Short Term Longitudinal Changes in Subcutaneous Fat Distribution and Body Size among Japanese Women in the Third Decade of Life

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Abstract. This research clarified the changes in body shape among Japanese women aged in their 20’s, by measuring the subcutaneous fat distribution over the whole body and its circumference at certain points. The subjects, 13 healthy women, were measured twice, once in their early 20’s and 5 years later in their late 20’s. Subcutaneous fat thickness was measured at 14 points on the body using the B-mode ultrasound method and the body size was measured directly at 8 points on the body using a steel measure. Subcutaneous fat thickness tends to increase with age, except at the cheek, neck, bust and leg. Significant increases were detected especially at lower parts of the trunk such as the waist and infragluteal region. Meanwhile, despite the significant change in subcutaneous fat thickness, the circumferences measured did not change, and also weight tended to decrease with age. Based on this finding, except for fat, body mass, such as muscle and bone, decreases with age due to decreased exercise and changes in calorie intake. Cluster analysis of the accumulation patterns of subcutaneous fat indicated that there were the following 3 patterns of subcutaneous fat accumulation from the early 20’s to the late 20’s.

I. Accumulation on the whole trunk (bust, abdomen, waist and back) and upper arm - trunk/upper arm accumulation pattern
II. Significant accumulation around waist - waist accumulation pattern
III. Even accumulation at abdomen, side abdomen, hip and lower hip - abdomen/hip accumulation pattern

Keywords: subcutaneous fat thickness, body size, anthropometric measurement, longitudinal change, accumulation pattern

Introduction

Most women are interested in their body shape, which leads to the idealization of the slim body shape, the so called “slim body admiration” (Matsuura, 1992). There are some reports about women’s consciousness of their body shape (Wadden, 1989; Moss, 1989), and the phenomenon of “slim body admiration” which is an especially interesting subject in this field. Studies about body shape are mainly conducted using measurements of weight and body size as well as subcutaneous fat distribution. In addition, different indices calculated from measurements of weight and body size such as Body Mass Index (BMI) and Waist to Hip Ratio (WHR), have been used together with subcutaneous fat thickness to discuss changes with age (Teh et al., 1996; Ross et al., 1997; SENECA 1996; Kanaley et al., 1993). Also, there is a report which categorized women’s body shapes based on subcutaneous fat distribution (Skerj et al., 1953) and a study of the relationship between body shape and subcutaneous fat thickness (Hoshi and Kouchi, 1978).

Specifically, in studies of the changes with age, there have been two different methods used; one is the cross-section method which studied the age change based on separate age groups at the same given time and the other was the longitudinal method which studied the change in the same subject over a number of years. As an example of the cross-section method, Yagasaki and Toyokawa (1989) measured the subcutaneous fat thickness of 1933 females having ages varying from newborn baby to 88 years old at 5 points on the leg and arm and 2 measurement points on the trunk. This study found that subcutaneous fat thickness was the highest at the subscapula and the supra-iliac at age 60’s while for the 20’s and older, it was larger at the supra-iliac than the posterior part of upper arm and anterior part of thigh. Also Fukunaga et al. (1993) confirmed that subcutaneous fat accumulation increased among older subjects up to 60 years old at the abdomen.
by measuring the fat thickness of women aged 30 to 70 years old at 6 measurement points. Our study found that the age difference became more significant closer to the trunk and less significant at the periphery by measuring skinfold thickness at 14 body points of two age groups, 20's and 40's (Murakami et al., 1994). Among studies using the longitudinal method, Tokuda and Hayashi (1988) measured 63 females, aged 69 to 71, at 5 and 10 years later. This study found that body sections shrunk evenly with age among the different body shapes, which varied widely from slim to stout, and that body shape tended to become more stout with age. Also, Watanabe et al. (1996) studied female high school students using a longitudinal method and reported that their weight significantly increased by 5.6 kg after 3 years (increased by 11%), and the circumference tended to increase at the bust, waist and thigh.

It is important to identify the changes with age among subjects for age specific studies, and the longitudinal method is ideal for characterizing this process of change. As described earlier, there are only a few reports that use longitudinal data (Yagasaki and Toyokawa, 1989; Kawamura, 1954), and there has been no longitudinal study made for women in their 20's. Instead, they dealt with puberty and old age when the female body shape changes significantly due to hormone imbalances caused by menarche and menopause. Using the cross-section method, our studies found that there was significant changes in subcutaneous fat distribution between the early 20's and later 20's by measuring skinfold thickness specifically at the abdomen and hip, and during this age difference subcutaneous fat increased significantly (Murakami et al., 1997). As described earlier, women in their 20's are very conscious of body shape, with strong tendencies for “slim body admiration”. It is said that body shape itself has changed among young Japanese women as well as their body consciousness (Matsuura, 1992), making the study of body shape change among women in their 20's very interesting and useful.

Therefore, the purpose of this study was to investigate the body shape change among women of their 20's using the longitudinal method by measuring body size and analyzing subcutaneous fat distribution at 14 points on the body. Then, our comparison was made for the data measured in their early 20's and 5 years later in their late 20's so as to learn the current status of women in their 20's.

Methods

Subjects and period of examination

The subjects were 13 healthy women in their 20's. The measurements were made twice on the same subjects, once in October of 1992 and then in October, 1997. The average age of subjects was 22.0 years old at the time of the measurement in 1992. They were a group of average Japanese women who were healthy and had no history of major illness or special diets. All the subjects were students when measured in 1992, and all of them had jobs at the 1997 measurement. None of them had experienced childbirth.

Procedures and measurement points

The measurements taken were subcutaneous fat thickness, height, weight and circumference. The subcutaneous fat thickness was measured at the left side of body. Ultrasound Measurement Equipment (manufactured by Aroka, model SSD630, with probe 7.5 MHz) was used to measure skinfold thickness, using the B-mode method typical for these measurements. The contact pressure between the contact surface of probe and the skin surface was kept steady. Currently it is difficult to obtain a clear image that distinguishes the border between the skin and subcutaneous fat, so subcutaneous fat thickness evaluations included the skin itself (Weiss and Clark, 1985; Maruyama et al., 1991). Therefore, subcutaneous fat thickness including surface skin, true skin and subcutaneous fat was read and analyzed directly from the 2 dimensional images obtained in this study. As shown in Fig. 1, subcutaneous fat thickness was measured at 14 points of the body. Abdomen and neck were measured at front medial line and back medial line respectively. The upper arm was measured at the middle of the shoulder and at the elbow and rear side was measured at the middle of scapula line and side line. Except these points, the measurement was made at the mamilla line or scapula line. Circumferences were measured with a measuring tape at the following 8 points, neck, bust, waist, abdominal circumference, hip, upper arm, thigh and leg. Both the subcutaneous fat thickness and circumferences were measured when the subject was upright.

![Fig. 1 Measurement points of subcutaneous fat thickness.](image-url)
The measured values were used to calculate Body Surface Area (BSA), Fat Mass, Lean Body Mass, and Predicted Mean Skinfold Thickness (PMST). BSA was calculated using the formula of Fujimoto et al. (1968). While Fat Mass and Lean Body Mass were calculated using the formula of Brozek et al. (1963). PMST was calculated by dividing TSFV (Total Subcutaneous Fat Volume) with TSFA (Total Subcutaneous Fat Area) defined as below (1) (Murakami et al., 1997).

\[ PMST = \frac{TSFV}{TSFA} \]  \hspace{1cm} \text{Subcutaneous Fat% / Fat Density} \hspace{1cm} (1)

For our calculation, the values of 0.9007 g/ml (Brozek et al., 1963) and 0.804 (Fujimoto et al., 1968) were used for Fat Density and Body Surface Ratio of Subcutaneous Fat, respectively. Fat mass exists not only under the skin but also deep in the internal organs. 0.741 (Abe et al., 1995b) was used as the ratio of subcutaneous fat against total body fat in our calculations.

Energy intake

Typical nutritional energy intake was obtained using self-surveys along with the measurements in this research. The nutritional intake was analyzed based on the method of Kawamura et al. (1994), using the Four Food Grouping Method. The intake of 3 major nutrition components, protein, fat and glucose and the average daily intake of energy were calculated.

Data analysis

The data were presented as means ± standard deviations. The t-test was used to analyze the differences between the measurements in 1992 and 1997. The variation ratio for each measured value from each subject for two variables was obtained using formula (2) and the results correlated using straight-line regression analysis, and Pearson Correlation Coefficients (r). The statistically significant standard (p) was set to be 5% or less. Also, the accumulation types of subcutaneous fat were categorized with cluster analysis. Because there were significant variations in subcutaneous fat thickness on each body part, a Standard Score was calculated with formula (3) based on the change on each body point of each subject, and the values were used for this analysis.

The standard value of Euclid Distance was used for a measure of the distance between 2 individuals. The distance was set using Ward Method, which results in compact clusters of well distributed size when the number of clusters is relatively small.

\[ \text{PMST} = \frac{TSFV}{TSFA} \]  \hspace{1cm} (1)

\[ \text{PMST} = \frac{\text{TSFV}}{\text{TSFA}} \]  \hspace{1cm} (2)

\[ \text{Standard Score} = \frac{\text{measured value of 1997} - \text{measured value of 1992}}{\text{measured value of 1992}} \times 100 \]  \hspace{1cm} (3)

Results

Changes of anthropometric characteristics

Table 1 shows the average values and the standard deviations of body measurements taken in 1992 and 1997. The average values and the standard deviations of height and weight were provided for Japanese women of the age group of 20 to 24 years old and another group of 25 to 29 years old, reported by Research Institute of Human Engineering for Quality Life (HQL) are also shown in the table for comparison. Our measured values of height and weight in 1992 and 1997, closely matched those of the HQL and indicated our subjects consisted of typical Japanese women in their 20’s. There were no significant changes in height, weight, BMI, WHR and BSA over 5 years, although weight tended to decrease slightly. Fat mass increased significantly (p<0.01) in 1997 by an average value of 3.3 kg and PMST also increased significantly (p<0.01) by 3.3 mm. On the other hand, lean body mass decreased significantly (p<0.01) by 5.1 kg. Table 2 shows the average values and the standard deviations of circumference measurements at each body point taken in 1992 and 1997. The changes in circumference were similar as those in height and weight in that they showed no significant change at any point on the body in the 5 years except for a tendency of a slight increase in the abdominal circumference.

Table 1 Anthropometric characteristics of the subjects

<table>
<thead>
<tr>
<th></th>
<th>1992</th>
<th>1997</th>
<th>N.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>height (cm)</td>
<td>159.3</td>
<td>159.2</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td>(158.2 5.4)</td>
<td>158.2</td>
<td>(15.1)</td>
</tr>
<tr>
<td>weight (kg)</td>
<td>52.1</td>
<td>50.2</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>(51.4 6.8)</td>
<td>50.8</td>
<td>(6.2)</td>
</tr>
<tr>
<td>BMI</td>
<td>20.5</td>
<td>19.8</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>(19.8 1.3)</td>
<td>0.4</td>
<td>(1.4)</td>
</tr>
<tr>
<td>WHR</td>
<td>0.72</td>
<td>0.72</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>(0.72 0.03)</td>
<td>0.02</td>
<td>N.S.</td>
</tr>
<tr>
<td>BSA (m²)</td>
<td>1.48</td>
<td>1.46</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>(1.46 0.10)</td>
<td>0.09</td>
<td>(0.09)</td>
</tr>
<tr>
<td>fat mass (kg)</td>
<td>12.6</td>
<td>15.9</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>(15.9 4.7)</td>
<td>4.7</td>
<td>(4.7)</td>
</tr>
<tr>
<td>lean body mass (kg)</td>
<td>39.5</td>
<td>34.4</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>(34.4 3.7)</td>
<td>3.7</td>
<td>(3.7)</td>
</tr>
<tr>
<td>PMST</td>
<td>8.7</td>
<td>11.1</td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>(8.7 1.7)</td>
<td>2.9</td>
<td>(2.9)</td>
</tr>
</tbody>
</table>

Values are mean – SD. (: Research Institute of Human Engineering for Quality Life (HQL) reported at 1997. **: p<0.01 (Significant differences between value of 1992 and value of 1997).
Longitudinal Changes in Subcutaneous Fat Distribution

Relationship between weight change and circumference change

Regression analysis was used to examine the relationship between weight change and circumference change, using the change ratio of circumference of each subject as the dependent variable (Y) and the change ratio of weight as the independent variable (X). Table 3 shows the linear regression equations and their correlation coefficients. As a result, a significant positive correlation was determined for each point of the body indicating a relationship between weight change and circumference change. The relationships were particularly significant for the bust, waist and abdominal circumference, showing extremely high correlation coefficients (r) of 0.9 or higher and statistically significant (p) of 0.01 or lower. Fig. 2 shows the changes in waist measurements versus weight changes and their distribution. In this research, only 4 subjects gained weight over the 5 years, showing a positive tendency in weight change, whereas the weight of all other subjects either tended to stay same or decreased. The larger the weight decrease, the larger the decrease in circumference.

Change of subcutaneous fat thickness

Fig. 3 shows the average values and standard deviations of subcutaneous fat thickness at each point on the body measured in 1992 and 1997. Subcutaneous fat thickness showed tendency to increase at the upper arm and the trunk (inframammary region, back, abdomen, waist, hip and infragluteal region) except the bust. No change was determined at the cheek, neck and lower extremities (leg and thigh). The most significant increase was found at the waist, which had an average value of 11.5 mm in 1992 and 21.9 mm in 1997, a significant difference (p<0.001). In other words, the increase was 10.5 mm for the 5 years. Also, a significant increase was determined at the infragluteal region (p<0.01). The increase over 5 years was 6.2 mm at the infragluteal region. Especially significant increases were detected at lower parts of the trunk. It became evident in our research over the 5 years that the accumulation of subcutaneous fat was found at the trunk, and upper arm for women in their 20’s but the accumulation was not found at the cheek, neck and lower extremities.

Relationship between changes in weight and subcutaneous fat thickness

In order to examine the relationship between changes in weight and changes in subcutaneous fat thickness, a regression analysis was used where the change ratio of subcutaneous fat thickness of each subject was the dependent variable (Y) and the change ratio of weight was the independent variable (X). Table 4 shows the resulting linear regression equations and correlation coefficients. Positive correlations were determined except for the posterior part of leg, and statistically significant relationships were detected at the back, upper arm and waist (p<0.05). Fig. 4 shows the plot of the change ratios of subcutaneous fat thickness at the waist versus change ratio of weight. Unlike the relationship between circumference and weight, our studies found that subcutaneous fat thickness increased even for the subjects who lost weight. The same tendency was observed for

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**Table 2** Changes in girth (cm)

<table>
<thead>
<tr>
<th>measurement point</th>
<th>1992</th>
<th>1997</th>
<th>N.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>neck</td>
<td>40.2 - 3.3</td>
<td>40.7 - 1.9</td>
<td></td>
</tr>
<tr>
<td>bust</td>
<td>81.6 - 4.1</td>
<td>80.6 - 4.3</td>
<td></td>
</tr>
<tr>
<td>upper arm</td>
<td>25.1 - 1.7</td>
<td>24.4 - 1.5</td>
<td></td>
</tr>
<tr>
<td>waist</td>
<td>64.4 - 3.3</td>
<td>64.6 - 3.5</td>
<td></td>
</tr>
<tr>
<td>abdominal circumference (on iliocrisrale)</td>
<td>81.1 - 3.7</td>
<td>83.6 - 3.7</td>
<td></td>
</tr>
<tr>
<td>hip</td>
<td>90.1 - 3.5</td>
<td>89.3 - 4.3</td>
<td></td>
</tr>
<tr>
<td>thigh</td>
<td>50.4 - 2.9</td>
<td>50.2 - 3.2</td>
<td></td>
</tr>
<tr>
<td>leg</td>
<td>34.1 - 2.0</td>
<td>33.6 - 1.9</td>
<td></td>
</tr>
</tbody>
</table>

Values are means – SD.

**Table 3** Regression and correlation coefficients between percentage variations of weight and girth

<table>
<thead>
<tr>
<th></th>
<th>equation</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>neck</td>
<td>y = 0.854x + 4.769</td>
<td>0.564*</td>
<td></td>
</tr>
<tr>
<td>bust</td>
<td>y = 0.542x + 0.647</td>
<td>0.955**</td>
<td></td>
</tr>
<tr>
<td>upper arm</td>
<td>y = 0.727x + 0.082</td>
<td>0.827**</td>
<td></td>
</tr>
<tr>
<td>waist</td>
<td>y = 0.732x + 2.730</td>
<td>0.961**</td>
<td></td>
</tr>
<tr>
<td>abdominal circumference</td>
<td>y = 0.671x + 5.363</td>
<td>0.914**</td>
<td></td>
</tr>
<tr>
<td>hip</td>
<td>y = 0.597x + 1.207</td>
<td>0.751**</td>
<td></td>
</tr>
<tr>
<td>thigh</td>
<td>y = 0.550x + 1.489</td>
<td>0.638*</td>
<td></td>
</tr>
<tr>
<td>leg</td>
<td>y = 0.468x + 0.278</td>
<td>0.791**</td>
<td></td>
</tr>
</tbody>
</table>

X=variations of weight (%), Y=variations of girth (%). **: p<0.01, *: p<0.05.

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Fig. 2 Relationship between variations of weight and variations of waist girth.
other parts of the body where statistically significant relationships were determined. Also, compared to the relationship for circumference and weight, the correlation coefficient ($r$) between subcutaneous fat thickness and weight was low, showing a weaker relationship.

Relationship between changes in subcutaneous fat thickness and circumference

Table 5 shows the correlation coefficients between the change ratio of circumference of each subject and the change ratio of subcutaneous fat thickness at its corresponding part. As a result, a statistically significant

![Graph showing changes in subcutaneous fat thickness at measurement points. *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$ (Significant differences between value of 1992 and value of 1997).]
positive correlation (p<0.05) was detected at the neck, waist and abdomen, where our studies found that the increase of subcutaneous fat affected the increase of circumference. Also, a statistically negative correlation (p<0.05) was determined for the posterior part of leg.

Energy intake

Table 6 shows the average values and standard deviations of the daily total energy intake and the grams of protein, fat and glucose ingested, calculated using the Four Food Grouping Method (Kawamura et al., 1994). The total energy intake decreased significantly (p<0.05). Among the 3 major nutritional components, the intake of glucose decreased significantly (p<0.01) and was the main cause of the decrease in total energy.

Accumulation pattern of subcutaneous fat among women of their 20’s.

A cluster analysis was performed using standard scores calculated from formula (3) for the change in subcutaneous fat thickness at each measurement point on each subject. The results were then categorized into 3 groups. Fig. 5 shows the average value of subcutaneous

<table>
<thead>
<tr>
<th>measurement point at subcutaneous fat thickness</th>
<th>girth</th>
<th>correlation coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>neck</td>
<td>neck</td>
<td>0.683 *</td>
</tr>
<tr>
<td>bust</td>
<td>bust</td>
<td>0.109 NS</td>
</tr>
<tr>
<td>upper arm</td>
<td>upper arm</td>
<td>0.261 NS</td>
</tr>
<tr>
<td>waist</td>
<td>waist</td>
<td>0.534 *</td>
</tr>
<tr>
<td>abdomen</td>
<td>abdominal circumference</td>
<td>0.572 *</td>
</tr>
<tr>
<td>hip</td>
<td>hip</td>
<td>-0.113 NS</td>
</tr>
<tr>
<td>anterior part of thigh</td>
<td>thigh</td>
<td>0.059 NS</td>
</tr>
<tr>
<td>posterior part of thigh</td>
<td>thigh</td>
<td>0.269 NS</td>
</tr>
<tr>
<td>anterior part of leg</td>
<td>leg</td>
<td>0.341 NS</td>
</tr>
<tr>
<td>posterior part of leg</td>
<td>leg</td>
<td>-0.677 *</td>
</tr>
</tbody>
</table>

*: p<0.05.

Fig. 4 Relationship between variations of weight and variations of subcutaneous fat thickness of waist.

Fig. 5 Average of variations of subcutaneous fat thickness by clusters.
fat thickness change at each point for each group. Group I consisted of 5 subjects showing an increase in fat at the trunk and upper body (trunk/upper arm accumulation type). Compared with the other 2 groups, this group showed increase of subcutaneous fat at the whole body. Group II consisted of 4 subjects showing an increase at the waist and infragluteal region but no changes in other areas except a slight decrease at the bust (waist accumulation type). Group III consisted of 4 subjects showing a consistent increase of approximately 5 mm at the abdomen and hip (abdomen/hip accumulation type). The average change in body weight was +0.37 kg in Group I, -2.17 kg in Group II and -4.2 kg in Group III. A statistically significant difference of 5% or less was found between Group I and Group II. Group II showed a large decrease in body weight while Group I did not show large change in body weight.

Discussion

Comparing the distribution of subcutaneous fat among Japanese women and that among white women in the USA, fat accumulates more on the trunk around the abdomen for Japanese women while it accumulates on the arms and legs, particularly the thigh, for US women (Ishida et al., 1992). The distribution pattern at the abdomen observed among the Japanese women, is a characteristic accumulation pattern among Asians and Mexicans (Haffner et al., 1986; Malina et al., 1995). This study will discuss our subject groups by comparing them with data on the body measurements and subcutaneous fat thickness of Japanese women reported previously. The average values of height, weight and circumference at 8 points on the body for both the early 20's (in 1992) and at late 20's (1997), matched the average values reported by HQL (1997) from their approximately 2,000 subjects. Also our measured subcutaneous fat thickness showed similar average values to those of 10 healthy women aged 20 to 24 measured by Saito and Tamura (1992 and 1994) using B-mode ultrasound method. There is no data to compare our data of subcutaneous fat thickness for the late 20's, because many reports discuss subcutaneous fat thickness by treating the 20's as one group. However, our data showed similar trends to the average values of 17 healthy females who were measured previously using B-mode method at 4 points on the body; abdomen, waist, hip and thigh (Murakami et al., 1997). Based on these comparisons, it is believed that our subject group consisted of typical Japanese women in their 20's, despite the total of 13 subjects not being a particularly large sample, and that the results from this study represent typical body shape changes among Japanese women.

Our studies reported previously that as a result of our cross-section measurements, the change in subcutaneous fat distribution from the early 20's to the late 20's was more significant at the lower trunk such as the abdomen and waist (Murakami et al., 1997). This study also found significant accumulation of subcutaneous fat at the abdomen and waist, the same tendency as the measurements in our previous cross-section based research. The secondary characteristics of the human body manifest themselves at puberty when subcutaneous fat accumulates increasingly (Forbes, 1987). Following puberty, preparation for the physiological function of childbirth is exhibited, and subcutaneous fat accumulates increasingly through late 20's, characterizing female body shape.

Despite the obvious change in subcutaneous fat distribution (Fig. 3), little change was found in body measurement values such as height, weight and circumference (Table 1, Table 2). It is assumed that because lean body mass decreased and fat mass increased, there was little change in weight while significant changes were detected in body composition. It is generally understood that when nutritional energy intake exceeds energy consumption, the excess energy accumulates within body as body fat (Horio and Kawamura, 1998). According to the results of this research, energy intake decreased, especially glucose (Table 6). Ravussin et al. (1988) and others have pointed out that the important cause of accumulated fat in obesity was lower energy consumption at rest, not always a large energy intake. Also, Forbes (1987) reported that the amount of fat consumption reaches its peak at about 18 years of age, then starts decreasing with age. Furthermore, there is a report that lean body mass decreases when energy consumption becomes lower due to decrease in daily physical activities (Abe et al., 1995a). Although a rigorous survey was not conducted on physical activities in this study, according to our self survey, only 5 out of 13 subjects played sports such as tennis and table tennis on a regular basis, and the remaining 8 subjects did not participate in any sport.

<table>
<thead>
<tr>
<th></th>
<th>1992</th>
<th>1997</th>
</tr>
</thead>
<tbody>
<tr>
<td>total energy (kcal)</td>
<td>1597.5 – 271.2</td>
<td>1391.1 – 254.1</td>
</tr>
<tr>
<td>protein (g)</td>
<td>55.9 – 10.9</td>
<td>51.2 – 11.1</td>
</tr>
<tr>
<td>fat (g)</td>
<td>41.5 – 9.6</td>
<td>39.1 – 10.0</td>
</tr>
<tr>
<td>glucose (g)</td>
<td>207.4 – 54.4</td>
<td>162.1 – 26.9</td>
</tr>
</tbody>
</table>

Values are mean – SD. *p<0.05, **: p<0.01 (Significant differences between value of 1992 and value of 1997).
regularly. Except one, the 5 subjects who played sport regularly in 1992 played sports regularly 5 years later in 1997, but the frequency and duration had decreased somewhat by 1997. Also, because all the subjects had jobs at the 1997 measurement and were no longer students, it was predicted that their daily activities and nutritional intake changed significantly. The decrease in energy consumption due to changes in their daily activities is considered as one of reasons why subcutaneous fat thickness increased and lean body mass decreased.

Furthermore, a relatively high statistically significant correlation was found between weight change and circumference change through the whole body, especially at the abdomen circumference and waist circumference with the correlation coefficients (r) of 0.9 or higher and significant standard (p) of 0.01% or less (Table 3, Fig. 2). On the contrary, a significant correlation in subcutaneous fat thickness change was determined at only 3 points on the body, although the correlation was low (Table 4, Fig. 4). Also, when the body weight of subjects increased (change in the positive direction), the circumference increased in the positive direction, then when their body weight decreased (change in the negative direction), the circumference changed in the negative direction. However, subcutaneous fat thickness increased at the abdomen and waist where statistically significant relationships were found, even though weight changed in negative direction. Accordingly, it can be predicted that a diet focusing only on changes in body weight can decrease circumference and the appearance of size, but fat consumption has decreased but subcutaneous fat itself may not have decreased. Also, unlike other body parts, a negative correlation was determined only at the posterior part of the leg between the subcutaneous fat thickness change and circumference change (Table 5). Thus, circumferences increase as subcutaneous fat thickness decreases. In consideration of relation between muscle mass and fat thickness, the energy required to contract muscle is generated from subcutaneous fat only when the energy amount kept in muscle is not sufficient to contract muscle. Therefore, it is predicted in such case that subcutaneous fat decreases and muscle mass increases. Among all body parts, muscle mass is largest at the posterior part of leg where subcutaneous fat thickness is less than 10 mm (Abe et al., 1995a). This indicates muscle mass affects circumference more at the posterior part of the leg than any other parts of body. Further research is necessary to study the relationship between circumference, subcutaneous fat and muscle mass.

Because the changes in each subject can be measured by using the longitudinal method on the same subjects, accumulation patterns of subcutaneous fat may be categorized into 3 types. This is a valuable characteristic of data collected through longitudinal research, unlike in cross-section studies which only allow comparison among different age groups. Our results were categorized into 3 types according to the distribution and quantity of subcutaneous fat accumulations; trunk/upper arm accumulation type, waist accumulation type and abdomen/hip accumulation type (Fig. 5). Saito and Tamura (1992 and 1994) reported that fat accumulated significantly more at the rear of the upper arm and the lower hip of subjects who had a tendency to become obese. Their measurements were almost twice as thick as the average fat thickness on the abdomen, while fat accumulated evenly on the subjects who had a tendency to be slim. Comparing with our 3 types, the trunk/upper arm accumulation type is similar to their obese type and abdomen/hip accumulation type is similar to their slim type. Skerj et al. (1953) and others categorized 8 groups according to quantity and distribution of subcutaneous fat; normal, Rubens, superior, inferior, truncic, extremital, mammary and trochanteric. They reported that for Rubens and superior types fat accumulation increased with age and was detected over the whole trunk. Also, although it was with cross-section measurements, Fukunaga et al. (1993) reported that subcutaneous fat was thick at the abdomen and upper arm among middle and old age groups and fat accumulation was found on their trunk. Trunk/upper arm accumulation type showed the same tendency with age change. An interpretation could be that the subjects of this group show changes with age earlier than other groups.

Using the longitudinal method, the changes in body measurements of subcutaneous fat and circumferences were measured successfully on the whole body of women in their 20's. The results support the data from cross-section methods used in the past. This study clarified the changes with age for each subject, unlike the cross-section method which allows only comparison of average values among groups. Our study indicates there is significant change in body compositions among Japanese women in their 20's, even when no external change is observed using a body shape index such as BMI. In particular, this study indicates significant change in subcutaneous fat and its distribution. This study found that even in subjects who have a standard body shape, their subcutaneous fat accumulates differently, and can be categorized into 3 patterns.

In this study, we analyzed groups including almost all standard body shapes using a small number of subjects (n=13). In the future, it is necessary to expend the number of body shapes and age groups of our subjects for further study and discussion.

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