Subcutaneous Fat Mass in Japanese Young Children

Komiya, Shuichi Graduate School of Human-Environment Studies, Kyushu University

Eto, Chieko Graduate School of Human-Environment Studies, Kyushu University

Otoki, Kodo Graduate School of Human-Environment Studies, Kyushu University

Teramoto, Keisuke Atago Orthopedic Surgery

https://doi.org/10.15017/723

出版情報:健康科学. 23, pp.31-39, 2001-03-01. Institute of Health Science,Kyushu University バージョン: 権利関係: - ORIGINAL -

Subcutaneous Fat Mass in Japanese Young Children

Shuichi KOMIYA, Chieko ETO¹⁾, Kodo OTOKI¹⁾ and Keisuke TERAMOTO²⁾

Abstract

The risk of excess fat appears to be greater in individuals who have larger subcutaneous fat measurements during childhood. However, the development of a subcutaneous fat mass (SFM) is difficult to define because it is generally difficult to measure directly. The purpose of this study was to investigate SFM in young children by measurement of anthropometric variables. The objectives of the study were to examine the differences in SFM between boys and girls, and the interrelationships between SFM and other anthropometric indices (e.g. skin-folds and skin-fold ratios) or total body fat mass (TBFM), in a homogeneous group of healthy young children. SFM was determined from anthropometric measurements, and TBFM by bioelectrical impedance analysis, in a sample of 141 boys and 139 girls, aged between 3-6 years. For each sex, the "normal-weight" group was defined based on a body mass index lying between the 25th and 75th percentiles. Sixty-nine boys (weighing 17.2 \pm 2.6 kg) and 70 girls (weighing 16.7 \pm 1.9 kg) were designated as being in the normal-weight groups. The normal-weight girls had significantly thicker skin-fold than the normal-weight boys: extremity skin-fold (37.9 \pm 5.2 vs. 35.0 \pm 6.0 mm, p < 0.01) and trunk skin-fold (19.3 \pm 4.1 vs. 17.1 \pm 3.2 mm, p < 0.001). Absolute SFM was higher in normal-weight girls than in normal-weight boys $(1.4 \pm 0.4 \text{ vs.} 1.2 \pm 0.4 \text{ kg}, p < 0.01)$. Of all the anthropometric variables, the extremity skin-fold showed the strongest correlation with SFM for the normal-weight boys (r = 0.819, p < 0.001), while the trunk skin-fold showed the strongest correlation for the normal-weight girls (r = 0.807, p <0.001). The SFM was related independently to TBFM after controlling for each anthropometric variable. The regression slopes between SFM and TBFM were not statistically different (0.251 kg SFM/kg TBFM in boys and 0.290 kg SFM/kg TBFM in girls) for either sex. It can be concluded that there are no differences in TBFM or internal fat mass between normal-weight boys and girls, whereas, in contrast, sex differences in SFM are evident. The rate of increase in SFM relative to TBFM appears to be similar for both groups.

Key words: body mass index, anthropometrics, skin-fold, subcutaneous fat mass

(Journal of Health Science, Kyushu University, 23:31-39, 2001)

Introduction

There is considerable interest in the ontogeny

of "fat patterning", because a "centripetal" distribution of subcutaneous adipose tissue, in which skin-fold thickness on the trunk is relatively

¹⁾ Graduate School of Human-Environment Studies, Kyushu University 11, Kasuga 816-8580, Japan

²⁾ Atago Orthopedic Surgery, 3–161 Atago-machi, Nobeoka 882–0872, Japan

greater than that on the limbs, is associated with an increased risk of diabetes, cardiovascular disease and hypertension in adulthood $^{(1)(2)(3)(4)(5)}$.

The risk of excess fat appears to be greater in individuals who have larger subcutaneous fat measurements during childhood⁶⁾. Several reports have appeared correlating serial measurements of skin-fold thickness in individuals from childhood to maturity⁷⁾⁸⁾. Skin-folds at the subscapular and suprailiac sites were found to increase in thickness relative to the skin-fold thickness at the triceps in each sex in late childhood, possibly coincident with pubescence or with maturation of the adrenal gland⁹⁾. These increases occurred at a younger age in girls than in boys¹⁰. However, little is known regarding patterns of change in distribution of adipose tissue the within particularly individuals, with respect to maturation events such as puberty and the Cross-sectional analyses menopause. indicate that adipose tissue is distributed peripherally in most children, irrespective of sex, prior to adolescence¹⁰.

The fat in adipose tissue is highly labile and large changes may occur over a short period of time. These changes are associated with diet, level of exercise and emotional state. With an obese child, the main problem is to estimate the fat content and distribution accurately, and to determine whether it poses a health risk. Simple weight excess evaluation, as well as the commonly used anthropometric indices (body mass index, BMI; waist to hip ratio, WHR), do not seem to be accurate enough for this purpose in children¹¹). Moreover, errors in the measurement of skin-fold thickness using calipers can be large and may increase with increasing levels of adiposity¹²⁾. The development of subcutaneous adipose tissue in young children is difficult to define because it is generally difficult to measure directly by computed tomography (CT) or magnetic resonance imaging (MRI). As a result, patterns of change in adipose tissue distribution may be complex and difficult to measure accurately. Current information on the link

between fat distribution in childhood and health problems later in life is limited to the measurement of fat distribution using crude anthropometric indices. Previous studies are limited by a lack of understanding of the relationship between subcutaneous adipose tissue content and anthropometric indices.

The objectives of this study were to examine gender differences in subcutaneous fat mass (SFM), and the interrelationships between SFM and other anthropometric indices (e.g. skin-fold thickness and skin-fold ratios) or total body fat mass (TBFM) in a homogeneous group of healthy young children.

Subjects and methods

Subjects

During October and November 1998, 280 healthy children (141 boys and 139 girls) attending three kindergartens in different parts of Fukuoka were examined. For each sex, the "normalweight" group was defined based on a BMI between the 25th and 75th percentiles. Sixty-nine (48.9%) boys and 70 (50.4%) girls were designated as belonging to the "normal-weight groups", respectively. All parents of the children their written informed consent gave to participate in the study after receiving a detailed explanation of the purpose and risks involved.

Measurement of anthropometry and total body composition by bioelectrical impedance analysis (BIA)

Height was measured to the nearest 0.1 cm. Body weight was measured to the nearest 0.02 kg on a calibrated balance-beam scale with subjects wearing light underwear. BMI was calculated as weight/height², where weight is expressed in kg and height in m. Abdominal and hip circumferences were measured with a metric plastic tape while the children stood upright. Abdominal circumference was measured at the level of the umbilicus, and hip circumference was recorded at the maximum gluteal protuberance

of the buttocks. The WHR was calculated as waist circumference/hip circumference. Skin-fold measurements were obtained using Harpenden skin-fold calipers (British Indicators, England) at the right cheek, chest 1 (diagonal fold just superior and lateral to the nipple), chest 2 (vertical fold on the mid-axillary line at the level of the xiphoid process), abdomen, suprailiac, scapula, back 1 (vertical fold just triceps. adjacent to, and level with, the vertebra prominens), back 2 (vertical fold just adjacent to the spinal column and level with, and just below, the arcus costalis), thigh 1 (vertical fold on the anterior aspect of the thigh midway between the superior aspect of the patella and anterior superior iliac spine), thigh 2 (vertical fold on the posterior aspect of the thigh), knee, calf (vertical fold on the posterior aspect of the calf at the level of maximum circumference, subject seated with lower leg dangling) and chin sites (those used by Komiya and others, 1992¹³⁾). All anthropometric measurements were performed by the same researcher and are presented here as the mean of three measurements.

TBFM and lean body mass (LBM) were estimated from total body resistance measured with a tetrapolar bioelectrical-impedance analyser (TP-95K, Toyo Physical, Inc., Fukuoka, Japan) as described previously¹⁴. Since bioelectricalimpedance analysis (BIA) and total body water (TBW by $H_2^{18}O$ dilution) data showed a very close correlation in 4- to 6-year-old children¹⁵⁾, we feel justified in taking BIA data as a measure of body composition in children. Goran and others (1993)¹⁵⁾ suggested that the Kushner equation (1992)¹⁶⁾ for TBW can be transformed into an equation for LBM by using published age- and gender-specific constants for the hydration of LBM in children¹⁷⁾: hydration of LBM = 76.9 - 0.25 age (yr) -1.9 gender where girls equals 0 and boys equals 1. The equation provides an estimate for LBM :

LBM (kg) = $[(ht^2/R)*0.59 + (wt*0.065) + 0.04]/$ [0.769-(0.0025*age)-(0.019*gender)] where ht is the subject's height (cm), R is the body's resistance (ohm), wt is the subject's body weight (kg), age in years, and gender is 0 for girls and 1 for boys. TBFM was obtained by subtracting LBM from total body weight. The percentage body fat (%fat) was calculated from the TBFM by dividing by total body weight.

Measurement of SFM and internal fat mass

SFM was calculated by measuring skin-fold thickness at 14 sites and using a modification of the equation derived by Skerjl and others $(1953)^{18}$ and Davies and others $(1986)^{19}$. The main modifications of the equation in the present study were the introduction of (1) mean thickness of adipose tissue over body surface / 2 and (2) skin weight.

 $\begin{array}{l} {\rm SFM}\ (g) = \left[\begin{array}{c} {\rm mean}\ {\rm thickness}\ {\rm of}\ {\rm adipose}\ {\rm tissue} \\ {\rm over}\ {\rm body}\ {\rm surface}\ ({\rm cm})\ /\ 2^*\ {\rm body} \\ {\rm surface}\ {\rm area}\ ({\rm cm}^2)^*\ {\rm density}\ {\rm of}\ {\rm fat} \\ {\rm (g/cm^3)} \right] - {\rm skin}\ {\rm weight}\ (g) \end{array}$

Body surface area was calculated using the equation of Fujimoto and others $(1968)^{20}$. The density of fat was taken as 0.900 g/cm^{3} ²¹⁾. Skin weight was calculated from body weight using the equation of Satake and Ozaki $(1991)^{22}$. Subcutaneous fat distribution was estimated from the ratio of trunk skin-fold (sum of chest 1, chest 2 and abdomen) to extremity skin-fold (triceps, thigh 1 and calf). Internal fat mass (IFM) was calculated as the difference between TBFM and SFM.

Statistical analyses

All statistical analyses (calculation of percentiles, regression analyses, statistics) were performed using Excel 98 and StatView J-4.5. Variables are presented as means \pm standard deviations. Sex-related differences between variables were tested by Student's t-test for unpaired data after analysis of variance. Pearson correlation andpartial correlation coefficients were used to assess the relationship between SFM and various anthropometric indices (e.g. BMI, TBFM, IFM and skin-folds). Differences with p values less than 0.05 were considered significant.

Results

The physical characteristics and body composition data for all boys (n = 141) and girls (n = 139)in the study, and boys (n = 69) and girls (n =70) based on a BMI between the 25th and 75th percentile (normal-weight groups), are shown in Table 1. There were no significant differences between the boys and girls in this study for any of the variables listed in Table 1. The %fat was significantly higher for the girls in the normalweight group, although the BMI was significantly lower in this group. The normal-weight girls had significantly thicker skin-fold than normalweight boys: extremity skin-fold $(37.9 \pm 5.2 \text{ vs.})$ 35.0 ± 6.0 mm, p < 0.01) and trunk skin-fold $(19.3 \pm 4.1 \text{ vs.} 17.1 \pm 3.2 \text{ mm}, p < 0.001).$ Absolute SFM was higher in normal-weight girls than in normal-weight boys $(1.4 \pm 0.4 \text{ vs. } 1.2$ ± 0.4 kg. p < 0.01).

There were no significant differences in the TBFM, IFM or trunk-to-extremity skin-fold ratio. In addition, abdominal circumference, hip circumference and WHR were similar in both groups.

SFM correlated strongly with TBFM in normalweight boys (r = 0.506, p < 0.001) and in normal-weight girls (r = 0.546, p < 0.001), and SFM and %fat in normal-weight girls also correlated (r = 0.352, p < 0.01), as shown in Table 2. However, the correlation coefficients between SFM and IFM were not significant for either group.

The correlation coefficients for SFM or TBFM and simple anthropometric variables, and the partial correlation coefficients between SFM and TBFM after adjustment for each anthropometric variable, are shown in Table 3. SFM correlated with all of the anthropometric variables except WHR for both sexes, and with trunk/extremity skin-fold ratio in normal-weight boys. Of all the anthropometric variables measured for normal-weight boys, the extremity skin-fold showed the strongest correlation with SFM (r =0.819, p < 0.001), while the trunk skin-fold showed the strongest correlation for normalweight girls (r = 0.807, p < 0.001). Furthermore, the index of body fat distribution in common use, trunk/extremity skin-fold ratio, was only related to SFM for normal-weight girls (r =

	То	tal	25~75%ile			
	Boys N=141 Mean±S.D.	Girls N=139 Mean±S.D.	Boys n=69 Mean±S.D.	Girls n=70 Mean±S.D.	P value	
Age, yr	5.0±0.9	5.0±0.9	4.9±0.9	4.8±0.8		
Height, cm	106.0±07.1	105.5±6.6	105.2±7.5	104.4±6.3		
Weight, kg	17.6±3.1	17.2±2.6	17.2±2.6	16.7±1.9		
BMI, kg/m ²	15.6±1.3	15.4±1.2	15.4±0.4	15.2±0.4	0.0128	
Abdominal circumference, cm	48.6±3.9	48.9±3.3	48.2±2.7	48.2±2.1		
Hip circumference, cm	54.4±4.3	54.8±3.9	53.8±3.2	53.9±2.7		
WHR	0.90±0.04	0.89±0.04	0.90±0.04	0.89±0.03		
Trunk skinfold, mm	18.5±6.9	20.4±6.4	17.1±3.2	19.3±4.1	0.0007	
Extremity skinfold, mm	36.6±9.4	39.3±7.2	35.0±6.0	37.9±5.2	0.0035	
Trunk/extremity skinfold ratio	0.50±0.09	0.52±0.10	0.50 ± 0.08	0.51±0.09		
Total body fat mass by BIA, kg	3.1±1.3	3.4±1.2	2.9±0.9	3.1±0.8		
Subcutaneous fat mass, kg	1.3±0.9	1.5±0.7	1.2±0.4	1.4±0.4	0.0051	
Internal fat mass, kg	1.8±0.8	1.8±0.8	1.7±0.7	1.7±0.7		
%Fat	17.5±5.2	19.4±5.4	16.8±4.3	18.5±4.4	0.0245	

Table 1. Physical characteristics, body composition and body fat distribution for total children and children based on BMI mached between 25 and 75% ile.

There are no significant differences by t-test between the total boys and girls.

	Subcutaneous fat mass	Internal fat mass	Total body fat mass	Percentage of body fat
SFM		0.023	0.506***	0.162
IFM	0.019	_	0.872***	0.882***
TBFM	0.546***	0.846***	-	0.834**
%Fat	0.352**	0.835***	0.888***	_

Table 2. Correlation coefficients among the four adiposity indices in children based on BMI mached between 25 and 75% ile.

upper; Boys, lower; Girls **p<0.01, ***p<0.001

Table 3. Correlations between SFM or TBFM and simple anthropometric variables, and partial correlations between SFM and TBFM after adjustment for each anthropomentric variable for children based on BMI mached between 25 and 75% ile.

	Correlation with SFM		Correlation with TBFM		Partial Correlation between SFM and TBFM Adjusted for Anthropometric Variables	
	Boys	Girls	Boys	Girls	Boys	Girls
Age	0.512***	0.308**	0.357**	0.120	0.403***	0.539***
Height	0.619***	0.392**	0.409***	0.306*	0.353**	0.487***
Weight	0.677***	0.472***	0.424***	0.347**	0.328**	0.462***
BMI	0.483***	0.271*	0.165	0.119	0.493***	0.538***
Abdominal circumference	0.622***	0.536***	0.392***	0.369**	0.364**	0.443***
Hip circumference	0.585***	0.561***	0.360**	0.505**	0.390**	0.368**
WHR	0.010	0.116	0.010	0.220	0.506***	0.537***
Chest1 skinfold	0.555***	0.698***	0.215	0.202	0.476***	0.578***
Chest2 skinfold	0.666***	0.722***	0.264*	0.389**	0.459***	0.415***
Abdominal skinfold	0.637***	0.679***	0.338**	0.229	0.401***	0.547***
Triceps skinfold	0.542***	0.538***	0.162	0.243*	0.504***	0.507***
Thigh1 skinfold	0.777***	0.718***	0.387**	0.411***	0.353**	0.396***
Calf skinfold	0.673***	0.449***	0.331**	0.193	0.405***	0.523***
Trunk skinfold	0.735***	0.807***	0.331**	0.303*	0.411***	0.535***
Extremity skinfold	0.819***	0.769***	0.382**	0.385**	0.364**	0.424***
Trunk / extremity skinfold ratio	0.077	0.348**	0.083	0.081	0.503***	0.555***

* p<0.05, ** p<0.01, *** p<0.001

0.348, p < 0.01). For both groups, age correlat ed significantly with SFM but was not related to TBFM for the girls (r = 0.120, p > 0.05). The BMI, WHR, chest 1 skin-fold and trunk/extremity skin-fold ratio did not correlate significantly with TBFM in either sex. In general, the associations between SFM and anthropometric variables were stronger than those observed for TBFM. In addition, SFM was related independently to TBFM after controlling for each simple anthropometric variable.

The regression slope for SFM vs. TBFM is shown in Figure 1. A high correlation was observed in both normal-weight boys and



Fig. 1. Relationship between subcuraneous fat mass (SFM) and total body fat mass (TBFM) in normal weight boys (solid line) and normal weight girls (dotted line).

normal-weight girls, although the slopes were not statistically different (0.251 kg SFM/kg TBFM and 0.290 kg SFM/kg TBFM).

Discussion

A number of studies have reported a stability in the fatness ranking between early infancy and childhood^{23) 24) 25)}. The evidence, based on group data, suggests that subcutaneous adipose tissue does not track well from birth to about 5 or 6 years of age, and that subcutaneous adipose tissue, therefore, appears to be highly labile during infancy and early childhood¹⁰. Conversely, sex differences in body fat distribution has been the topic of several investigations^{26) 27) 28)}. More than 50 years ago, Vague (1947)²⁹⁾ documented the metabolic implications of regional peripheral adipose tissue distribution and was first to emphasise the health hazards related to an android fat pattern, although consistent associations have not been found during childhood^{30) 31)}. The risk of excess fat appears to be greater in those who have larger subcutaneous fat measurements during childhood⁶⁾. Given the importance of subcutaneous fat in the development of obesity, the availability of a noninvasive method for measuring subcutaneous fat mass would be a significant advance. However, there is little information on the factors accounting for differences in fat distribution in Japanese children and the normal developmental changes in subcutaneous fat stores are unknown. Therefore, from a clinical perspective it is becoming more important to identify good diagnostic tools for estimating subcutaneous adipose tissue that do not rely primarily on expensive and heavily used clinical equipment with radiation exposure. In addition, more accurate estimates of SFM may be obtained by including regional measurements of body fat by CT and dual-energy X-ray absorptiometry (DXA). For example, the use of CT in healthy Caucasian and Mohawk Indian children (4.4-8.8-years-old), in a single slice at the level of

the umbilicus. revealed a mean abdominal subcutaneous adipose tissue area of 65.3 ± 44.8 cm², and a mean intra-abdominal adipose tissue area of 8.3 ± 5.8 cm² ³²⁾. In another study on children aged 7.7 ± 1.6 DXA vears. measurements provided strong evidence of sex differences in absolute subcutaneous abdominal adipose tissue (SAAT): the SAAT was 65 ± 67 cm^2 and 172 ± 102 cm^2 in white boys and girls, respectively³³⁾. Although CT can be used to measure regional body fat, this technique cannot resolve total body subcutaneous adipose tissue from the whole body. We propose that SFM determined from anthropometric variables could be used as an index of subcutaneous fat accumulation that is independent of the various anthropometric variables. Use of this index allows the examination of gender differences in SFM in young children. However, there have been no studies of age-related changes and sex differences in body fat distribution (i.e. the relative proportions of SFM and IFM), a parameter that varies with ethnicity and illness. Age-related changes and sex differences in body fat distribution are an important aspect of health related to nutritional status. Unfortunately there is little evidence regarding the precision of anthropometric measures of SFM in whole-body.

The main objective of this study was to compare the relationship between SFM and TBFM in young boys and girls. The results demonstrate that the accumulation of TBFM is proportionally similar in both sexes. However, girls presented significantly higher amounts of SFM than boys. The rate of increase in SFM relative to TBFM has also been shown to be similar in both sexes. Finally, the results suggest that SFM is related independently to TBFM after controlling for each anthropometric variable. These preliminary data provide the framework for further studies examining the determinants of biological variability in subcutaneous adipose tissue during growth and and the relationship development, between subcutaneous adipose tissue early in life and

later health outcome.

Acknowledgements

We are grateful to all of the individuals who participated in this study for their excellent cooperation and to the dedicated staff of the Osa, Miyatake and Minamifukuoka Kindergartens. Sincere thanks are expressed to T. Masuda, M. Ube and T. Ueda for their help in the collection of the data.

REFERENCES

- Lapidus L, Bengtsson C, Larsson B, Pennert K, Rybo E, Sjostrom L (1984) : Distribution of adipose tissue and risk of cardiovascular disease and death: A 12 year follow up of participants in the population study of women in Gothenburg, Sweden. British Medical Journal, 289: 1257-1261.
- Larsson B, Svardsudd K, Welin L, Wilhelmsen L, Bjorntorp P, Tibblin G (1984): Abdominal adipose tissue distribution, obesity, and risk of cardiovascular disease and death: 13 year follow up of participants in the study of men born in 1913. British Medical Journal, 288: 1401-1404.
- Ducimetiere P, Richard J, Cambien F (1986): The pattern of subcutaneous fat distribution in middle-aged men and the risk of coronary heart disease: the Paris prospective study. International Journal Obesity, 10: 229-240.
- Haffner SM, Stern MP, Hazuda HP, Rosenthal M, Knapp JA, Malina R (1986): Role of obesity and fat distribution in noninsulin-dependent diabetes mellitus in Mexican-Americans and non-Hispanic whites. Diabetes Care, 9: 153-161.
- 5) White FMM, Pereira LH, Garner JB (1986): Association of body mass index and waist: hip ratio with hypertension. Canadian Medical Association Journal, 135: 313-320.
- Malina RM, Bouchard C (1991): Adipose tissue changes during growth. In Growth,

maturation, and physical activity. Human Kinetics Books, Champaign, Illinois pp 133-149.

- Hawk LJ, Brook CGD (1979): Influence of body fatness in childhood on fatness in adult life. British Medical Journal, 1: 151-152.
- B) Garn SM, LaVelle M (1985): Two-decade follow-up fatness in early childhood. American Journal of Disease of Children, 139: 181-185.
- 9) Hediger ML, Katz SH (1986): Fat patterning, overweight, and adrenal androgen interactions in Black adolescent females. Human Biology, 58: 585-600.
- 10) Baumgartner RN, Roche AF (1988): Tracking of fat pattern indices in childhood: the Melbourne growth study. Human Biology, 60: 549-567.
- 11) Zonderland ML, Erich WBM, Erkelens DW, Kortlandt W, Wit JM, Huisveld IA, de Ridder CM (1990): Plasma lipids and apoproteins, body fat distribution and body fat distribution and body fatness in early pubertal children. International Journal of Obesity, 14: 1039-1046.
- 12) Johnston FE, Mack RW (1985): Interobserver reliability of skinfold measurements in infants and young children. American Journal of Physical Anthropology, 67: 285-289.
- 13) Komiya S, Muraoka Y, Zhang F-S, Masuda T (1992): Age-related changes in body fat distribution in middle-aged and elderly Japanese. Journal of the Anthropology Society of Nippon, 100: 161-169.
- 14) Komiya S, Masuda T (1990): Estimation of human body composition by bioelectrical impedance measurements-Equation for estimating total body water in Japanese subjects. Japanese Journal of Physical Fitness and Sports Medicine, 39: 53-59.
- 15) Goran MI, Kaskoun MC, Carpenter WH, Poehlman ET, Ravussin E, Fontvieikke AM (1993): Estimating body composition of young

children by using bioelectrical resistance. Journal of Applied Physiology, 75: 1776-1780.

- 16) Kushner RF, Schoeller DA, Fjeld CR, Danford L (1992): Is the impedance index (ht²/R) significant in predicting total body water ? American Journal of Clinical Nutrition, 56: 835-839.
- 17) Fomon SJ, Haschke F, Ziegler EE, Nelson SE (1982): Body composition of reference children from birth to age 10 years. American Journal of Clinical Nutrition, 35: 1169 1175.
- 18) Skerjl B, Brozek J, Hunt EE (1953):
 Subcutaneous fat and age changes in body build and body form in women. American Journal of Physical Anthropology, 11: 577-580.
- 19) Davies PSW, Jones PRM, Norgan NG (1986): The distribution of subcutaneous and internal fat in man. Annals of Human Biology, 13: 189-192.
- 20) Fujimoto S, Watanabe T, Sakamoto K, Yukawa K, Morimoto K (1968): Studies on the physical surface area of Japanese. Part 18, Calculation formulas in three stages over all ages. Japanese Journal of Hygiene, 23: 443-450 (in Japanese).
- 21) Fidanza F, Keys A, Anderson JT (1953): Density of body fat in man and other mammals. Journal of Applied Physiology, 6: 252-256.
- 22) Satake T. Ozaki T (1991): Skin and subcutaneous adipose tissue weights in older Japanese determined by cadaver dissection. American Journal of Human Biology, 9: 371-376.
- 23) Rolland-Cachera M, Deheeger M, Guilbud-Bataille M, Avons P, Patois E, Sempe M (1987): Tracking the development of adiposity from 1 month of age to adulthood. Annals of Human Biology, 14: 219-229.
- 24) Agras WS, Kraemer HC, Berkowitz RI, Hammer LD (1990): Influence of early

feeding style on adiposity at 6 years of age. Journal of Pediatrics, 116: 805-809.

- 25) Wells JCK, Stanley M, Laidlaw AS, Day JE, Davies PSW (1996): The relationship between components of infant energy expenditure and childhood body fatness. International Journal Obesity, 20: 848–853.
- 26) Vague J (1956): The degree of masculine differentiation of obesities: а factor determining predisposition diabetes. to atherosclerosis. gout and ulric calculous disease. American Journal of Clinical Nutrition, 4: 20-34.
- 27) Kvist H, Chowdury B, Gangard U, Tylen U, Sjostrom L (1988): Total and visceral adipose-tissue volumes derived from measurements with computed tomography in adult men and women: predictive equations. American Journal of Clinical Nutrition, 48: 1351-1361.
- 28) Sjostrom L, Kvist H (1988): Regional body fat measurements with CT-scan and evaluation of anthropometric predictions. Acta Medica Scandinavica, supplement, 723: 169-177.
- 29) Vague J (1947): Sexual differentiation as a factor determining the forms of obesity. Presse Medicale, 30: 339-340.
- 30) Dietz WH (1981): Obesity in infants, children, and adolescents in the United States. Identification, natural history, and after effects. Nutrition Research, 1: 117-137.
- 31) Dietz WH, Bandini LG, Schoeller DA (1986): Total body fat, fat distribution and glucose tolerance in adolescents. American Journal of Clinical Nutrition, 43: 696 (abstract).
- 32) Goran MI, Kaskoun MC, Shuman WP (1995): Intra-abdominal adipose tissue in young children. International Journal of Obesity, 19: 279-283.
- 33) Goran MI, Nagy TR, Treuth MS, Trowbridge C, Dezenberg C, McGloin A, Gower BA (1997): Visceral fat in white and

African American prepubertal children. American Journal of Clinical Nutrition, 65: 1703 - 1708.