (0.9)[#]**	7.7 (0.9)
TCCT (repetitions)	12.5 (4.3)	12.3 (4.4)	12.0 (3.1)
Flexibility score[b]	3.4 (0.8)	3.6 (0.7)	3.3 (0.9)
Covariates			
Body fat %	**19.7 (6.1)****	22.1 (7.6)	27.2 (9.2)
Pubertal status[c]	2.9 (1.0)	3.1 (0.7)	3.4 (0.5)
Society SSS[d]	3.3 (1.7)	4.1 (1.7)	3.1 (1.2)

Statistically significant differences marked with bold.
[a]Fitness index, Average of sex-specific z-scores of different fitness characteristics.
*Difference between Very good and Fair or poor groups (*p<0.05, **p<0.01)
[#]Difference between Good and Fair or poor groups ([#]p<0.05); Statistically significant differences marked with bold.
[b]Sum from four binary flexibility results.
[c]Pubertal status, Self-assessed maturation status based on Tanner scale and pubic hair prevalence.
[d]Subjective social status of the family in the society (Society SSS).
ANOVA, analysis of variance; MVPA, moderate-to-vigorous PA; PA, physical activity; TCCT, throwing-catching combination test.

No statistically significant associations between accelerometer-based MVPA and self-rated health were observed (figure 2). Favourable associations were observed between higher fitness index and higher self-rated health (β 0.282–0.283, p=0.002) in boys, but not in girls (β 0.161–0.162, p=0.051), independent of PA (accelerometer-based MVPA or self-reported PA), body fat percentage and pubertal status.

Analyses revealed that fitness index, accelerometer-based MVPA, self-reported PA, self-rated health, body fat percentage and pubertal status were considerably correlated in the cross-sectional analyses, especially in girls, indicating the complex

Table 3 Differences in physical activity, physical fitness and selected covariates between self-rated health groups analysed with one-way ANOVAs Tukey post hoc test in boys

Boys	Very good self-rated health n=33 Mean (SD)	Good self-rated health n=65 Mean (SD)	Fair or poor self-rated health n=6 Mean (SD)
Physical activity			
Accelerometer-based MVPA (min/day)	55.9 (25.2)	54.2 (24.8)	38.1 (33.9)
Self-reported PA (weekdays with PA>60 min)	**6.7 (1.5)***	6.3 (1.7)	4.8 (1.7)
Physical fitness			
Fitness index[a]	**0.3 (0.63)[&]**	−0.1 (0.7)	−0.4 (0.8)
20 m shuttle run (laps)	61.2 (18.1)	52.0 (18.5)	46.8 (19.3)
Push-up (repetitions)	21.5 (11.1)	20.5 (12.2)	18.0 (13.0)
Curl-up (repetitions)	**49.6 (20.3)[&]**	39.5 (18.2)	37.5 (26.6)
5-leaps (m)	**9.7 (1.0)[&]**	9.1 (1.1)	8.7 (1.3)
TCCT (repetitions)	**14.0 (3.8)[&] ****	11.5 (4.7)	8.0 (5.1)
Flexibility score[b]	3.3 (0.8)	3.3 (0.9)	3.3 (0.5)
Covariates			
Body fat %	12.3 (5.8)	14.2 (6.7)	16.7 (10.0)
Pubertal status[c]	3.2 (1.1)	3.3 (1.0)	3.8 (0.8)
Society SSS[d]	3.4 (1.7)	3.5 (1.2)	4.0 (0.9)

Statistically significant differences marked with bold.
[a]Fitness index, Average of sex-specific z-scores of different fitness charachteristics
*Difference between Very good and Fair or poor groups (*p<0.05, **p<0.01).
[b]Sum from four binary flexibility results.
[&]Difference between Very good and Good groups ([&]p<0.05).
[c]Pubertal status, Self-assessed maturation status based on Tanner scale and pubic hair prevalence.
[d]Subjective social status of the family in the society (Society SSS).
ANOVA, analysis of variance; MVPA, moderate-to-vigorous PA; PA, physical activity; TCCT, throwing-catching combination test.

associations between these variables. These associations are shown in figure 2.

Longitudinal associations between PA, PF and self-rated health

Higher self-reported PA had positive longitudinal associations with self-rated health in boys (β 0.289, p=0.003), but not in girls. Accelerometer-based MVPA showed no longitudinal associations with self-rated health in girls or boys when adjusted with overall fitness index. However, in the analyses where each fitness characteristic was used in the model separately, higher baseline accelerometer-based MVPA was associated with higher self-rated health at follow-up in boys. However, in girls with 5-leaps or curl-up as the fitness characteristic, higher accelerometer-based MVPA was associated with lower self-rated health at follow-up (online supplemental document 3).

PF showed no longitudinal associations with self-rated health in girls or boys when using either the fitness index (figure 2) or when each fitness characteristic was handled separately (online supplemental document 3).

Self-rated health at follow-up was strongly explained by self-rated health at baseline in both sexes (β 0.506–0.519, p<0.001 girls, β 0.378–0.421, p<0.001 boys, figure 2), independent of baseline PA (accelerometer-based MVPA or self-reported PA), fitness index, body fat percentage and pubertal status. Additionally in girls, advanced baseline pubertal status was associated with better self-rated health at follow-up (β 0.186–0.187, p=0.010–0.013). Self-rated health showed reciprocal associations in girls, as higher baseline self-rated health explained higher accelerometer-based MVPA and self-reported PA levels, and higher fitness index at follow-up. No similar associations were observed in boys (figure 2).

DISCUSSION

Main findings

We assessed the associations between PA, PF and self-rated health in adolescents. Self-reported PA showed the most systematic positive associations with self-rated health and it might explain current and future self-rated health better than accelerometer-based MVPA and PF. This study provides novel insights into the relationships between accelerometer-based MVPA, self-reported PA, PF and self-rated health in youth, and that these relationships may be sex-dependent and vary between accelerometer-based and self-reported PA, and the used indicator of PF. These findings also support the use of self-reported PA in large-scale monitoring systems to assess the health status of adolescents.

PA and self-rated health

The majority of previous studies have examined associations between self-reported PA and self-rated health. A recent meta-analysis found positive associations between self-reported PA and self-rated health in 58 studies out of 62.[8] Our study agreed with these findings and showed in a cross-sectional design that adolescents with very good self-rated health to have higher self-reported PA levels than adolescents with fair/poor self-rated health in both sexes. Additionally, the cross-sectional associations between higher self-reported PA and higher self-rated health were statistically significant in both sexes, independent of PF, body fat percentage and pubertal status.

Our study showed longitudinal associations between higher baseline self-reported PA and higher self-rated health in boys, but not in girls. This finding partially agrees with the meta-analysis, where eight studies out of nine showed favourable associations between self-reported PA and self-rated health.[8] However, our study

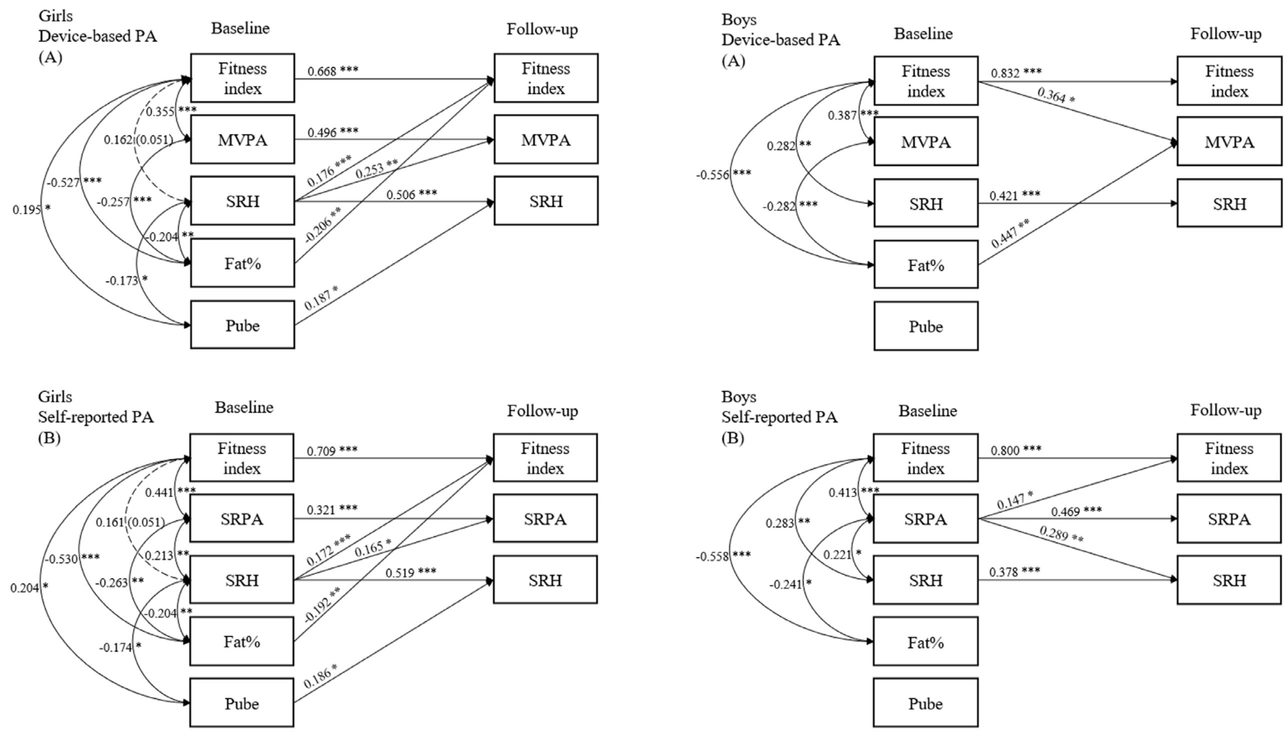

Figure 2 Cross-lagged path model showing cross-sectional and longitudinal associations of accelerometer-based moderate-to-vigorous physical activity (MVPA) (A) or self-reported PA (SRPA) (B) with fitness index, and self-rated health (SRH), independent of body fat % (Fat%), and pubertal status (Pube) in girls and boys. *p<0.05, **p<0.01, ***p<0.001.

implies differences between boys and girls, but the meta-analysis reported no sex differences.[8]

Here, we provide the findings of this study in the context of previous literature. Our data indicated no cross-sectional associations between accelerometer-based MVPA, and three categories of self-rated health, evaluated as group differences (ANOVA) or adjusted for PF, body fat percentage and pubertal status (cross-lagged path analysis). These findings are partially in contradiction to previous studies using device-based measures of MVPA. Herman *et al* showed cross-sectional associations between higher accelerometer-based MVPA and higher self-rated health in children aged 8–10 years.[9] In the study by Husu *et al,* cross-sectional associations of several device-measured PA domains were compared with self-rated health in children aged 7–14 years.[10] Similar to our study, accelerometer-based MVPA established no statistically significant associations with higher self-rated health, while higher amount of steps per day did.[10]

In our study, despite the lack of cross-sectional associations, favourable longitudinal associations between accelerometer-based MVPA and self-rated health were found in boys, depending on the used PF indicator as the covariate. No longitudinal associations between accelerometer-based MVPA and self-rated health were found when the model included overall fitness index. However, in girls, some of these similar associations were adverse (higher baseline accelerometer-based MVPA was associated with lower self-rated health at follow-up).

The authors are not aware of studies comparing associations between accelerometer-based MVPA and self-reported PA with self-rated health in adolescents. Previously, Niemelä *et al* have shown in a cross-sectional study that the dose–response association between self-reported PA and self-rated health was stronger than with device-based PA and self-rated health in middle-aged men and women.[31] Our study agreed with this finding and showed more favourable and stronger associations between self-reported PA and self-rated health than between accelerometer-based MVPA and self-rated health.

PF and self-rated health

The findings of our study are in agreement with previous findings that selected PF characteristics and self-rated health have cross-sectional associations. Higher cardiorespiratory, muscular and motor fitness in adolescents are associated with higher self-rated health.[12,14] In our study, adolescents reporting higher self-rated health had higher overall fitness index and power (5-leaps) in both sexes. Selected markers of cardiorespiratory, muscular and motor fitness were positively associated with higher self-rated health in boys and girls (20 m shuttle run and push-up in girls, and curl-up and throwing-catching combination in boys). Self-rated health status was not associated with flexibility in either sex. The favourable association between overall fitness index and self-rated health persisted even after adjusting for PA (accelerometer-based MVPA or self-reported PA), maturity status and body fat % but only in boys.

Despite the cross-sectional associations, we did not observe longitudinal associations between PF and self-rated health. The previously conducted longitudinal studies for PF and self-rated health have shown inconsistent associations. Padilla-Moledo *et al* found cardiorespiratory fitness (20 m shuttle run) and a global fitness index (z-score average from Assessing Levels of Physical Activity (ALPHA)-fitness tests) to have positive longitudinal associations with self-rated health, but not muscular strength (handgrip nd standing long jump).[14] Hanssen-Doose *et al* reported no association between cardiorespiratory fitness (attained watts in a ergometer test at a heart rate of 170 beats per minute (PWC170)) and future self-rated health, but did with muscular fitness (standing long jump, push-up and sit-up) and coordination (sideways jumping and balance test).[16]

Possible explanations for these findings are discussed. Self-rated health is considered to provide a holistic view of health, including both somatic and mental aspects.[5] Our sensitivity analyses supported this interpretation and showed that poorer self-rated health was associated with higher prevalence of headaches and sleep disturbances, insomnia in girls and more frequent alcohol consumption in boys. Therefore, unwell adolescents may simultaneously exhibit several characteristics that all reflect their state of unwellness; lower self-rated health, less PA and poorer fitness. In addition, the different associations between self-reported and device-based PA with self-rated health is another key finding of this study. There is a well-established relationship between PA and health already in adolescents.[32] As devices and questionnaires measure partly similar but partly different constructs of PA, we aimed to elucidate their relationships with self-rated health. Our results support the hypothesis that self-reported metrics are more highly correlated with each other, reflect the state of overall well-being, and are also relevant metrics for future well-being.[33]

Strengths and limitations

The strengths of this study include accelerometer-based MVPA, longitudinal study design and robust analyses. However, the limitations include low number of adolescents with fair or poor self-rated health in the study sample, and drop-out experienced at follow-up, which could affect generalisability of the findings. These findings need to be replicated with larger studies and with children with different background. We also acknowledge that the multiple comparisons might be a source for type I error.

Policy implications

Of evaluated metrics, self-reported PA performed best by showing most systematic positive associations with self-rated health. These findings indicate that self-reported PA might explain current and future self-rated health better than accelerometer-based MVPA and PF. This phenomenon is recommended to be acknowledged when interpreting the metrics of population-level surveillance systems.

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Patient consent for publication Not applicable.

Ethics approval This study involves human participants and the study was approved by the Ethics Committee of the University of Jyväskylä. Participants gave informed consent to participate in the study before taking part. All measurements were carried out by trained personnel and in accorance with the Declaration of Helsinki.

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