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Association of a Central Pattern of Body Fat with Blood Pressure and Lipoproteins from Adolescence into Adulthood

The Amsterdam Growth and Health Study

Frank J. van Lenthe, Willem van Mechelen, Han C. G. Kemper, and Jos W. R. Twisk

The association between the change in a central pattern of body fat and blood pressure and lipoprotein levels was investigated longitudinally in a healthy population of young males and females over 15 years. The subjects (males, n = 84; females, n = 98), participants in the Amsterdam Growth and Health Study, were measured six times between the mean ages of 13 and 27 years. As an indicator of a central pattern of body fat, subscapular/triceps skinfold ratio (S/T ratio) was used as an independent variable. Systolic blood pressure (SBP), diastolic blood pressure (DBP), total serum cholesterol (TC), high density lipoprotein cholesterol (HDL-C), and TC/HDL-C ratio were used as dependent variables. Longitudinal associations were analyzed by generalized estimating equations (GEE) in which data of the six periods of measurement were included simultaneously. Between ages 13 and 27 years, and after adjustment for the sum of four skinfolds, physical activity, smoking, and alcohol intake, the increase of the S/T ratio was significantly associated with an increase in SBP in males and females and with a decrease in level of HDL-C in males only. The change in central pattern of body fat negatively affects the change in established risk factors for cardiovascular diseases early in life. *Am J Epidemiol* 1998;147:686–93.

adolescence; body constitution; blood pressure; lipoproteins; longitudinal studies

Prospective studies have shown that a central pattern of body fat, with relatively more fat stored on the trunk than the extremities, is associated with mortality from cardiovascular diseases in adults (1–4). Reported associations of a central pattern of body fat with increased levels of blood pressure (5, 6) and serum cholesterol (7), and decreased levels of high density lipoprotein cholesterol (HDL-C) (8, 9) suggest that this association, at least partly, is mediated through these established cardiovascular disease risk factors.

It has been recognized that late childhood and youth are important periods for the development of characteristics predisposing to cardiovascular disease (10, 11). As a consequence, the change in blood pressure and levels of lipoproteins in youth has been studied extensively. During adolescence, systolic blood pressure (SBP) and diastolic blood pressure (DBP) tend to increase (12). Increases were also found for levels of total serum cholesterol (TC) in males and females from adolescence into adulthood (13–15). A decrease in level of HDL-C has been reported from adolescence into adulthood in males, while in females the change in HDL-C levels is relatively constant during adolescence and increases from adolescence into adulthood (15).

Longitudinal research on the change in a central pattern of body fat, in particular in youth and young adulthood, is limited. Recently, we reported that the change in a central pattern of body fat, mainly occurring in males, starts in adolescence (16). Longitudinal studies on the association of the change in a central pattern of body fat with the change in levels of lipoproteins and blood pressure from youth into adulthood could contribute to the elucidation of the pathophysiologic mechanism relating this pattern of body fat to the increased occurrence of cardiovascular disease.

In the Amsterdam Growth and Health Study, a longitudinal study carried out in the Netherlands, indicators of body composition and cardiovascular disease risk indicators were measured over a period of 15

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Abbreviations: CI, confidence interval; DBP, diastolic blood pressure; GEE, generalized estimating equations; HDL-C, high density lipoprotein cholesterol; SBP, systolic blood pressure; SSF, sum of four skinfolds; S/T ratio, subscapular/triceps skinfold ratio; TC, total serum cholesterol.

From the Institute for Research in Extramural Medicine, Faculty of Medicine, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands.

Reprint requests to Prof. dr. HCG Kemper, Institute for Research on Extramural Medicine, Faculty of Medicine, Vrije Universiteit Amsterdam, Van der Boechorststraat 7, 1081 BT Amsterdam, The Netherlands.

years between 13 and 27 years of age (17). In the present study, the association between the change in a central pattern of body fat and blood pressure and lipoprotein levels was investigated between 13 and 27 years of age in healthy males and females.

MATERIALS AND METHODS

Study design and population

The design of the Amsterdam Growth and Health Study, recruitment of subjects, and methods used have been described in detail elsewhere (17–19). In short, the initial aim of the study was to describe physical growth and psychological development in terms of changes of body composition, physical fitness, personality traits, and biologic and life-style risk indicators for cardiovascular disease.

For that purpose, subjects in the first and second grade of a secondary school in Amsterdam, the Netherlands, were invited to participate in the study. At the initial measurement in 1977, subjects had a mean age of 13 years (±0.6 years). During 1977–1980, annual measurements were performed. Additional follow-up measurements were carried out in 1985 and 1991 with the subjects at mean ages of 21 and 27 years, respectively.

Of the initial population of 148 boys and 159 girls, 46 boys (31.1 percent) and 28 girls (17.6 percent) dropped out of the study between 1977 and 1980. Major reasons for this loss to follow-up were leaving school and/or moving out of town. From 1980 to 1991, another 18 males (17.6 percent) and 33 females (25.2 percent) dropped out of the study, either because they were not reachable or not motivated to participate any longer. As a result, complete follow-up data were available for 84 men and 98 women between the mean ages of 13 and 27 years.

Central pattern of body fat

Two trunk skinfolds (subscapular, suprailiac) and two extremity skinfolds (biceps, triceps) were measured with a Harpenden caliper (Holtain, Dyfed, UK) to the nearest 0.1 mm according to the recommendations of the International Biological Programme (20). Two measurements were done and the highest value was used in the analyses. Over the entire period of study, only two trained examiners (RV from 1977 until 1985 and WvM in 1991) were involved in the measurements of the skinfolds. In order to examine reproducibility of the skinfold measurements, correlation coefficients were calculated for every skinfold between all possible periods of measurements. The interperiod correlation coefficients (IPC) were regressed on the time between the measurements. Van't Hof et al. (21) showed that the intercept of such a regression equation, which approximates the correlation between the measurements when the time between the measurements is assumed to be zero, may be interpreted as a coefficient of reproducibility. For the single skinfolds, these reproducibility coefficients were ≥0.8 for the single skinfolds. The reproducibility coefficients, based on the measurements of the first examiner only (approximate within-examiner coefficients) were 0.02 to 0.07 higher. The subscapular/triceps skinfold ratio (S/T ratio) was used as an indicator of a central pattern of body fat:

$$\text{S/T ratio} = \frac{\text{subscapular}}{\text{triceps}}.$$

Biologic risk indicators for cardiovascular diseases

Systolic (SBP) and diastolic blood pressure (DBP) were measured in duplicate with a sphygmomanometer with the subject in a sitting position by the same examiner (HCGK) at all periods of measurement. A standard pressure cuff (23 × 12 cm) was placed around the left arm. Diastolic blood pressure was based on the disappearance of the fourth Korotkoff sound. In young subjects, excitement may easily elevate the resting blood pressure. Because the upper arm diameter increases during adolescence and the same cuff was used, this could also result in an overestimation of the blood pressure. Therefore, the lowest value of the two blood pressure measurements was used in the analyses.

With the subjects in non-fasting state, a sample of 10 ml blood was taken from the vena antecubita. From this sample, TC was obtained as described by Huang et al. (22) and Abell et al. (23). HDL-C was obtained as described by Burstein et al. (24). From both measurements, the TC/HDL-C ratio was calculated.

Potential confounding variables

The sum of four skinfolds (SSF) was calculated in order to adjust for the potential confounding effect of total body fatness. Seidell et al. (25) concluded that physical activity and smoking could confound the relation between the distribution of body fat and diseases. In the Amsterdam Growth and Health Study, physical activity was assessed with a standardized interview, enquiring about activities in the previous 3 months. Activities were translated into metabolic-equivalent (MET) scores (an activity of 1 MET demands the energy equivalent of the basal metabolic rate). A weighted activity score was calculated from all activities demanding more than 4 METs by multi-

plying the total amount of time spent to an activity with a fixed value based on categories of energetic intensity in which the activities were categorized (5.5 for light, 8.5 for medium, and 11.5 for heavy activities) (26, 27). As a result, the weighted physical activity scores took into account both the time and intensity of an activity.

From information obtained by questionnaire, individuals were characterized as smokers (>0 cigarettes per week) or nonsmokers at every period of measurement. Alcohol intake was found to be related to both the distribution of body fat (28) and blood pressure and lipoproteins (29) and could therefore also confound this relation. In our study, information on alcohol intake was obtained as part of a cross-check dietary history interview at every period of measurement (30). Subjects were classified as alcohol users (mean alcohol intake >0 g alcohol per week) or nonusers.

Statistical analysis

In order to investigate the change in the S/T ratio and blood pressure or levels of lipoproteins, generalized estimating equations (GEE) analysis was used (31, 32). By means of this longitudinal data analysis method, data obtained at several periods of measurement could be used simultaneously. The following model was used to analyze the data:

$$Y_{it} = \beta_0 + \sum_{j=1}^{J} \beta_{1j} X_{ijt} + \beta_2 t + \sum_{k=1}^{K} \beta_{3k} Z_{ikt} + \epsilon_{it},$$

where Y_{it} = observations of individual i from t_1 to t_m (and m = the number of measurements); t = time; β_0 = intercept; J = number of independent variables; β_{1j} = standardized regression coefficient of the independent variable j; X_{ijt} = independent variable j of subject i at time t; β_2 = regression coefficient of time; K = number of time-dependent covariates; β_{3j} = standardized regression coefficient of time-dependent covariate k; Z_{ikt} = time-dependent covariate k of individual i; and ϵ_{it} = measurement error of individual i.

Inclusion of all available data is allowed in GEE analyses because correction has to be made for within-subject correlation. Based on the actual correlation coefficients between the S/T ratio at all periods of measurement, a stationary m-dependent correlation structure was used, in which the correlation coefficients between maximally m periods of measurements have different values (>0) and correlations between data obtained more than m periods of measurement apart are zero. In this study, we used data from six periods of measurement in the analysis, and a stationary 5-dependent correlation structure was chosen. Prior to the analysis, all data were z-converted and hence the coefficients of interest (β_1) could be interpreted as standardized longitudinal regression coefficients or, because they vary between −1 and 1, as longitudinal correlation coefficients.

In a first analysis, the associations between change in the S/T ratio (independent variable) and SBP, DBP, levels of TC, HDL-C, or the TC/HDL-C ratio (dependent variables) were investigated. We sought to find out whether this association was different over time by investigating a possible interaction effect, i.e., S/T ratio × time. In subsequent analyses, SSF was forced into the model in order to adjust for total body fatness. Finally, physical activity, alcohol intake, and smoking behavior were entered into the model as covariates. Analyses were carried out with the use of SPSS (33) and SPIDA (34).

SF ratio

RESULTS

Means (and standard deviations) of the independent and dependent variables at all periods of measurement are presented in tables 1 and 2 for males and females, respectively. The S/T ratio started to increase in adolescence, particularly in males. In general, blood pressure and lipoprotein levels developed unfavorably from adolescence into adulthood.

Tables 1 and 2 also show the mean values at the first period of measurement for the subjects who dropped out of the study. No statistically significant differences were found for males between those who remained in and those who dropped out of the study at the first period of measurement. In females, the subscapular skinfold thickness was significantly higher and the mean level of HDL-C was significantly lower in the dropouts compared with the longitudinal group ($p < 0.05$).

Table 3 presents the results of the GEE analyses in which the association between the change in a central pattern of body fat and blood pressure was investigated for males and females. Increase in the S/T ratio was significantly associated with increase in SBP for males between ages 13 and 27 years. After adjustment for SSF and the behavioral variables (physical activity, smoking, and alcohol intake), the association remained statistically significant. A significant negative interaction effect was found, which indicates that the association between the S/T ratio and SBP was stronger at younger ages compared with older ages. This was confirmed in analyses for the period between ages 13 and 16 years (β = 0.15, 95 percent confidence interval (CI) 0.02–0.28) and between ages 13 and 21 years (β = 0.16, 95 percent CI 0.04–0.28). No significant association was found between change in S/T ratio and DBP in males. In females, only after adjustment for

TABLE 1. Means (and standard deviations) of skinfolds, blood pressure, and lipoproteins at six periods of measurement between 13 and 27 years of age in males (n = 84): the Amsterdam Growth and Health Study, 1977–1991

Variable	Mean age (years)						
	13	13	14	15	16	21	27
	*Dropouts**	*Study participants*					
Triceps (10^{-1} mm)	98 (45)	94 (34)	92 (32)	81 (28)	79 (25)	82 (32)	87 (32)
Subscapular (10^{-1} mm)	72 (57)	66 (31)	68 (26)	72 (29)	74 (20)	103 (29)	115 (37)
S/T ratio†	0.75 (0.27)	0.71 (0.18)	0.78 (0.21)	0.92 (0.24)	0.97 (0.23)	1.34 (0.35)	1.39 (0.34)
SBP† (mmHg)	124 (10)	124 (9)	124.7 (8.5)	127.2 (8.9)	131.0 (9.6)	133.2 (10.5)	136.1 (10.7)
DBP† (mmHg)	74 (8)	74 (8)	74.8 (7.5)	71.8 (8.0)	72.5 (8.7)	79.0 (7.7)	82.1 (8.4)
TC† (mmol/liter)	4.52 (0.74)	4.45 (0.64)	4.25 (0.65)	4.07 (0.67)	3.95 (0.61)	4.47 (0.79)	4.94 (0.89)
HDL-C† (mmol/liter)	1.45 (0.30)	1.50 (0.27)	1.42 (0.26)	1.25 (0.21)	1.29 (0.19)	1.16 (0.20)	1.19 (0.22)
TC/HDL-C ratio	3.20 (0.01)	3.05 (0.62)	3.07 (0.66)	3.35 (0.76)	3.12 (0.55)	3.96 (0.94)	4.28 (1.05)

* Mean values at first period of measurement for those who dropped out of the study.
† S/T ratio, subscapular/triceps ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total serum cholesterol; HDL-C, high density lipoprotein cholesterol.

↑central BF ↑ sep ♂, ♀

SSF and the behavioral variables was increase in S/T ratio significantly associated with increase in SBP between ages 13 and 27 years. No associations were found between change in S/T ratio and in DBP.

Table 4 presents the results of the analyses in which the associations between change in a central pattern of body fat and levels of lipoproteins were investigated for males and females. In males, the increase of the S/T ratio was significantly associated with decrease in TC level between ages 13 and 27 years. However, after adjustment for SSF, this association no longer remained statistically significant. The increase in S/T ratio was statistically significantly associated with decrease in level of HDL-C. After adjustment for SSF, physical activity, smoking, and alcohol intake, the association remained statistically significant. No association was found between the change in S/T ratio and the TC/HDL-C ratio in males. In females, no statistically significant associations were found between change in the S/T ratio and the lipoprotein levels.

DISCUSSION

↑SES

In this study, change in a central pattern of body fat was investigated in relation to changes in blood pressure and levels of lipoproteins in a healthy population aged 13–27 years. The results suggest that, independent of total body fatness, physical activity, smoking, and alcohol intake, the increase of a central pattern of body fat is associated already with an increase in SBP in the second decade of life in males and females. After adjustment for the above-mentioned variables, the increase of a central pattern of body fat was further associated with a decrease in level of HDL-C in males aged 13–27 years.

In order to interpret our results, several considerations need to be taken into account.

From the income of the parents, level of education, and occupation, it appeared that the mean socioeconomic status of the population was slightly above the mean of the Dutch population (35). It therefore seems

TABLE 2. Means (and standard deviations) of skinfolds, blood pressure, and lipoproteins at six periods of measurement between 13 and 27 years of age in females (n = 98): the Amsterdam Growth and Health Study, 1977–1991

Variable	Mean age (years)						
	13	13	14	15	16	21	27
	Dropouts†	*Study participants*					
Triceps (10^{-1} mm)	136 (55)	120 (44)	133 (43)	144 (46)	152 (48)	167 (52)	150 (48)
Subscapular (10^{-1} mm)	102 (57)	81 (28)*	90 (29)	102 (29)	107 (38)	140 (55)	124 (47)
S/T ratio‡	0.76 (0.28)	0.70 (0.18)	0.70 (0.17)	0.73 (0.20)	0.73 (0.20)	0.86 (0.24)	0.85 (0.24)
SBP‡ (mmHg)	125 (7)	124 (9)	122.1 (10.2)	121.3 (10.2)	120.6 (9.2)	124.5 (10.1)	123.2 (9.2)
DBP‡ (mmHg)	76 (8)	78 (7)	76.7 (7.3)	75.1 (8.0)	75.1 (7.5)	78.1 (8.3)	79.6 (7.6)
TC‡ (mmol/liter)	4.31 (0.67)	4.40 (0.72)	4.36 (0.68)	4.43 (0.71)	4.37 (0.72)	4.48 (0.70)	5.28 (0.94)
HDL-C‡ (mmol/liter)	1.31 (0.22)	1.43 (0.30)*	1.40 (0.26)	1.33 (0.25)	1.40 (0.27)	1.40 (0.29)	1.63 (0.36)
TC/HDL-C ratio	3.35 (0.66)	3.19 (0.71)	3.20 (0.65)	3.41 (0.71)	3.22 (0.76)	3.61 (0.81)	3.34 (0.80)

*$p < 0.05$ between dropouts and study participants at first period of measurement.
† Mean values at first period of measurement for those who dropped out of the study.
‡ S/T ratio, subscapular/triceps ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total serum cholesterol; HDL-C, high density lipoprotein cholesterol.

TABLE 3. Standardized longitudinal regression coefficients (β)† for the change in the subscapular/triceps skinfold ratio and systolic and diastolic blood pressure in males and females between 13 and 27 years of age: the Amsterdam Growth and Health Study, 1977–1991

	Univariate		Adjusted for sum of four skinfolds		Adjusted for sum of four skinfolds and behavioral variables‡	
	β	95% CI§	β	95% CI	β	95% CI
Males (n = 84)						
SBP§	0.10¶	0.01 to 0.20*	0.11	0.02 to 0.20*	0.12	0.03 to 0.21*
DBP§	0.04	−0.07 to 0.14	0.04	−0.05 to 0.16	0.04	−0.06 to 0.14
Females (n = 98)						
SBP	0.07	−0.03 to 0.17	0.16	−0.00 to 0.32	0.20	0.03 to 0.38*
DBP	0.01	−0.09 to 0.10	0.03	−0.09 to 0.14	–#	

*$p < 0.05$.
† Due to the z-conversion of the data, all coefficients vary between −1 and 1 and can be interpreted as longitudinal correlation coefficients.
‡ Physical activity, smoking, and alcohol intake.
§ CI, confidence interval; SBP, systolic blood pressure; DBP, diastolic blood pressure.
¶ Negative interaction effect over time.
# Did not converge in 50 iterations.

reasonable to expect that the health status of our population is slightly above the mean health status of the Dutch population. This was further confirmed by comparing the prevalences of risk factors in our population with those in the Dutch population. For example, it is estimated that 45 percent of the males and 35 percent of the females in the Dutch adult population have a body mass index (BMI) (kg/m^2) ≥25 (36), while in our population 19 percent of males and 15 percent of females have such a BMI. If an association between a central pattern of body fat and blood pressure or lipoproteins only occurs above a certain level of central pattern of body fat, this could have resulted in an underestimation of the association from youth into adulthood.

In this study, data were analyzed using GEE analysis, a promising technique for analyzing longitudinal epidemiologic data. The use of data from several periods of measurements improves the statistical efficiency of estimations of longitudinal associations. In traditional regression analysis, the assumption of independence of the errors does not allow use of repeated measurements from the same subjects. GEE analysis requires a defined correlation structure in order to correct for within-subject correlation. The choice for this structure has to be made on biologic reasons. Although it can not be guaranteed that the right choice was made (i.e., the stationary 5-dependent correlation structure), an advantage of GEE analysis is that the estimation of the regression coefficient is rather robust for the choice of the correlation structure. For example, using an exchangeable structure (in which the correlation between data obtained at different periods of measurement are all the same) in the

TABLE 4. Standardized longitudinal regression coefficients (β)† for the association between the change in the subscapular/triceps skinfold ratio and levels of total serum cholesterol (TC), high density lipoprotein cholesterol (HDL-C), and the TC/HDL-C ratio in males and females between 13 and 27 years of age: the Amsterdam Growth and Health Study, 1977–1991

	Univariate		Adjusted for sum of four skinfolds		Adjusted for sum of four skinfolds and behavioral variables‡	
	β	95% CI§	β	95% CI	β	95% CI
Males (n = 84)						
TC	−0.11	−0.19 to −0.02*	−0.08	−0.16 to 0.01	−0.08	−0.18 to 0.01
HDL-C	−0.12	−0.23 to −0.02*	−0.15	−0.24 to −0.05*	−0.14	−0.24 to −0.05*
TC/HDL-C ratio	0.04	−0.06 to 0.15	0.08	−0.01 to 0.18	0.08	−0.02 to 0.18
Females (n = 98)						
TC	0.02	−0.06 to 0.11	0.09	−0.04 to 0.21	−0.01	−0.34 to 0.34
HDL-C	−0.04	−0.15 to 0.06	−0.08	−0.22 to 0.06	0.01	−0.15 to 0.16
TC/HDL-C ratio	−0.00	−0.10 to 0.09	−0.04	−0.22 to 0.14	−0.11	−0.32 to 0.11

* $p < 0.05$.
† Due to the z-conversion of the data, all coefficients vary between −1 and 1 and can be interpreted as longitudinal correlation coefficients.
‡ Physical activity, smoking, and alcohol intake.
§ CI, confidence interval.

analysis between a central pattern of body fat and blood pressure or TC over the entire period of study did not result in essential changes in β in males (maximum difference was 0.03). In addition, GEE analysis produces a robust estimator of the variance, which reduces the possibility of incorrect statistical inferences.

In the analysis, z-scores were used. Thus, development over time of the mean values (being zero at all periods of measurement) was best described by a linear function. The advantage of using z-scores was that they resulted in standardized regression coefficients which could be compared with each other. According to tables 1 and 2, however, the change in several variables was probably better described by a non-linear function of time. Using the absolute values of the variables in a polynomial regression analysis, it appeared that for the change in DBP, TC, and HDL-C in males and SBP and DBP in females, a second-degree polynomial function should be considered (data not shown). Therefore, GEE analyses were carried out using the absolute values of these variables in a second-degree polynomial function. Unfortunately, these equations could not be solved due to the occurrence of collinearity. The possibility cannot be excluded, however, that if these equations could be solved they would have resulted in more statistically significant associations.

A major obstacle in studies of the distribution of body fat in youth is the choice of the most appropriate indicator. To date, skinfold ratios, contrasting subcutaneous fat on the trunk with fat on the extremities, and circumference ratios such as the waist-to-hip ratio (WHR) and the waist-to-girth ratio (WGR) are among the most frequently used indicators. In an often-cited hypothesis concerning the mechanism relating a central pattern of body fat to blood pressure or lipoproteins, hypertrophied intra-abdominal adipocytes play a key role. Validated with computed tomography, WHR would be a slightly better indicator of a central distribution of body fat compared with trunk-extremity skinfold ratios in adulthood (37, 38). The use of WHR, however, has not yet been validated in adolescents (39). Probably the use of the conicity index (40) could result in an improvement of measuring the distribution of body fat in adolescents. In longitudinal studies, however, trunk and extremity skinfolds remain important indicators of body fat distribution in adolescence.

As an indicator of a central pattern of body fat, the S/T ratio was used in this study. Theoretically, an increase of this ratio could be due to an increase of the subscapular skinfold thickness and/or a decrease in the triceps skinfold thickness. Investigating the association between the change in separate skinfolds and blood pressure or lipoprotein levels could yield additional information, particularly after adjustment for total body fatness. However, the presence of collinearity did not allow these analyses, particularly in males.

Obviously, from the four skinfolds measured, several ratios could be constructed in which fat on the trunk was contrasted with fat on the extremities. In addition to the S/T ratio, we constructed the SS/SSBT ratio, i.e.,

$$\text{SS/SSBT ratio} = \frac{\text{subscapular} + \text{suprailiac}}{\text{biceps} + \text{triceps} + \text{subscapular} + \text{suprailiac}}.$$

We found essentially the same associations for this ratio with blood pressure and lipoprotein levels as we found for the S/T ratio (data not shown). However, in males, there was a positive association between change in SS/SSBT ratio and TC/HDL-C ratio (β = 0.14, 95 percent CI 0.04–0.24), although this association did not remain statistically significant after adjustment for SSF (β = 0.14, 95 percent CI −0.03 to 0.15). In females, a weak and unexpected negative association was found between change in SS/SSBT ratio and TC/HDL-C ratio (β = −0.07, 95 percent CI 0.13 to −0.02) which did remain statistically significant after adjustment for SSF (β = 0.07, 95 percent CI −0.13 to −0.01).

An important question, however, is what exactly is measured by trunk-extremity skinfold ratios. If the association between central pattern of body fat and blood pressure or lipoproteins is mediated by hypertrophied intra-abdominal adipocytes, trunk-extremity skinfold ratios could be a weak reflection of the amount of intra-abdominal fat. Therefore, the associations reported would underestimate the real association. It can also be speculated, however, that trunk-extremity skinfold ratios measure a different aspect of body composition compared with the amount of intra-abdominal fat, as has been suggested by Hafner et al. (41). As a consequence, our results justify more research on the interpretation of trunk-extremity skinfold ratios and their metabolic complications.

Using data from the Fels Longitudinal Study, Baumgartner et al. (42) found an association between the change in a central pattern of body fat (also measured by the S/T ratio) and decreasing HDL-C concentrations for boys between 11 and 18 years of age. This relation was confirmed in a cross-sectional study among children and adolescents (43). Stallones et al. (44) reported a statistically significant association between trunk-extremity skinfold ratio and SBP for white males between 12 and 17 years of age. After adjustment for body weight, this association was no

longer significant. In the Bogalusa Heart Study (45), a statistically significant correlation was found between a central pattern of body fat and SBP and DBP for males, even after adjustment body height. During adolescence, this association was slightly lower than it was in young adulthood. For females, the weak association between a central pattern of body fat and SBP between ages 13 and 17 years became nonsignificant between ages 18 and 24 years.

Our findings that change in a central pattern of body fat is associated with an increase in SBP in both sexes and a decrease in level of HDL-C in males only between ages 13 and 27 years indicated that there is a need to search for determinants of the change in a central pattern of body fat. In a previous study (46), we reported the association of early menarche with relatively higher mean levels of the S/T ratio between ages 13 and 27 years. With regard to primary prevention of the change in a central pattern of body fat, future research should investigate the effects of behavioral determinants on change in a central pattern of body fat in youth.

In conclusion, after adjustment for SSF, physical activity, smoking, and alcohol intake, a significant association was found between the increase of a central pattern of body fat and the increase in SBP for both males and females between ages 13 and 27 years in our study. In addition, in males between ages 13 and 27 years, the increase of a central pattern of body fat was associated with a decrease in level of HDL-C.

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