Changes in physical activity explain paradoxical relationship between baseline physical activity and adiposity changes in adolescent girls: the FLVS II study.

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CHANGES IN PHYSICAL ACTIVITY EXPLAIN PARADOXICAL RELATIONSHIP BETWEEN BASELINE PHYSICAL ACTIVITY AND ADIPOSITY CHANGES IN ADOLESCENT GIRLS. THE FLVSII STUDY.

Short running head: Changes in physical activity and adiposity changes in girls.

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ABSTRACT

Objective: To investigate in adolescents, relationships between habitual physical activity (PA) and changes in several indicators of adiposity.

To investigate in adolescents from a population-based study, relationships between habitual physical activity (PA) and changes in several indicators of adiposity.

Design: Longitudinal population-based study. The Fleurbaix-Laventie Ville Santé II (FLVS II) study in northern France.

Subjects: A total of 222 boys and 214 girls aged 8-18 y, not obese at inclusion.

Measurements: PA (*Modifiable Activity Questionnaire)* and adiposity (BMI, % body fat by bio-impedance analysis, sum of 4 skinfolds, waist circumference) were assessed in 1999 and 2001. Adiposity indicators adjusted for age and pubertal stage were compared between groups of baseline PA and between groups of PA changes, separately by sex.

Results: At baseline, PA was not associated with adiposity indicators in both sexes. In girls only, being in the group with the highest age-relative level of moderate PA at baseline predicted the highest adiposity gain from baseline to follow-up, for all indicators. After adjustment for baseline values, all adiposity indicators were higher at follow-up in girls who had decreased their relative level of moderate PA during follow-up. In boys, changes in adiposity during follow-up were not significantly different across groups of PA changes. However, the sum of skinfolds at follow-up, adjusted for baseline value, tended to be higher in those who decreased their vigorous PA level and lower in those who increased it.

Conclusion: In adolescent girls, a decrease in PA rather than inactivity *per se* may result in increased adiposity over time.

Keywords: physical activity; obesity; adiposity; longitudinal study; epidemiology; adolescents

Introduction

Increase in obesity prevalence in children and adolescents is a serious public health concern worldwide in both developed and developing countries. If the prevalence of childhood obesity and overweight remains higher in North America [1, 2] than in Europe [3-8], time-trends are similar in both areas, with a 2-fold increase of that prevalence during the last decade. In France, prevalence of childhood obesity reached 3.5 % and overweight 12 to 18 % during the past ten years with a fourfold increase since 1960. [3, 9]

Such trends suggest an increasing imbalance between energy intake and expenditure over time. While according to several studies, total energy intake has decreased since 1970, a strong ecological correlation has been reported in Great Britain between increasing prevalence of adult obesity and indicators of screen viewing such as television (TV) viewing. [10] In pre-pubertal and pubertal children, longitudinal population-based studies, conducted in the USA and Canada, suggest that adiposity changes as assessed by the BMI or skinfolds, may be related to baseline level of habitual physical activity (PA) and TV watching. [11-18] However in an Italian study, Maffeis et al. [19] found no relationship between changes in BMI and baseline PA or TV viewing in 112 pre-pubertal children followed-up for 4 years.

Marked changes of height and body composition occur during puberty. Variation in BMI during this life period may thus not accurately reflect changes in relative adiposity. Moreover, changes in BMI related to PA may reflect variation in the muscular compartment of fat-free mass rather than fat mass. This suggests that studies on relationships between changes in adiposity and PA should not only rely on the BMI, but also make use of other adiposity measurements. This might especially apply to populations with lower obesity prevalence such as in Western Europe compared to Northern America. [3]

The aim of this study was to investigate the relationships of PA and time spent watching television or playing video games (screen viewing) with various indicators of adiposity during a 2 year follow-up of a population-based cohort of non-obese pre-pubertal and pubertal boys and girls. We also examined the relationship between variation of physical activity or screen viewing and adiposity changes through the follow-up period.

Methods

Participants

Subjects were participants in the Fleurbaix-Laventie Ville Santé II (FLVS II) study which aim is to study risk factors for weight gain and changes in adiposity in a community-based cohort. Back in 1992, all families (n=579), with at least one child in primary school in the two cities of Fleurbaix and Laventie in Northern France, were included in a community wide nutritional education project (Phase I of the study [20]). In 1999, 393 families were still residing in the area, and 294 (1175 parents and children ≥ 8 y) of them accepted to participate in the baseline examination of Phase II. These families were more likely to live in the main cities of Fleurbaix and Laventie than in surrounding villages and were less likely to have obese children than those who refused the study. For the present analyses, we included the 507 children aged 8 to 17 y. We excluded the 10 (2.0%) children classified as obese at baseline in 1999 according to the age and sex related cut-off points established by Cole et al. [21] Indeed, obese children may change their PA level or screen viewing as a consequence of excess body weight and including them may have obscured temporal relationships between these behaviours and changes in adiposity. Among the 497 non-obese subjects, 436 (87.7%) had completed the entire assessment protocol on adiposity measurements and a questionnaire

on PA both at inclusion (1999) and follow-up (2001) examinations. The FLVSII study protocol was approved by the regional ethic committee.

Measurements

Weight (to the nearest 0.1 kg) and percent body fat were determined using the Tanita TBF 310 tetrapolar foot-to-foot bio-impedance analyzer (Tanita Corp, France), with subjects barefooted and wearing light clothes. Height was measured to the nearest 5 mm with a stadiometer. Overweight and obesity were defined using age and sex related BMI cut-off points established by Cole et al. [21] for children and teenagers. Bicipital, tricipital, suprailiac and subscapular skinfolds were measured twice (to the nearest 0.1 mm) with a Harpenden caliper and averaged. The sum of the 4 skinfolds was used in the analyses. Waist circumference (WC) was recorded to the nearest 5 mm at midpoint between the iliac crest and the lowest rib. Pubertal stage was assessed by direct observation according to the Tanner classification. [22]

Ambulatory activity was measured at inclusion only (1999) by an electronic pedometer (Yamax, Digiwalker DW-450, Yamax, Japan) worn at the waist from morning to evening during 7 consecutive days. [23] To limit the effect of technical errors due to the misuse of the device, we excluded measurements in 4 boys and 13 girls giving a log-transformed value out of range of mean value ±3 SD in each sex group.

PA and screen viewing behaviours were assessed with French versions [24, 25] of Kriskas's Modifiable Activity Questionnaire (MAQ) for adults [26] and adolescents [27]. In 1999, the MAQ for adolescents was completed by a trained interviewer to evaluate leisure time activity during the past 2 week and the past-year. The younger children answered with assistance from their parents. At follow-up, subjects < 18 y answered the version for

adolescents and older subjects the version for adults. Both versions of the MAQ include identical questions to assess total time per week ($h.wk^{-1}$), spent in leisure-time PA during the past year. Total time per week ($h.wk^{-1}$), spent watching television or playing video games during the past year was recorded from the adolescent version at baseline and follow-up. In the adolescent version, subjects were also asked the number of days in the past 2 weeks including at least 20 minutes of vigorous (*i.e.* hard enough to make them breathe heavily and make their heart beat fast) or moderate (*i.e.* not hard enough to make them breathe heavily and make their heart beat fast) PA. Subjects selected a response among the following 5 choices: never, 1 or 2 days, 3 to 5 days, 6 to 8 days, 9 days or more.

Statistical analysis

Analyses were conducted separately in boys and girls. Logarithmic transformation of BMI and the sum of skinfolds were performed because of a skewed distribution. Comparisons between included and excluded subjects and between sexes in included subjects were performed with the Student t test for continuous variables and the Chi-square test for categorical variables (pubertal stage, vigorous and moderate PA). The variation between baseline and follow-up was tested by the paired Student t test for adiposity and continuous PA / sedentarity variables and the Wilcoxon signed rank test for pubertal stage, vigorous and moderate PA.

Association between age and PA or screen viewing variables was determined at baseline and follow-up. As some of these variables were ordinal, the relationship was established by Kendall's tau-b coefficient, which is a non-parametric measure of association for both continuous and ordinal variables.

As absolute level and range of PA and screen viewing level depend on age, subjects were identified as being at low or high level of activity according to the median value of the

corresponding activity within their sex and age strata. In each sex, subjects were sorted by age and then classified into 6 strata balanced for frequency. The association between any two of these dichotomous PA or screen viewing variables adjusted for a remaining age confounding, was evaluated as an odds-ratio (OR) and 95% confidence interval. An additional variable combined the dichotomous variables for moderate and vigorous PA in 2 levels, high if moderate or vigorous PA was high, and low if both were low.

Changes in PA or screen viewing were categorized into four levels: high activity at baseline and low at follow-up, low at baseline and follow-up, high at baseline and follow-up, low at baseline and high at follow-up. The relationship between adiposity and PA or screen viewing variables was analyzed by mixed linear models. Each model included an adiposity measurement as the dependent variable, a binary variable for activity as predictor and age and Tanner pubertal stage as adjustment variables. Models predicting WC were also adjusted for height. Models predicting adiposity at follow-up were adjusted for the corresponding adiposity variable at baseline. To take into account correlations between siblings, a family variable was introduced as a random effect at the level of the intercept, and the other variables were declared as fixed effects. Results are given as the mean and 95% confidence interval of the adiposity variable in each group of baseline or change in PA / screen viewing. Analyses of the effect of changes in physical activity over follow-up were performed with all activity variables except pedometer measurements which were not performed at follow-up.

At follow-up, 64 subjects aged ≥ 18 y had completed the adult version of the questionnaire, in which several questions are not identical to their equivalent in the adolescent version. Therefore, longitudinal analyses on moderate and vigorous activity, and time spent watching television or playing video games, were limited to 372 subjects who had answered the adolescent PA questionnaire both at baseline and follow-up examinations.

All analyses were performed with the SAS statistical package (version 8.2, SAS, Cary, NC).

Results

Comparison with subjects lost for follow-up

Comparison between the 436 subjects included for this study and the 61 non-obese subjects lost for follow-up showed no difference at baseline in 1999 in term of adiposity measurements, and pubertal stage distribution. In girls but not in boys, mean age (y) was lower in study subjects than in those lost for follow-up (13.3 ± 2.6 vs. 14.5±2.8; p=0.03). PA level was comparable in both groups. In boys, mean time spent watching TV or playing video games ($h.wk^{-1}$) tended to be lower in study subjects than in those lost for follow-up (13.4 ± 7.2 vs. 17.1±9.8 ; p=0.06).

Comparison between sexes and between baseline and follow-up (Table 1)

At baseline, boys and girls were similar for age and pubertal stage distribution. Sum of skinfolds and percent body fat were higher and waist circumference lower in girls compared to boys. Leisure-time PA, ambulatory activity, and vigorous PA were significantly higher in boys than in girls, whereas there was no difference between sexes for moderate PA and television watching or video games playing. Differences between sexes were similar at follow-up to those at baseline, except for time spent watching television or playing video games which were higher in boys than in girls, and a tendency for a higher pubertal stage in girls.

From baseline to follow-up, pubertal stage increased significantly in both sexes, more so in girls than in boys. BMI, sum of skinfolds and WC increased in both sexes whereas percent

body fat decreased in boys and did not change in girls. In both sexes, time spent watching television or playing video games increased whereas duration of leisure-time PA and number of days with moderate PA decreased over 2 years. Level of vigorous PA remained unchanged over time in both sexes.

Relationship between PA or screen viewing and age at baseline and follow-up

At baseline, only moderate PA in girls (Kendall tau-b = -0.13; P = 0.008) and ambulatory activity in boys (Kendall tau-b = -0.14; P = 0.003) decreased significantly with age. At follow-up, a significant decrease of PA with age was noted for all variables in both sexes (all Kendall tau-b values ≤ -0.11 ; all P values ≤ 0.04) while time spent watching TV or playing video games was not associated with age in boys (Kendall tau-b=0.08 ; P value=0.11) and girls (Kendall tau-b = -0.06 ; P value=0.26).

Inter-relationships of PA and screen viewing variables after adjustment for age

In both sexes, only relationships involving leisure time activity with other PA variables were significant. Boys declaring more leisure time activity were more likely to declare more frequent moderate PA at follow-up only (OR 2.06 (1.15 – 3.67); P=0.01). In girls leisure time activity was associated with moderate and vigorous PA at baseline (OR 1.89 (1.10 – 3.26); P=0.02) and (OR 2.24 (1.29 – 3.88); P = 0.005) and at follow-up (OR 3.50 (1.89 – 6.49) ; P < 0.0001) and (OR 2.46 (1.33 – 4.52) ; P = 0.004).

Relationship between adiposity and PA or sedentarity (Table 2)

At baseline, PA and screen viewing were not associated with any adiposity indicator in both sexes, nor was a variable combining vigorous and moderate PA (results not shown).

Adiposity at follow-up was predicted by the level of moderate PA at baseline in girls (Table 2) but not in boys (data not shown). For girls, being in the group with the highest age-relative level of moderate activity at baseline, predicted the highest adiposity gain from baseline to follow-up, as assessed by all 4 adiposity indicators.

Relationship between PA or sedentarity changes and adiposity variation (Table 3)

In girls, change in all adiposity variables tended to differ among groups of moderate PA change. BMI, percent body fat, skinfolds, and WC were higher at follow-up, after adjustment for baseline value, in girls who decreased their relative level of moderate PA. Changes in moderate PA level and in the relative level of time spent watching TV or playing video games were not significantly related. However, the group who increased relative level of time spent watching TV or playing video games, tended to have a higher sum of 4 skinfolds at follow-up than others.

In boys, changes in adiposity over follow-up were not significantly different according to groups of changes in PA or screen viewing variables (results not shown), except for the sum of 4 skinfolds which was higher at follow-up in those who had decreased their level of vigorous PA and lower in those who had increased it (Figure 1).

Discussion

In this study, we investigated, in a population-based cohort of non-obese boys and girls aged 8-18 y, relationships between variables describing habitual PA and 2-year changes in several adiposity indicators. In both genders, no cross-sectional association was found at baseline or follow-up between PA and adiposity indicators. Unexpectedly, in girls, but not in boys, being in the group with the highest moderate PA level at baseline predicted the highest adiposity gain during follow-up. Furthermore, all adiposity indicators were higher at follow-

up in girls who had decreased their moderate PA level over time. A trend for a similar relationship was found in boys, with higher sum of skinfolds at follow-up in those who had decreased their vigorous PA level during follow-up.

Some characteristics of our sample have to be underlined. The study was conducted in a semi-rural homogeneous limited geographic area with easy access to leisure time activities and sports equipments. Children are from families who agreed to participate in a longitudinal epidemiologic study. In about one third of these families, one parent at least had reached an University degree. Children were recruited in both private and public schools involved in a special nutritional education program. These characteristics may explain that we observed a lower obesity prevalence than expected from contemporaries samples in France. [3, 9, 28]

This unexpected association of higher adiposity gain in girls with highest levels of baseline moderate PA contrasts with current thinking about the development of obesity and prior reports of a negative relationship between PA and adiposity changes. [12, 15, 17] Although not highlighted by the authors, findings similar to ours were however previously observed in girls in a study by Horn et al. [14], among 302 children in grades 1 to 4 followed-up for 2 years.

This paradoxical relationship may be explained in our study by a higher adiposity gain in girls who experienced a relative decrease in time spent at moderate PA level during follow-up. A similar trend was also seen for WC , with leisure-time PA. Furthermore, an opposite trend was observed with time spent watching TV or playing video games that could have reflected opposite variations in PA during follow-up. However, after taking age into account, we did not identify such opposite variations beween PA variables and time spent watching TV or playing video games. In boys, a similar trend was also observed but only for the sum of skinfolds with changes in vigorous PA. In US male adolescents, Gordon Larsen et al. [16] reported that baseline values and changes over a 1-year period in moderate to vigorous PA were independent predictors for the odds of overweight. However, as weight status was

determined only at follow-up in that study, it gives no information about the relationship between PA and adiposity changes. In 146 children aged 3 to 4 y followed-up for 2 y, Klesges et al. [12] identified baseline aerobic activity and changes in leisure activity (as continuous variable) as independent predictors of inverse BMI change. Two studies conducted in adolescents[29] and children 3 to 5 y of age [17] found inverse longitudinal relationship between PA and fat mass estimated from skinfolds. These two latter studies investigated concurrent variation over time in PA and adiposity without predicting adiposity changes by the initial PA level.

The relationships of baseline PA and PA changes with adiposity changes were observed in girls but not boys. Several previous longitudinal studies showed gender differences in children for the prediction of adiposity changes by PA level. [13, 14, 17] Puberty is a period of great behavioural changes, including for PA, and the concept of "habitual PA" may then be less relevant than in adults. Variations in habitual PA level across puberty may limit the predictive power of baseline PA on adiposity changes. O' Loughlin [15] found effects of PA on adiposity changes after 1 but not 2 years in girls and only after 2 years in boys. These authors emphasized that changing PA levels over follow-up may have contributed to these differences. Our results demonstrate the importance of taking into account changes in PA to interpret changes in adiposity. They also indicate that at least in adolescents, decreases and increases in PA may not have symmetrical effects on adiposity changes. Using categorical variables to identify the relative level of PA according to age, provide another way to examine the issue and can complement the findings from studies using other methodologies.

This study confirms a tendency in both sexes [16, 29-32], for a decrease in the time devoted to moderate to intense physical activities during adolescence. During puberty, in spite of this decrease in the time spent in PA, refined studies using double-labelled water and indirect calorimetry have shown that activity-related energy expenditure, is higher in both sexes, in

pubertal than in pre-pubertal children, but more so in boys than girls [33]. The higher increase in energy expenditure in boys is mainly related to a higher increase in basal metabolic rate as a consequence of the development of fat-free mass [33, 34]. This may explain why percent body fat is higher in girls than in boys and increases in girls but decreases in boys during puberty. [35, 36] Therefore, compared to girls, boys may be relatively protected against adiposity gain related to changes in PA, as they experience a decrease of PA contribution to total energy expenditure during puberty. These distinct patterns in boys and girls for the relationship between PA and adiposity changes may be related to hormonal changes. Growth hormone and testosterone are lipolytic hormones that may oppose, in pubertal boys, the effects of behavioural factors promoting adiposity. [37] In contrast, low level of testosterone and stimulatory effect of estradiol on leptin may potentiate such effects in girls. [38, 39]

In our population, we observed no cross-sectional relationship between the level of PA or screen viewing and the level of adiposity at baseline or follow-up. This may be related to the fact that we had excluded obese subjects at baseline, but may also be related to a lack of accuracy or appropriateness of instruments for PA assessment Adiposity changes were predicted by the level of moderate PA in the past 2 weeks, but not by other PA variables, including objective assessment of ambulatory activity using a step-counter. Recording the number of days with at least 20 minutes of moderate PA during the past 2 weeks may give a better evaluation of the habitual PA level than other measurements. Vigorous PA, yet assessed the same way as moderate PA, ambulatory activity and total leisure time PA may be too selective to provide a reliable estimation of habitual PA in adolescents, particularly in girls. It has also to be emphasized that changes overtime were more significant with our moderate PA variable that with our vigourous PA variable. Ideally, PA assessment should be reliable, simple to perform, and reflect usual rather than current activity. Cross-sectional studies in children show small to moderate mean effect size between PA and adiposity,

depending on the type of PA measurements used. [40] Greater effects were found when using motion counters compared to questionnaires. Motion counters are thought to offer an objective measure of PA and they may acceptably reflect habitual PA, provided that the recording period would be of several days. Pedometers only provide data on the number of steps performed when walking or running, and give no indication on PA intensity. [23] A recent cross-sectional study using accelerometers has found that childhood overweight is more significantly related to vigorous than moderate PA in both boys and girls. [41]

In line with data reported by Maffeis et al. [19], our results suggest that in Europe, where the prevalence of obesity is lower than in the USA, a lack of PA is probably not a main explanatory factor for adiposity gain during puberty in non-obese subjects. PA decrease during puberty may be preponderant over inactivity before puberty, as a risk factor for obesity. In this view, children with the highest levels of PA before puberty may be particularly at risk for obesity. Maintaining PA level in these subjects throughout puberty, and beyond, could be a major goal for intervention programs. Interventions may also need to be differentiated between girls and boys. Ideally, a trial intended to prevent obesity in children should target globally physical and sedentary activities, as well as nutritional behaviours in both school and family environments. Results of several trials performed in this field [42-46] are encouraging, but they suggest that the effect of PA alone on preventing adiposity gain is limited. Rather than a global promotion of PA, a relevant approach for such programs would be to focus on determinants of PA decrease during puberty. To better delineate these determinants appears a priority for the design of obesity prevention interventions in children.

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Table 1 Characteristics of the population at baseline and follow-up

	At baseline (1999)			*At follow-up (2001)*			*Changes*	
	Boys	*Girls*	*P-value*	*Boys*	*Girls*	*P-value*	*P-value in Boys*	*P-value in Girls*
N	222	214		222[a]	214[a]			
Age (y)	13.5 ± 2.4	13,3 ± 2.6	0.36	15,4 ± 2.4	15,2 ± 2.6	0.36		
Tanner stage								
I	20.7	19.2		7.7	6.1			
II	20.3	14.5	0.12	9	6.1	0.05	<0.0001	<0.0001
III	18.9	20.6		14.4	11.7			
IV	26.6	26.6		30.2	27.6			
V	13.5	19.2		38.7	48.5			
Body mass index (kg/m^2)	18.4 ±3.0	18,7 ± 2.8	0.29	19,6 ± 3.2	19.7 ± 2.8	0.75	<0.0001	<0.0001
Percent body fat	13.3 + 6.0	22.7 + 7.6	<0.0001	11.7 ± 6.0	22.5 ± 7.3	<0.0001	<0.0001	0.76
Sum of skinfolds (mm)	36.5 ± 21.1	48.6 ± 21.4	<0.0001	38.2 ± 22.3	51.6 ± 22.1	<0.0001	0.06	0.006
Waist circumference (cm)	67.2 ± 0;81	64,6 ± 7.1	0.0003	70.7 ± 8.4	66.3 ± 6.4	<0.0001	<0.0001	<0.0001
Vigorous PA[b]			<0.0001			0.008	0.37	0.26
1	14.4	28.0		17.5	21.4			

2	26.6	37.4		25.3	35.4			
3	29.3	22.0		28.4	24.7			
4	14.4	9.8		18.6	13.5			
5	15.3	2.8		10.3	5.0			
Moderate PA[b]								
1	8.6	7.9		17.5	12.4			
2	23.9	32.7	0.19	27.3	30.3	0.94	0.006	0.02
3	31.5	26.2		25.8	33.7			
4	15.8	16.8		16.0	15.2			
5	20.3	16.4		13.4	8.4			
Leisure time PA (h/wk)	6.9 ± 5.7	3.9 ± 3.4	<0.0001	5.7 ± 5.9	3.6 + 4.11	<0.0001	0.008	0.25
Ambulatory activity (1000 steps/d)	64 ± 28	53 ± 20	<0.0001					
TV/video games (h/wk)	13.4 ± 7.2	13.1 ± 7.7	0.71	18.4 ± 10.1	15.3 ± 8.2	0.002	<0.0001	0.01

Results are given as % or mean value ± SD. PA: physical activity. [a]Except for vigorous and moderate PA and TV/video games (n=194 in boys, n=178 in girls). [b]Number of days in past 2 weeks with at least 20 minutes of the corresponding PA.

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Table 2 Adiposity at follow-up according to baseline physical activity levels in girls

	Adiposity at follow-up							
	Body Mass Index (kg/m^2)[a]	*P-value*	*Percent body fat*	*P-value*	*Sum of skinfolds (mm)[a]*	*P-value*	*Waist circumference (cm)*	*P-value*
Level of vigorous PA								
Low	19.6 (19.4-19.9)	0.37	23.0 (22.2-23.8)	0.14	48.0 (45.9-50.3)	0.70	66.5 (65.9-67.2)	0.43
High	19.5 (19.3-19.7)		22.1 (21.3-23.0)		47.4 (45.1-49.8)		66.1 (65.5-66.8)	
Level of moderate PA								
Low	19.4 (19.2-19.6)	0.03	21.8 (21.0-22.6)	0.01	45.6 (43.5-47.9)	0.01	65.8 (65.1-66.5)	0.03
High	19.7 (19.5-20.0)		23.3 (22.5-24.1)		49.7 (47.5-52.1)		66.8 (66.2-67.5)	
Level of leisure-time PA								

Low	19.4 (19.2-19.6)	0.04	22.6 (21.8-23.4)	0.96	48.6 (46.3-51.0)	0.29	66.1 (65.5-66.8)	0.34
High	19.7 (19.5-20)		22.6 (21.8-23.4)		46.9 (44.7-49.2)		66.6 (65.9-67.2)	
Level of ambulatory activity								
Low	19.5 (19.3-19.8)	0.52	22.6 (21.8-23.4)	0.69	48.4 (46.1-50.8)	0.61	66.6 (65.9-67.3)	0.52
High	19.6 (19.4-19.9)		22.8 (22.0-23.6)		47.5 (45.3-49.9)		66.3 (65.6-67.0)	
Level of TV/video games								
Low	19.6 (19.4-19.9)	0.34	22.6 (21.7-23.4)	0.94	48.5 (46.2-50.9)	0.35	66.7 (66.1-67.4)	0.11
High	19.5 (19.3-19.7)		22.6 (21.8-23.4)		47.0 (44.8-49.3)		66.0 (65.3-66.6)	

All models took into account familial link as a random effect and included adjustment on Tanner stage, age and the corresponding adiposity variable at baseline. Waist circumference was adjusted for height at baseline. Results are given as mean value (CI95%). PA: physical activity. “Low” and “High” were determined with reference to the median value in age-related sextiles. [a]Log-corrected.

Table 3 Adiposity at follow-up according to variation of physical activity from baseline to follow-up in girls

	Body Mass Index (kg/m^2)[a]	*P-value*	*Percent body fat*	*P-value*	*Sum of skinfolds (mm)*[a]	*P-value*	*Waist circumference (cm)*	*P-value*
Level of vigorous PA								
Decreasing	19.1 (18.8-19.5)		22.4 (21.1-23.6)		48.2 (44.9-51.8)		65.7 (64.6-66.7)	
Sustained low	19.4 (19.1-19.7)	0.55	23.3 (22.1-24.4)	0.28	48.5 (45.4-51.9)	0.11	66.5 (65.6-67.4)	0.54
Sustained high	19.4 (19.0-19.8)		21.4 (20.0-22.9)		43.3 (40.0-47.0)		65.5 (64.3-66.7)	
Increasing	19.5 (19.1-19.9)		22.4 (21.1-23.8)		45.0 (41.8-48.6)		65.9 (64.8-67.0)	
Level of moderate PA								
Decreasing	19.6 (19.3-19.9)		24.1 (22.8-25.3)		49.0 (45.8-52.4)		67.0 (66.1-68.0)	
Sustained low	19.3 (18.9-19.6)	0.06	21.4 (20.1-22.7)	0.02	44.4 (41.2-47.8)	0.06	65.5 (64.5-66.6)	0.06
Sustained high	19.5 (19.1-19.8)		22.6 (21.4-23.8)		48.4 (45.3-51.8)		66.0 (65.0-67.0)	
Increasing	18.9 (18.6-19.3)		21.4 (20.1-22.7)		43.5 (40.4-46.9)		65.0 (63.9-66.0)	
Level of leisure-time PA								
Decreasing	19.8 (19.5-20.2)	0.21	23.3 (22.0-24.5)	0.37	47.9 (44.6-51.4)	0.55	67.6 (66.7-68.7)	0.03
Sustained low	19.4 (19.2-19.7)		22.9 (21.9-23.9)		49.1 (46.3-52.1)		66.1 (65.3-66.9)	

Sustained high	19.7 (19.4-20.0)		22.1 (20.9-23.2)		46.1 (43.2-49.1)		65.6 (64.7-66.5)	
Increasing	19.3 (18.9-19.7)		21.9 (20.4-23.3)		47.6 (43.9-51.7)		66.0 (64.9-67.1)	
Level of TV/video games								
Decreasing	19.2 (18.8-19.5)		21.9 (20.5-23.3)		46.6 (41.2-48.3)		65.7 (64.5-66.8)	
Sustained low	19.1 (18.8-19.4)	0.17	21.4 (20.2-22.6)	0.13	44.1 (41.2-47.2)	0.09	65.3 (64.4-66.3)	0.13
Sustained high	19.4 (19.1-19.7)		23.0 (21.9-24.1)		47.6 (44.7-50.8)		65.8 (64.9-66.7)	
Increasing	19.6 (19.2-20.1)		23.4 (22.9-24.9)		50.2 (46.1-54.7)		67.2 (66.0-68.5)	

All models took into account familial link as a random effect and included adjustment on adiposity, Tanner stage and age at baseline. Waist circumference was adjusted for height at baseline and all adiposity . Results are given as mean value (CI95%). PA physical activity. [a]Log-corrected.

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Figure 1 Adiposity at follow-up according to variation of vigorous physical activity from baseline to follow-up in boys.

Results are given as mean value 95% confidence interval. A Log transformation was used for skinfolds. All models were adjusted for Tanner pubertal stage, age and the corresponding adiposity value at baseline and for a family variable as a random effect. Waist circumference was adjusted for height.