

Differences in Health Behavior, Physical Fitness, and Cardiovascular Risk in Early, Average, and Late Mature Children

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This study examined the association between biological maturity, CVD risk, fitness and health behavior in 709 (359 male, 350 female) 8-year-old children (range: 6.3–8.9 years). Sports participation and sedentary behavior was assessed via parent questionnaire. Height and weight was measured and maturity status was predicted based on % of adult-height reached. Fitness was assessed via a test battery and CVD risk was determined using mean arterial pressure, cholesterol and intra-abdominal fat. BMIpercentiles (BMIPCT) differed significantly among early, average and late maturing children. Early maturing children displayed a higher CVD risk profile (0.5 vs. -0.2), lower fitness scores (-0.4 vs. 0.2), and spent more time watching TV (51 vs. 43 min/day) compared with their peers. After controlling for BMIPCT differences remained only for fitness in boys and TV time in girls.

Introduction

The increasing prevalence of overweight and obesity in children has led to an increase in comorbidities such as type 2 diabetes, hypertension, and dyslipidemia that were previously observed in adults only (18). As these cardiovascular disease (CVD) risk factors track from childhood and adolescence into adulthood it is

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necessary to increase the understanding of underlying causes for weight gain and CVD risk at young ages (5,29). Primarily a lack of physical activity (PA) and increased caloric intake have been suggested as the major cause for weight gain (27). Even though environmental constraints affect health behavior, biological aspects, such as the timing and tempo of maturation along with maturity status, need to be considered. The relationship between maturation and growth rates of fat mass and fat free mass, for example, has been well recognized, with early maturing children displaying higher % body fat compared to late maturing children (26). Further, Chen et al. (15) showed that women who reported a younger age at menarche displayed significantly higher body fat and a less favorable metabolic profile throughout adulthood. No such association, however, was observed in boys (11). Maturation has also been shown to be independently associated with PA (25) and the observed decline in habitual PA with increasing age in humans as well as animals further undermines the biological basis of PA (45,46,50). At the same time an increase in sedentary behavior with age has been observed (6,39) and Bradley et al. (10) reported a higher amount of sedentary behaviors in early maturing girls.

Behavioral changes along with changes in body composition are also related to physical fitness, which has been shown to independently affect CVD risk (23). Further, differences in maturity status may provide advantages or disadvantages in physical fitness (30,38). Jones et al. (28), for example, showed higher fitness levels in early maturing boys even when accounting for their increased size and mass which has been shown to be associated with sports participation as well (2,22). On the other hand, psycho-social aspects such as social physique anxiety or self esteem and body image have been shown to negatively affect the motivation for PA or sports, especially in early maturing girls (4,37). While various studies suggested that biological age, rather than chronological age is a major correlate with changes in activity behavior (17,48), research on the effect of timing and tempo of biological maturation on health behavior has been limited (47) and predominantly focused on pubertal adolescents as differences by maturity status are most pronounced during this period (8,36). Differences in body composition by maturity status, however, have been shown to occur as early as 6 years of age (36), and, therefore, potential differences in physical fitness, health behavior and the CVD risk profile may start to emerge already at younger ages.

The purpose of this study was to examine differences in PA, sedentary behavior, fitness and CVD risk between early, average, and late maturing elementary school children. It was hypothesized that early maturing children display higher CVD risk values, due to increased body fatness. Further, early maturing children are thought to engage in less PA and more sedentary behavior compared to their peers. Concerning fitness, it is hypothesized that early maturing girls display lower fitness levels, while higher fitness levels are expected in early maturing boys.

Methods

Baseline data from a school-based intervention program (URMEL-ICE, Ulm Research on Metabolism, Exercise and Lifestyle in Children), which focused on a healthy lifestyle, in southwest Germany was used. 1118 (592 male, 526 female) elementary school-children provided informed consent and child assent. Average age

of the sample was 7.6 ± 0.4 years (range: 6.3–8.9 years). After excluding children with a reported chronic disease and those who were missing parental height for the prediction of maturity status 709 (359 male; 350 female) subjects remained for data analysis. Due to incomplete data, the actual sample size, however, varies for each analysis. The study protocol was approved by the institutional review board and is in accordance with the declaration of Helsinki.

Children's height and weight was measured in a standardized manner by trained medical staff of the endocrine outpatient clinic of Ulm Children's Hospital. Height was measured to the nearest 0.1 cm using a stadiometer (Ulm Stadiometer, Busse Design, Ulm, Germany) and weight was measured to the nearest 0.1 kg using a balance beam scale (Seca, Hamburg, Germany) with the children wearing only underwear. Subsequently BMI was calculated (kg/m^2) and converted to BMI percentiles (BMIPCT) using representative German reference values and classified as normal weight ($> 3\text{rd}$ BMIPCT), overweight ($> 90\text{th}$ BMIPCT), or obese ($> 97\text{th}$ BMIPCT; 32). Health behavior was assessed via parent questionnaires. As currently no validated instrument for the assessment of health behavior is available in German, questions were based on the KiGGS survey, which assessed health behavior in 18,000 German children and adolescents (33). Specifically parents were asked about their child's sports participation (club and nonclub), time spent watching TV and playing computer. In addition, height and weight of the biological parents of the child was self-reported by the parents.

Biological maturity status was estimated based on % of predicted adult-height reached, which is moderately-to-highly correlated with skeletal maturity in prepubertal children (36). Using midparental height, as well as height, weight and age of the child the expected adult-height was calculated (31). The median deviation of predicted adult height and height achieved at the age of 18 was 2.2 cm and 1.7 cm for males and females respectively, but the estimations were similar to those including skeletal age (31). Even though, the height prediction was established on a US sample, it should be comparable to the population of this study as both groups consisted of only white participants. Based on the estimation of predicted adult height, % of predicted adult-height reached was calculated and converted to z-scores using reference values from the Berkeley Guidance Study (7). As only full years of chronological age could be used for the calculation of z-scores, cut-offs for chronological age were 0.5 and 0.49, respectively (i.e.: $5.5\text{--}6.49 = 6$ years, $6.5\text{--}7.49 = 7$ years, . . .). Subsequently children were classified as early, average, or late maturing using a z-score deviation of ± 0.5 as cutpoints.

Physical fitness was assessed during a single PE lesson using a modified version of the AST ("General motor abilities test for children"; 14), which is a commonly used fitness test in Germany (12). Test-retest reliability for individual tests has been shown to be between 0.73 and 0.96 with an average test-retest reliability of 0.85 (13). After a warm-up game trained technicians administered 4 tests in the following order: 20m-sprints, obstacle course run, medicine-ball shot put, and 6-min run. Children performed 2 trials for the 20m-sprint, the obstacle course run and the medicine ball shot put and 1 trial for the 6-min run. On the obstacle course run, the first trial was a practice run and the second trial was used in the analysis while for the 20m-sprint and the shot-put trials the better result was included in the analysis. Principal component analysis indicated a single fitness factor (Eigenvalue = 2.02) which explained 58.5% of the variance. The loadings for the individual

components were 0.72 for the 6min run (m), 0.60 for the shotput (cm), -0.78 for the 20m-sprint (sec), and -0.72 for the obstacle run (sec).

Similar to the fitness score a CVD risk score was determined via principal component analysis including mean arterial pressure (MAP), the ratio of total cholesterol:HDL (TC:HDL), and intraabdominal fat (IAF), which all contributed to a single factor (Eigenvalue = 1.18) that explained 42.33% of the variance. Component loadings were 0.76, 0.69, and 0.37 for IAF, TC:HDL, and MAP, respectively. Blood pressure was measured twice with the child in a seated position according to the guidelines of the national high blood pressure education program (40) and MAP was calculated ($MAP = 2/3 \text{ diast. BP} + 1/3 * \text{syst. BP}$). Blood samples obtained via venous puncture, with the children in a fasting state, were processed shortly after withdrawal. Chemical analyses were performed following standard procedures to determine total cholesterol, HDL-, and LDL-cholesterol. Sonographic measures of intra-abdominal depth using a 3.5 MHz convex transducer (Esaote Techno MPX; Esaote S.p.A., Genova, Italy) were used to determine intraabdominal fat. Compared with computed tomography (CT) this technique has been shown to be a very good predictor of visceral abdominal fat (53). A single well trained technician carried out 2–3 measurements with the child lying in a supine position along the linea alba at the height of the branching of the arteria mesenterica. Measurements were taken at the end of the expiration following recommendations by Armellini (3). An intraclass correlation of 0.93 for IAF measurements shows acceptable intraobserver agreement for these measurements

Descriptive statistics were calculated and sex-specific differences by maturity group were analyzed using ANCOVA, initially controlling for age. As body fatness has been shown to affect CVD risk, fitness and PA as well as sedentary behavior, BMIPCT was also included as a covariate in a second analysis. All statistics were performed in SPSS 19.0 using Bonferroni adjustment for multiple comparisons. Statistical significance was set at $p < .05$.

Results

Of all children 12.0% were classified as overweight or obese. Specifically 8.9% of the boys and 8.2% of the girls were overweight, while 4.0% and 2.9% of boys and girls, respectively, were obese. Self-reported parental height (male 178.5 ± 7.0 cm, female 165.7 ± 6.0 cm) as well as the predicted adult-height of the children (male 179.7 ± 6.5 cm, female 166.1 ± 5.1 cm) was comparable to average self-reported adult heights of 178 cm and 165 cm in German males and females, respectively (21). Adult heights were also comparable to the reference sample used to estimate maturity status. There were no sex differences observed for BMIPCT, sports participation or time spent watching TV. Boys, however, spent more time playing computer games and performed better on the individual fitness tests, which was reflected by a higher overall fitness score. In addition, boys had higher IAF, while girls had a higher TC:HDL ratio. Overall CVD risk, however, did not differ between boys and girls.

Descriptive characteristics by maturity group are shown in Table 1. BMIPCT differed significantly between all maturity groups in boys and girls with early maturing children displaying the highest values and late maturing children displaying

Table 1 Descriptive Statistics by Maturity Group. Values are Mean \pm SD

	Early (N = 180)	Average (N = 299)	Late (N = 230)
Maturity z-score	1.5 \pm 0.8	0.0 \pm 0.3	-1.0 \pm 0.4
% pred. adult height*	75.0 \pm 3.6	73.2 \pm 3.0	72.5 \pm 2.7
BMI Mother†	25.3 \pm 4.4	23.9 \pm 4.1	23.1 \pm 3.7
BMI Father*	27.1 \pm 3.5	26.0 \pm 3.1	25.2 \pm 2.9
Age (years)†	7.4 \pm 0.4	7.6 \pm 0.4	7.6 \pm 0.4
Height (cm)*	130.5 \pm 5.3	127.4 \pm 4.7	123.2 \pm 5.0
Weight (kg)*	31.5 \pm 4.9	26.0 \pm 3.1	22.4 \pm 2.5
BMIPCT*	79.4 \pm 19.5	48.9 \pm 23.8	27.4 \pm 19.4
Overweight (N/%)	50/28%	9/3%	0/0%
Obese (N/%)	24/13%	0/0%	0/0%
MAP (mmHg)†	78.4 \pm 8.1	76.2 \pm 7.0	74.6 \pm 7.8
TC:HDL†	3.3 \pm 0.8	3.1 \pm 0.7	3.0 \pm 0.5
Intraabd Fat (mm)*	56.4 \pm 7.9	53.4 \pm 6.8	50.7 \pm 6.7
6-min run (m)†	796.3 \pm 125.4	870.8 \pm 132.4	870.3 \pm 134.8
Medicine ball (cm)††	278.9 \pm 62.4	277.0 \pm 64.0	258.6 \pm 60.6
20m run (sec)*	5.2 \pm 0.5	4.9 \pm 0.4	5.0 \pm 0.4
Obstacle course (sec)†	26.0 \pm 4.8	23.4 \pm 3.9	23.3 \pm 4.6
TV Time (min/day)*	50.5 \pm 17.9	44.9 \pm 19.9	40.4 \pm 19.2
Computer time (min/day)	13.5 \pm 17.2	13.3 \pm 17.2	11.4 \pm 14.8
Time spent walking (min/day)	60.3 \pm 48.8	58.9 \pm 48.7	56.1 \pm 44.0

*all groups differ significantly ($p < 0.05$)

†early maturing differ significantly from average and late maturing children ($p < 0.05$)

†† Late maturing differ significantly from average and early maturing children ($p < 0.05$)

the lowest values. CVD risk, controlling for age, was also significantly different among maturity groups ($F_{\text{boys}}(2, 250) = 13.73, p < .01$; $F_{\text{girls}}(2, 239) = 27.38, p < .01$). Early maturing children displayed the highest CVD risk scores and late maturing participants displayed the lowest CVD risk scores (Figure 1). After additionally controlling for BMIPCT results were no longer significant. Accordingly, ANCOVA for the individual CVD risk components, controlling for age only, resulted in significantly higher risk in MAP, TC:HDL, and IAF in early maturing subjects while after additionally controlling for BMIPCT a significant difference only remained for MAP between early and late maturing girls. No differences in any of the CVD risk factors remained in boys (Table 2a).

Lower fitness scores were observed in early maturing children compared to average or late maturing children when controlling for age ($F_{\text{boys}}(2, 341) = 17.37, p < .01$; $F_{\text{girls}}(2, 333) = 7.20, p < .01$; Figure 2). After additionally controlling for BMIPCT differences in fitness only remained in boys. Both, early maturing boys

Table 2a. Maturity-Related Differences in Time Spent Watching TV, Fitness Parameters and Indicators of CVD Risk in Boys. Values Are Adjusted Means (age; age and BMIPCT)± SD

Adjusted for	Early (N = 86)			Average (N = 178)			Late (N = 95)		
	age	age, BMIPCT	age, BMIPCT	age	age, BMIPCT	age, BMIPCT	age	age, BMIPCT	age, BMIPCT
TV time (min/day)	*49.7 ± 20.3	48.7 ± 19.7	44.9 ± 20.0	45.2 ± 19.9	41.9 ± 19.8	42.6 ± 20.0			
MAP (mmHg)	*78.5 ± 8.0	77.0 ± 8.1	76.5 ± 6.6	76.6 ± 6.5	*75.6 ± 8.8	77.2 ± 8.7			
TC-HCL	*3.1 ± 0.8	3.1 ± 0.7	3.0 ± 0.6	3.0 ± 0.8	*2.9 ± 0.5	2.9 ± 0.6			
Intraabd Fat (mm)	†58.1 ± 8.0	55.6 ± 8.0	54.0 ± 6.8	54.2 ± 6.8	52.7 ± 5.7	54.6 ± 5.4			
6-min run (m)	†822 ± 127	863 ± 129	912 ± 132	908 ± 132	916 ± 134	881 ± 132			
Medicine ball (cm)	295.0 ± 64.5	293.0 ± 65.7	295.3 ± 62.4	295.8 ± 63.1	285.7 ± 54.3	288.3 ± 54.4			
20m run (sec)	5.0 ± 0.5	5.0 ± 0.5	†4.8 ± 0.4	†4.8 ± 0.4	5.0 ± 0.4	5.0 ± 0.4			
Obstacle run (sec)	†25.5 ± 4.9	*24.5 ± 4.8	22.6 ± 3.9	*22.7 ± 3.9	22.2 ± 4.2	22.9 ± 4.2			

*sig. difference between these values (p < 0.5)

†sig. difference from other two groups (p < 0.5)

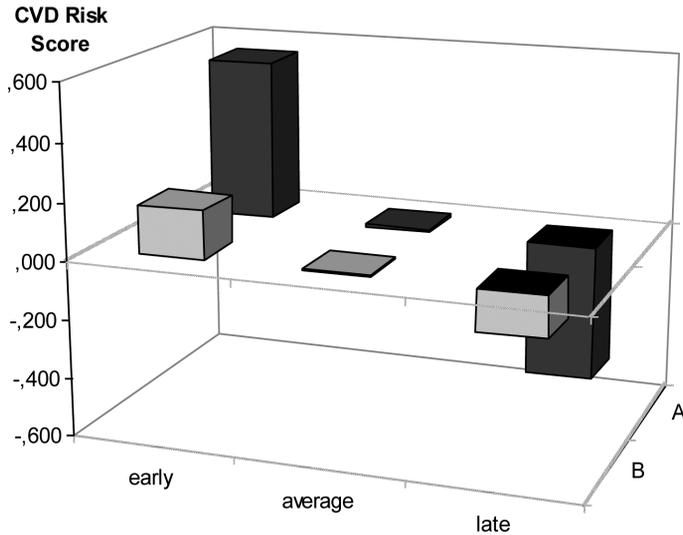


Figure 1 — CVD risk by maturity group. Values are age- and sex-adjusted means (A: sex and age; B: sex, age and BMIPCT).

and girls performed worse on the individual fitness tests except for shotput, where early maturing girls performed significantly better than late maturing girls. While the differences in shotput remained after controlling for BMIPCT differences in other fitness tests disappeared in girls. In boys differences in the 20m-sprint and obstacle course remained significant while they were no longer present for the 6-min run after controlling for BMIPCT in addition to age (Table 2b).

For behavioral aspects there was a lower parent-reported sports participation for early maturing boys ($F_{\text{clubsport}}(2, 340) = 9.58, p < .01$; $F_{\text{sport}}(2, 324) = 3.05, p < .05$) while no difference occurred for girls. These results remained after additionally controlling for BMIPCT. There were no differences for time spent playing computer for either boys or girls, but early maturing boys and girls spent significantly more time watching TV compared to their peers ($F_{\text{boys}}(2, 680) = 14.25, p < .01$; $F_{\text{girls}}(2, 680) = 14.25, p < .01$; Table 2). The difference in TV time disappeared in boys but remained in girls after controlling for BMIPCT in addition to age.

Discussion

Even though participants in this study were prepubertal, an association between maturity status and body composition, health behavior and cardiovascular risk factors was already present. Early maturing children displayed a higher CVD risk along with lower fitness levels and increased sedentary behavior, but body composition affected these associations as well. Denzer et al. (19), actually, argue that body weight influences biological maturation and, therefore, early maturation may be triggered by increased body weight, rather than increased body weight being the

Table 2b. Maturity-Related Differences in Time Spent Watching TV, Fitness Parameters and Indicators of CVC Risk in Girls. Values are Adjusted Means (age; age and BMIPCT) \pm SD

Adjusted for	Early (N = 86)		Average (N = 178)		Late (N = 95)	
	age	age, BMIPCT	age	age, BMIPCT	age	age, BMIPCT
TV time (min/day)	†52.0 \pm 15.5	*53.1 \pm 15.5	44.4 \pm 19.8	*44.9 \pm 19.5	39.2 \pm 18.7	*38.4 \pm 18.9
MAP (mmHg)	†78.7 \pm 8.3	†79.0 \pm 8.3	75.5 \pm 7.5	75.5 \pm 7.5	73.8 \pm 6.9	73.7 \pm 6.9
TC-HCL	*3.4 \pm 0.8	3.3 \pm 0.8	3.3 \pm 0.7	3.3 \pm 0.7	*3.0 \pm 0.6	3.1 \pm 0.6
Intraabd Fat (mm)	*55.2 \pm 7.5	51.4 \pm 7.5	*52.1 \pm 6.6	52.4 \pm 6.4	*49.1 \pm 7.0	51.8 \pm 7.0
6-min run (m)	*775 \pm 1.22	800 \pm 121	809 \pm 108	806 \pm 109	*838 \pm 126	830 \pm 126
Medicine ball (cm)	†268.1 \pm 57.4	*270.4 \pm 57.7	248.0 \pm 56.2	249.0 \pm 56.5	238.8 \pm 57.1	*234.4 \pm 56.2
20m run (sec)	†5.2 \pm 0.5	5.2 \pm 0.5	5.0 \pm 0.4	5.0 \pm 0.4	5.0 \pm 0.4	5.1 \pm 0.4
Obstacle run (sec)	†26.6 \pm 4.7	26.0 \pm 4.7	24.5 \pm 3.7	24.4 \pm 3.7	23.9 \pm 4.7	24.4 \pm 4.8

*sig. difference between these values ($p < 0.05$)

†sig. difference from other two groups ($p < 0.05$)

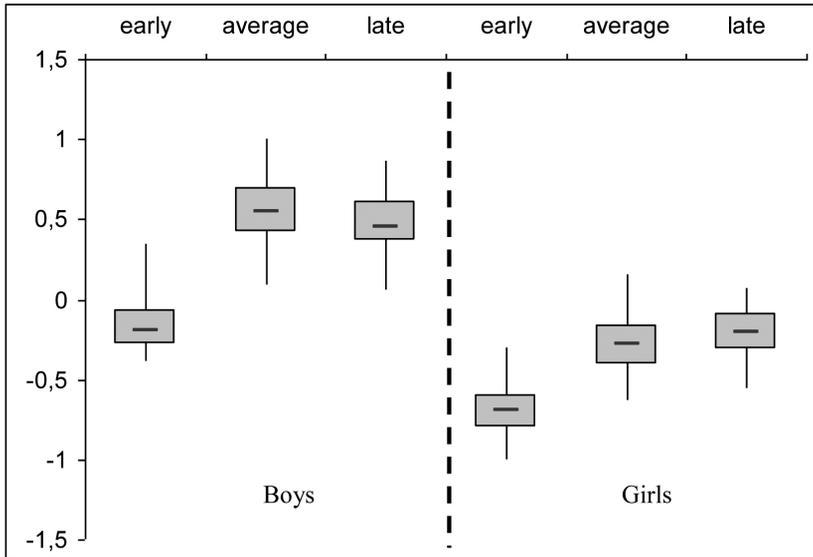


Figure 2 — BoxPlot for fitness score by sex and maturity group. Values are adjusted for age and BMIPCT.

result of early maturation. The higher parental BMI of early maturing children may also indicate that increased body fatness in children due to a shared environment could be associated with earlier maturation. Vandewater and Huang (52), however, did not show a relationship between parent weight status and child weight status in 6- to 9-year-old boys. Due to the cross-sectional design of the current study a causal relationship between body composition of children and maturity status cannot be determined and the directionality of the association between body fatness and maturation remains to be examined. After considering BMIPCT as additional confounding variable differences between maturity groups disappeared for CVD risk. Similarly, differences in endurance capacity disappeared, but a lower performance on speed and agility tests remained in early maturing boys. Current results also suggest that sports participation in elementary school girls is independent of maturity status and body composition while in boys a lower sports participation was observed in early maturing boys. On the other hand, maturity status affected time spent watching TV in girls but not in boys.

To this point only a few studies examined the effect of maturity status on health behavior and CVD risk in children. In adolescents, an inverse relationship between age at menarche and CVD risk factors has been shown (1,44). Even after controlling for body fatness, early maturing girls displayed higher blood pressure and lower glucose-to-insulin ratio (44). The increased blood pressure in early maturing girls was also observed in the younger sample of the current study. Remsberg et al. (44) further showed that the disadvantage of early maturing girls for CVD risk remains throughout adolescence and into young adulthood. Nevertheless, body fatness,

which was higher in early maturing children, plays a crucial role concerning CVD risk as well. This was also evident in the current study as the increased overall CVD risk in early maturing children was no longer present after controlling for BMIPCT. Adult studies also show clear indications for a causal relationship between obesity and increased CVD risk (24) and higher BMI during childhood or adolescence has been shown to increase CHD mortality later in life (4). Further, Psarra et al. (43) showed a strong association between maturity status and body composition in a two-year longitudinal study using the same methodology as the current study to estimate maturity status. The high prevalence of overweight and obesity in the early maturing children in the present sample also suggests an association between maturity status and body composition, but as has been mentioned previously, family environment needs to be considered as well.

Concerning the relationship between maturity and physical fitness, results of the current study suggest a disadvantage of early maturing boys and girls. This is in contrast to previous studies in adolescents (28,36) as earlier maturation in boys is associated with increased lean body mass and, therefore, would result in a better performance on fitness tests (36). Relying on self-reported development of sex characteristics (i.e., breast, genitals, pubic hair), Jones et al. (28), reported increased physical fitness in early maturing 10- to 16-year-old boys and girls. The association, however, was less pronounced in girls and disappeared after controlling for body composition. Similarly, no relationship between physical fitness and maturity status assessed via skeletal age was shown after adjusting for body composition in 6- to 16-year-old girls. Overall, Beunen et al. (9) reported that skeletal or chronological age, as well as stature or height explained less than 10% of most fitness items in girls. In boys the correlation between aerobic capacity and skeletal age was also weaker at younger ages compared with pubertal adolescents. As several studies have shown that physical fitness items are generally poorly predicted by biological maturation, chronological age or body size (28,30), Beunen and Malina (8) argue that neuromuscular maturation, which may not necessarily be reflected by skeletal maturation, plays a crucial role in performance of fitness tests in children.

The lower fitness levels in early maturing boys in the current study may also be explained by the lower sports participation of this group as sports participation or PA has been shown to correlate with physical fitness (34). Sports participation, however, is only one aspect of PA and especially in younger children habitual PA rather than sports participation may be the primary form of moderate-to-vigorous activity (54). This could also explain the lack of association between sports participation and fitness in girls but Niven et al. (41) did not show any differences in self-reported PA by maturity status in adolescent girls either. Similarly, using estimated age at peak height velocity (APHV), no difference in PA between early and late maturing girls, was shown using accelerometry (49) while Drenowatz et al. (20) reported more steps per day in early maturing girls. These differences, however, disappeared after controlling for BMIPCT. Data on the association between maturity status and PA in boys has been more conflicting. While the current study showed an inverse relationship between maturity status and sports participation van Jaarsveld et al. (51) reported a positive relationship between maturity status, assessed via a pubertal development scale, and PA in 12-year-old adolescents. Using self-reported development of secondary sex characteristics, Bradley et al. (10), on the other hand, did not show any differences in PA or sports participation in middle-school boys by

maturity status. These authors, however, did show increased sedentary behavior in early maturing girls, which is consistent with results of the current study. Similarly, van Jaarsveld et al. (51) showed increased sedentary behavior in early maturing girls but these differences were no longer present in adolescents (39,51). Murdey et al. (39) argue that changes in sleep-time rather than maturity status were associated with differences in sedentary behavior in 10- to 15-year-old youth and even though Machado Rodriguez et al. (35) reported a significant effect of maturity status on sedentary time, they acknowledged that the effect size was small.

Pangrazi and Corbin (42) also argue that biological maturity is only a small piece in a very large puzzle of the complex interaction between PA, sedentary behavior, fitness, CVD risk and body composition. The complexity of the relationships along with small effect sizes of individual components may be one explanation for inconsistent results. The variation in age range and differences in the maturational process of the participants along with different methodologies used to estimate maturity status, however, may be of greater concern (16,47). Despite moderate to high correlations between skeletal age, secondary sex characteristics, and somatic indicators to estimate biological maturation (8,33) the development over time differs, which makes it difficult to compare different age groups. The prediction of adult height based on midparent height does also add some error. Due to the young age of the sample the utilization of secondary sex characteristics for an estimation of maturity status, however, was not possible and using skeletal age was not feasible. The present study, therefore, relied on an estimation of % of predicted adult-height, which has been shown to provide a reasonable estimate for maturity status while not exposing children to radiation (36). An additional limitation of the current study was the reliance on parent-report for health behavior and the utilization of sports participation as a proxy for PA. For CVD risk, only blood pressure, cholesterol levels and intraabdominal fat were used as indicators but the utilization of an overall CVD risk score could be considered a strength of this study. Similarly, various tests to determine endurance, strength, power, speed, and agility for the assessment of physical fitness and the development of a single fitness score is a positive aspect of the study. Finally, the inclusion of BMIPCT and chronological age as covariates allow for the examination of the independent effect of maturity status on various health related aspects in prepubescent children.

In summary, it was shown that early maturing children have a higher CVD risk and display lower fitness levels with increased sedentary behavior. The increased body fatness in early maturing children, however, needs to be considered when interpreting the results. It also remains to be determined whether increased body fatness during childhood triggers earlier maturation or whether increased body fatness occurs as a result of early maturation. Nevertheless, maturity status has been shown to affect health behavior, fitness and CVD risk even in prepubertal children and, therefore, should be considered in the examination of the complex relationship between PA, sedentary behavior, fitness and CVD risk in children. To address the growing problems associated with an unhealthy lifestyle and early indicators of CVD an increased understanding of the underlying processes is necessary. A better understanding of the complex interaction between biological and environmental constraints on health behavior, body composition and CVD risk would allow for the development of intervention programs that target the specific needs of different

populations including early maturing children, as they seem to be more vulnerable than their peers.

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