Relationships between Nutrition Intake Status, Nutritional Condition and Physical Fitness in Elderly Women

Yoko Sakato*, Kai Tanabe*, Takahiko Nishijima*, Tetsuo Fukunaga** and Shinya Kuno*

*Graduate School of Comprehensive Human Sciences, University of Tsukuba
1-1-1 Tennodai, Tsukuba, Ibaraki 305-8577 Japan
kunopro@wellness.taiiku.tsukuba.ac.jp
**Faculty of Sport Sciences, University of Waseda
2-579-15 Mikajima, Tokorozawa, Saitama 359-1192 Japan
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The purpose of this study was to examine the relationships between nutrition intake status, nutritional condition and physical fitness in elderly women. One hundred-seventy seven community-dwelling healthy elderly people (age = 68.7±5.0 years) were measured for physical activity, diet, physical fitness, biochemical parameters, and body composition. There were no significant differences between the 60-69 year-old group and the 70+ year-old group in nutrition intake and nutritional condition, which were higher than the national average in each age. Both nutrition intake and blood data satisfied an age standard level, and all subjects were in good nutritional condition. There was a significant positive correlation between protein intake and energy consumption ($p<0.05, r=0.17, n=170$). There was no significant correlation between energy intake and physical fitness score ($r=0.08, n=131$). However, there was significant correlation between protein intake ($p<0.05, r=0.21, n=131$), fat intake ($p<0.01, r=0.25, n=131$) and physical fitness score. A significant correlation was obtained among total cholesterol concentration ($p<0.05, r=0.21, n=147$), hemoglobin concentration ($p<0.01, r=0.25, n=167$), and energy consumption. On the other hand, there were no significant correlations between serum albumin and physical fitness elements. These results suggest that nutrition intake might be correlated with physical fitness in community-dwelling healthy elderly people.

Keywords: health promotion, nutrition, dietary intake, malnutrition, physical fitness

1. Introduction

Health promotion does not aim to extend life but to maintain and improve activity of daily living (ADL) and quality of life (QOL) for elderly people. Therefore, in aspect of physical fitness, it is very important to maintain and enhance of physical function. In this respect, balanced exercise and nutrition need to be established. Many previous studies have dealt with health promotion of elderly, however, most have only assessed single effects of exercise or nutrition and few studies have examined synchronous effects of exercise and nutrition.

In physiology, people tend to have less appetite in advanced age. In addition to this physiological decline in appetite, if pathological factors such as depression or dementia are added, appetite decreases further and even weight loss may occur (Morley, 2003). Dietary intake also decreases with anorexia, which forces elderly people into protein energy malnutrition (PEM). Serum albumin is thought to be the best marker which can objectively screen malnutrition such as PEM (Shibata, et al., 1991; Corti, et al., 1996; Persson, et al., 2002). Until now, there are reports that the malnourished elderly have a high decrease rate in walking velocity (Kumagai, 2004), low handgrip strength, and low knee extension power (Kwon, et al., 2005). In an intervention study of frail elderly subjects, nutritional supplementation proved to be effective for maintenance of physical composition such as body weight and BMI and improvement of physical fitness (Fiatarone, et al., 1994; Bonnefoy, et
al., 2003). These reports demonstrate a relationship between nutrition condition and physical fitness in the malnourished elderly, suggesting that preventing malnutrition is important to maintain physical functions.

In Japan, more than 80 percent of elderly live an independent life without any nursing cares and most of them are not malnourished (Sugiyama, et al., 2004). Relationships among nutrition guidance, the status of nutrition intake, physical composition and physical fitness factors have never been examined in independent elderly people. It is important to examine relationships between the status of nutrition/dietary intake and physical fitness factors when we try to prepare effective health promotion guidance for independent elderly who constitute most of the general elderly.

Exercise is most commonly administered for health promotion of elderly, and many studies have reported its effects. There are, however, hardly any studies describing heightening of exercise effect through nutrition guidance in exercise classes for elderly, which aims for maintenance and promotion of physical functions. In the meantime, since requirements of protein for muscle protein composition and micronutrients for faster metabolic turnover are thought to increase more at training than in normal daily life, sometimes nutrition may become insufficient for ample training effect depending on the status of nutrition intake. To the contrary, those who maintain enough nutrition intake and who have good nutrition condition are expected to produce constantly high level of muscle protein composition as well as physical fitness factors, which relate to muscle cross-sectional area and muscle volume. It is interesting to study if nutrition condition relates to exercise-related body composition and physical activity. No studies have examined independent elderly to find how well-managed daily dietary intake and nutrition condition affect physical activity, fitness and composition. Generally, both exercise and nutrition are important to maintain and promote physical functions. Nevertheless, the influence of dietary nutrition intake on physical fitness factors and exercise effect is almost scientifically unsubstantiated.

The purpose of this study is to make a cross-sectional examination with independent and healthy elderly women over 60 years of age on the relationship of daily dietary intake and nutrition condition on physical fitness factors and physical composition.

2. Methods

2.1. Subjects

The subjects were 177 elderly women (68.7±0.5yrs (60-82yrs)) who were willing to participate in exercise classes planned at two municipalities of Ibaragi Prefecture and one municipality of Saitama Prefecture. All subjects were healthy and independent elderly who were diagnosed by medical checks to be capable of participating in the exercise classes. To compare measurements, we divided them into two groups: the 60-69 year-olds (102: 65.2±2.5yrs) and the 70+ year-olds (75: 73.5±3.1yrs). Before the start of measurement, the content of the study was explained and only those who consented participated in the investigation. The study was approved by the Ethics Committee of Institute of Health and Sport Sciences of Tsukuba University.

2.2. Anthropometric measurements

The subjects were measured in height, body weight, body fat rate, and the cross-sectional area of the femoral muscle and the major psoas muscle. A bioelectrical impedance measurement instrument (Muscle-α, 50 kHz, 500μA: Art Heaven Nine Co., Ltd., Kyoto) was used to measure body fat rate. An MRI (Sigma: GE Co., Ltd., NY) was used to measure muscle cross-sectional area. An abdominal cross-sectional image of the naval line was used to measure the major psoas muscle. The femur was measured in an interval of every 2cm of the right leg and muscle cross-sectional area was measured at the 30% region from the femoral caput, where the area from the femoral caput to the top of the knee was set to be 100%. The MRI images were used to determine the cross-sectional area using analysis software (NIH image Ver.1.62, NIH, MD). The measurement of muscle cross-sectional area was obtained in the femoral extensor muscle group, the flexor muscle group and the major psoas muscle.

2.3. Nutrition evaluation

2.3.1. Blood Sampling

Blood was collected from the cubitus vein in a fasting state in early morning. Serum albumin
2.4. Measurement of Physical Fitness Factors

2.4.1. Measurement of Daily Physical Energy Consumption

The subjects wore a portable physical activity monitor (Lifecoder: Suzuken Co., Ltd., Nagoya), which permits time course and quantified measurement of physical activity, for two weeks to obtain energy consumption by daily physical activity. Physical activity was determined using the portable physical activity monitor by the following procedure: first, calculating exercise intensity (equivalent to 0 to 9 METs) from amplitude and oscillation frequency of the acceleration sensor; second, multiplying body weight to exercise coefficient corresponding to exercise intensity; third, converting it into four-second energy consumption; and lastly, adding the values for every four seconds. The validity of the portable physical activity monitor was reported in a study by Yokochi, et al., (1995).

2.4.2. Measurement of Physical Fitness

There were 131 subjects whose physical fitness was measured after being diagnosed as suitable for measurement based on doctors’ interviews and blood pressure. The Japan New Physical Fitness Test 1998 for 65-79 year-old elderly people by the Ministry of Education, Culture, Sports, Science and Technology was used for the physical fitness test. The measurement consisted of six items including handgrip strength, sit-ups, sit-and-reach, single-leg balance with eyes open, 10m hurdle walk, and 6-min walk. The records of these six items were converted to scores and the sum was used as the physical fitness score for comprehensive evaluation of physical fitness. A perfect score for each item was 10 points. Therefore, a perfect physical fitness score was 60 points.

2.5. Analysis and Statistical Processing

The results are expressed by means±SD. Differences between the 60-69yrs group and the 70+ group were tested by using an unpaired t-test. Pearson’s correlation coefficient was used to compare the relationship of nutrition intake, blood data, physical fitness factors and body composition. The level of statistical significance was p<0.05.

3. Results

3.1. Physical characteristics and physical fitness factors

Table 1 shows the subjects’ physical characteristics. The 70+ group showed significantly lower values than the 60-69yrs group in height (p<0.01) while the two groups had no significant differences in body weight and body mass index (BMI). Body fat rate was significantly higher in the 70+ group than the 60-69 yrs group (p<0.01). There was a positive significant correlation between age and body fat rate (p<0.01, r=0.37, n=147).

Energy consumption was significantly higher in the 60-69 yrs group than the 70+ group (p<0.01, Table 1). Energy consumption had a negative significant correlation with age (p<0.01, r=-0.41, n=170).

The physical fitness score was significantly higher in the 60-69 yrs group than the 70+ yrs group (p<0.01, Table 1). There was a significantly negative correlation between physical fitness score and age (p<0.01, r=-0.36, n=131), and body fat rate (p<0.01, r=-0.48, n=104, Figure 3). A significant positive correlation was observed between physical fitness concentration, hemoglobin concentration, and serume total cholesterol concentration were measured as nutritive indicators. Serum albumin concentration could not be obtained at one municipality. Therefore, the total number of the subjects available for the comparison was 71. Subjects who were under medication or treatment because of hypercholesterolemia were excluded from the analysis of the measurements of serum total cholesterol concentration.

2.3.2. Dietary evaluation

A three-day food records survey were conducted to investigate dietary nutrition intake. The subjects were asked to fill out a record sheet about all food and drink taken for three consecutive days except for weekends. For analysis of nutrition intake, PC software (Excel Eiyo-kun Ver.2.3, Kenpaku Co., Ltd., Tokyo) was used to calculate intake energy and nutrient content per day. All intake nutrient contents except for protein were calculated to determine intake as per 1000 kcal intake energy, and the values were used for statistical analysis. For protein intake, daily intake as well as intake per standard body weight were used for statistical analysis.
score and energy consumption ($p<0.01$, $r=0.24$, n=125).

Muscle cross-sectional area did not find any significant differences between the age groups in the femoral extensor muscle group, the femoral flexor muscle group, or the major psoas muscle. A significant positive correlation was recognized between muscle cross-sectional area of the major psoas muscle and the physical fitness score ($p<0.05$, $r=0.26$, n=76). Each muscle cross-sectional area--the femoral extensor muscle group, the femoral superficial flexor muscle, and the major psoas muscle--had a significant positive correlation with body weight (extensor muscle group: $p<0.01$, $r=0.41$, n=100; superficial flexor muscle: $p<0.01$, $r=0.45$, n=100; major psoas muscle: $p<0.01$, $r=0.29$, n=100) and BMI (extensor muscle group: $p<0.01$, $r=0.35$, n=100; superficial flexor muscle: $p<0.01$, $r=0.39$, n=100; major psoas muscle: $p<0.01$, $r=0.26$, n=100).

### 3.2. Intake energy, nutrient intake and nutrition status

Table 2 shows blood data and nutrition intake by the dietary survey. There were no significant age-related differences in intake energy, protein intake, protein intake per standard body weight, fat intake, carbohydrate intake and other nutrition intake. Both groups satisfied estimated energy requirements, recommended dietary allowance or adequate intake of protein, fat (energy ratio), carbohydrate (energy ratio), vitamin and mineral presented in the Japanese Dietary Intake Reference 2005.

Mean serum albumin concentration was 4.5±0.2 g/dl in the 60-69 yrs group and 4.4±0.2 g/dl in the 70+ yrs group, and no subjects displayed less than 3.8 g/dl, which was the reference value of malnutrition. Mean hemoglobin concentration was 13.3±1.0 g/dl in the 60-69 yrs group and 13.0±1.1 g/dl in the 70+ yrs group, both of which exceeded 12.0 g/dl, or the reference value of anemia. Total cholesterol concentration showed 226.1±31.7 mg/dl in the 60-69 yrs group and 216.1±33.7 mg/dl in the 70+ yrs group, and the mean of the 60-69 yrs group slightly exceeded 220mg/dl, the reference value for preventing life-style related disease. No significant difference was observed between the age groups in serum albumin concentration, hemoglobin concentration, or serum total cholesterol concentration. Cholesterol concentration had a significant negative correlation with both carbohydrate intake ($p<0.05$, $r=-0.16$, n=154) and protein intake per standard body weight ($p<0.05$, $r=-0.16$, n=154), but not with daily protein intake. Hemoglobin concentration had a significant positive correlation with protein intake ($p<0.05$, $r=0.16$, n=174).

### 3.3. Relationships between energy/nutrition intake and age/physical fitness factors

Table 3 shows the relationship between dietary nutrition intake and age, body fat rate, energy...
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Table 2  Dietary energy intake, nutrition intake and biomarkers of subjects.

<table>
<thead>
<tr>
<th></th>
<th>60～69 yr.</th>
<th>(N)</th>
<th>≥70 yr.</th>
<th>(N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy intake (kcal/day)</td>
<td>2027 ± 390</td>
<td>(102)</td>
<td>2098 ± 384</td>
<td>(75)</td>
</tr>
<tr>
<td>Protein intake (g./day)</td>
<td>81.0 ± 0.4</td>
<td>(102)</td>
<td>82.4 ± 0.4</td>
<td>(75)</td>
</tr>
<tr>
<td>Protein intake per standard body weight (g/wt./day)</td>
<td>1.6 ± 0.3</td>
<td>(102)</td>
<td>1.7 ± 0.3</td>
<td>(75)</td>
</tr>
<tr>
<td>Fat intake (g/1000kcal/day)</td>
<td>26.5 ± 5.8</td>
<td>(102)</td>
<td>26.4 ± 5.6</td>
<td>(75)</td>
</tr>
<tr>
<td>Carbohydrate intake (g/1000kcal/day)</td>
<td>148.7 ± 16.5</td>
<td>(102)</td>
<td>148.7 ± 15.5</td>
<td>(75)</td>
</tr>
</tbody>
</table>

Protein/Fat/Carbohydrate ratio

<table>
<thead>
<tr>
<th></th>
<th>60～69 yr.</th>
<th>(N)</th>
<th>≥70 yr.</th>
<th>(N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy supplied from protein (%)</td>
<td>16.1 ± 2.3</td>
<td>(102)</td>
<td>15.8 ± 2.3</td>
<td>(102)</td>
</tr>
<tr>
<td>Energy supplied from fat (%)</td>
<td>23.9 ± 5.2</td>
<td>(102)</td>
<td>23.8 ± 5.0</td>
<td>(102)</td>
</tr>
<tr>
<td>Energy supplied from carbohydrate (%)</td>
<td>60.1 ± 6.4</td>
<td>(102)</td>
<td>60.4 ± 5.9</td>
<td>(102)</td>
</tr>
<tr>
<td>Vitamin A (μgRE/[1/1000kcal/day])</td>
<td>648 ± 309</td>
<td>(102)</td>
<td>569 ± 450</td>
<td>(102)</td>
</tr>
<tr>
<td>Vitamin D (μg/1000kcal/day)</td>
<td>5.8 ± 2.9</td>
<td>(102)</td>
<td>5.7 ± 3.2</td>
<td>(102)</td>
</tr>
<tr>
<td>Vitamin E (mg/1000kcal/day)</td>
<td>5.2 ± 1.7</td>
<td>(102)</td>
<td>7.1 ± 17.3</td>
<td>(102)</td>
</tr>
<tr>
<td>Vitamin B1 (mg/1000kcal/day)</td>
<td>0.6 ± 0.1</td>
<td>(102)</td>
<td>0.9 ± 2.5</td>
<td>(102)</td>
</tr>
<tr>
<td>Vitamin B2 (mg/1000kcal/day)</td>
<td>0.8 ± 0.2</td>
<td>(102)</td>
<td>0.9 ± 0.3</td>
<td>(102)</td>
</tr>
<tr>
<td>Vitamin B6 (mg/1000kcal/day)</td>
<td>0.8 ± 0.2</td>
<td>(102)</td>
<td>1.3 ± 2.9</td>
<td>(102)</td>
</tr>
<tr>
<td>Vitamin B12 (mg/1000kcal/day)</td>
<td>5.2 ± 3.6</td>
<td>(102)</td>
<td>4.8 ± 3.9</td>
<td>(102)</td>
</tr>
<tr>
<td>Vitamin C (mg/1000kcal/day)</td>
<td>93 ± 39</td>
<td>(102)</td>
<td>80 ± 26</td>
<td>(102)</td>
</tr>
<tr>
<td>Niacin (mg/1000kcal/day)</td>
<td>9.6 ± 2.8</td>
<td>(102)</td>
<td>9.0 ± 2.5</td>
<td>(102)</td>
</tr>
<tr>
<td>Calcium (mg/1000kcal/day)</td>
<td>395 ± 94</td>
<td>(102)</td>
<td>369 ± 104</td>
<td>(102)</td>
</tr>
<tr>
<td>Iron (mg/1000kcal/day)</td>
<td>5.7 ± 1.3</td>
<td>(102)</td>
<td>5.4 ± 1.5</td>
<td>(102)</td>
</tr>
</tbody>
</table>

Biomarkers

<table>
<thead>
<tr>
<th></th>
<th>60～69 yr.</th>
<th>(N)</th>
<th>≥70 yr.</th>
<th>(N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albumin (g/dL)</td>
<td>4.5 ± 0.2</td>
<td>(49)</td>
<td>4.4 ± 0.2</td>
<td>(22)</td>
</tr>
<tr>
<td>Hemoglobin (g/dL)</td>
<td>13.3 ± 1.0</td>
<td>(100)</td>
<td>13.0 ± 1.1</td>
<td>(74)</td>
</tr>
<tr>
<td>Total cholesterol (mg/dL)</td>
<td>226.1 ± 31.7</td>
<td>(88)</td>
<td>216.1 ± 33.7</td>
<td>(66)</td>
</tr>
</tbody>
</table>

※1: RE=Retinol equivalent  Value is mean±SD  N=Number of subjects.
※: p<0.05, ※※: p<0.01 vs 60～69 yr

consumption, physical fitness score, and muscle cross-sectional area. Energy consumption found a significant positive correlation with protein intake (p<0.05, r=0.17, n=170) but not with energy intake, protein intake per standard body weight, fat intake, or carbohydrate intake.

Physical fitness score did not significantly correlate to energy intake but showed a significant positive correlation to protein intake (p<0.05, r=0.21, n=131) and fat intake (p<0.01, r=0.25, n=131) and a
Table 3  Relationships between age, %fat, energy consumption, muscle cross sectional area, physical fitness score and nutrition intake.

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>% Fat</th>
<th>Energy consumption</th>
<th>Physical fitness score</th>
<th>Tight extensor</th>
<th>Tight flexor</th>
<th>Psoas major</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=177</td>
<td>n=147</td>
<td>n=170</td>
<td>n=131</td>
<td>n=100</td>
<td>n=100</td>
<td>n=100</td>
</tr>
<tr>
<td>Energy intake (kcal/day)</td>
<td>0.073</td>
<td>-0.048</td>
<td>0.101</td>
<td>0.076</td>
<td>0.195</td>
<td>0.229</td>
<td>*</td>
</tr>
<tr>
<td>Protein intake (g/day)</td>
<td>0.033</td>
<td>-0.074</td>
<td>0.169</td>
<td>*</td>
<td>0.211</td>
<td>*</td>
<td>0.199</td>
</tr>
<tr>
<td>Protein intake per standard b weight (g/ht/day)</td>
<td>0.085</td>
<td>-0.056</td>
<td>0.005</td>
<td>0.124</td>
<td>0.119</td>
<td>0.043</td>
<td>0.071</td>
</tr>
<tr>
<td>Fat intake (g/1000kcal/day)</td>
<td>0.012</td>
<td>-0.079</td>
<td>0.116</td>
<td>0.253</td>
<td>**</td>
<td>-0.001</td>
<td>-0.208</td>
</tr>
<tr>
<td>Carbohydrate intake (g/1000kcal/day)</td>
<td>-0.018</td>
<td>0.113</td>
<td>-0.142</td>
<td>-0.273</td>
<td>**</td>
<td>-0.007</td>
<td>0.179</td>
</tr>
</tbody>
</table>

The data is a coefficient of correlation. n=Number of subjects.
※: p<0.05, ※※: p<0.01 vs 60~69 yr

Table 4  Relationships between age, %fat, energy consumption, muscle cross sectional area, physical fitness score and biomarkers.

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>% Fat</th>
<th>Energy consumption</th>
<th>Physical fitness score</th>
<th>Tight extensor</th>
<th>Tight flexor</th>
<th>Psoas major</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=71</td>
<td>n=43</td>
<td>n=65</td>
<td>n=67</td>
<td>n=34</td>
<td>n=34</td>
<td>n=34</td>
</tr>
<tr>
<td>Albumin</td>
<td>-0.175</td>
<td>0.014</td>
<td>0.016</td>
<td>0.188</td>
<td>-0.044</td>
<td>0.085</td>
<td>0.163</td>
</tr>
<tr>
<td>Hemoglobin</td>
<td>-0.099</td>
<td>0.247</td>
<td>**</td>
<td>0.253</td>
<td>**</td>
<td>-0.016</td>
<td>0.015</td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>-0.243</td>
<td>**</td>
<td>0.066</td>
<td>0.210</td>
<td>*</td>
<td>0.060</td>
<td>0.077</td>
</tr>
</tbody>
</table>

The data is a coefficient of correlation. n=Number of subjects.
※: p<0.05, ※※: p<0.01 vs 60~69 yr

A significant negative correlation to carbohydrate intake ($p<0.01, r=-0.27, n=131$).

In the relationship between nutrition intake and muscle cross-sectional area, there was a significant positive correlation between protein intake and cross-sectional area of the extensor muscle group ($p<0.05, r=0.20, n=100$), and between energy intake and muscle cross-sectional area of the flexor muscle group ($p<0.05, r=0.23, n=100$). A significant negative correlation was observed between fat intake and muscle cross-sectional area of the flexor muscle group ($p<0.01, r=-0.21, n=100$).

3.4. Relationships between nutrition status and age/physical fitness factors

Table 4 shows the relationship between biomarkers (nutrition status) and age, body fat rate, energy consumption, physical fitness score, and muscle cross-sectional area. A significant positive correlation was recognized between hemoglobin concentration and body fat rate ($p<0.01, r=0.25, n=145$). No correlation was observed between serum albumin concentration and energy consumption, whereas there was a significant positive correlation of energy consumption with hemoglobin concentration ($p<0.01, r=0.25, n=167$) and with serum total cholesterol concentration ($p<0.05, r=0.21, n=147$).

The biomarkers did not correlate to physical fitness score and muscle cross-sectional area.

4. Discussion

It is known that both exercise and nutrition are
important in promoting health in elderly people. The effect of daily dietary nutrition intake and nutrition status on physical fitness factors is not clear. The effect of nutrition on exercise is described in many studies. For instance, pre- or post-exercise carbohydrate intake suppresses muscle glycogen decrease during exercise (Haff, et al., 2000) and accelerates post-exercise glycogen resynthesis velocity (Pascoe, et al., 1993; Roy, et al., 1998). Protein and carbohydrate intake immediately after resistance exercise has a favorable effect on muscle protein composition and heightens training effects (Esmarck, et al., 2001). These results, however, were mostly proved by a protocol experimentally designed for verifying the effect of nutrition intake on the process of post-exercise metabolism. Therefore, in health promotion, how the status of dietary nutrition intake relates to physical fitness factors and exercise effects has not been clarified.

Thus, the present study aimed to examine the relationship between daily dietary intake/nutrition status and physical characteristics/physical fitness factors of community-dwelling healthy elderly women. There was a physiological anorexia of aging. Therefore, generally, food intake declines with age. (Morley., 2003). In the present study examining healthy middle-aged and elderly women aged from 60 to 82, age-related intake energy and main nutrient intake (i.e. protein, lipids, carbohydrates) did not decrease (Table 2). Subjects' all nutrition intake of both group satisfied estimated energy requirements, recommended dietary allowance or adequate intake of protein, fat (energy ratio), carbohydrate (energy ratio), vitamin and mineral presented in the Japanese Dietary Intake Reference 2005. When our subjects’ energy intake and nutrient intake were compared with the national average of the National Nutrition Survey 2002, they exceeded the means of the same age. It is evident that our subjects took enough nutrition from their diet and that protein, fat and carbohydrate intake were well balanced. It suggested that elderly women, like the subjects in our study, who are independent and willing to participate in exercise classes because they are concerned about health, maintain appetite and dietary intake beyond the standard level. Similar results were demonstrated in our previous dietary survey (Sakato, et al., 2004).

The results of previous studies which showed that the malnourished elderly, compared with normal elderly, 1) had less muscle strength (Kwon, et al., 2005), and 2) had greater rate of decrease in walking ability with age (Kumagai, 2004), suggested a relationship between nutrition intake status and physical fitness factors. The subjects studied in these examinations, however, were elderly who were extremely low in nutrition or physical fitness. To our knowledge, there have been no other studies precisely measuring healthy elderly people living a standard life for the relationships among daily dietary intake, nutrition intake status, and physical fitness factors. The present study found relationships between protein intake and energy consumption, physical fitness score and cross-sectional area of the femoral extensor muscle group, but found no relationships between nutrition intake and physical composition (body weight, BMI) (Figure 1). Further, a significant positive correlation was observed between energy intake and cross-sectional area of the femoral flexion muscle group, as well as between fat intake and physical fitness score (Table 3). It explained that among ordinary elderly people, dietary nutrition intake may relate to physical fitness factors and physical characteristics regardless of the subject’s body composition. Protein is a main constituent of muscles and protein composition and proteolysis are always repeated in muscles even at rest. When protein intake is sufficiently, nitrogen balance is positively maintained and protein synthesis is accelerated. In the meantime, if intake of protein and energy are not sufficiently, nitrogen balance is negatively maintained and proteolysis is accelerated. In regard to this metabolic mechanism, it may be important that a constant amount of protein intake should be routinely maintained and that intake energy should be secured in accordance with consumption. The relationship between protein intake and cross-sectional area of the femoral extensor muscle group presented in the present study suggests that a high level of protein intake may induce muscle protein metabolic turnover (synthesis). Previous studies have described that post-exercise protein intake facilitates muscle protein composition (Rasmussen, et al., 2000) and that training accelerates increase rate of muscle cross-sectional area (Esmarck, et al., 2001). Accordingly, maintenance of ample energy and protein intakes is important to retain muscle volume and keep a high level of physical fitness factors, to which muscle volume is related. The result of the present study supported these previous studies.
Nutrition and Physical Fitness

The result of the present study could not adequately explain the cause and effect of the relationships between daily physical activity and nutrition intake. Yet, it is assumed that enhancement of daily physical activity (consumption energy) stimulates appetite, promotes dietary nutrition intake and increases protein composition. It even accelerates increase in muscle volume and basal metabolism. The correlation of nutrition intake with physical fitness factors or physical characteristics displayed in the present study (Figure 1) is statistically low, so we cannot assert that dietary nutrition intake is influential on physical fitness factors and physical characteristics. Also, since the values of protein intake corrected into intake per standard body weight did not significantly correlate to physical fitness factors, further longitudinal studies on their relationship are needed with similar subjects. However, it is intriguing that some nutrition intake was related to physical fitness factors and physical characteristics in the elderly population who were independent and whose nutrition intake and intake balance satisfied their reference values. Properly balanced dietary nutrition intake may be an important factor to maintain physical fitness and physical characteristics.

As described above, the subjects in the present study had enough energy and nutrient intake regardless of age while their energy consumption tended to decrease with age (Table 1). In addition, body fat rate tended to increase as age advanced (Figure 2). It suggested that surplus intake energy ([intake energy] − [consumption energy]) increases with age and so does body fat. What was observed in all ages was a tendency for body fat rate to be higher while the physical fitness score was lower (Figure 3). Increase in body fat leads to decline of physical fitness and heightens risks of various diseases (Ruderman, et al., 1992). In considering health maintenance and promotion for the elderly, nutrition and exercise should be instructed to decrease body fat. To date, many studies have examined nutrition issues of the elderly in terms of malnutrition. Studies of this field have become popular since reports were published on the rise of mortality risk due to malnutrition subsequent to age-related lowering of dietary intake (Corti, et al., 1996; Shibata, 2001). However, independent and healthy elderly like our subjects sometimes suffer from excessive nutrition but not from malnutrition. As shown in the distribution of % fat and physical fitness score observed in this study, causes of high body fat rate might include not only elderly-specific decreases in muscle volume but also obesity. Such as independent and elderly people need nutrition guidance, in which they are instructed how to increase energy consumption and how to suppress excessive fat and carbohydrate intake. In such a nutrition guidance, it is important to secure protein intake in terms of maintenance and increase of muscle volume.

Blood albumin, hemoglobin, and cholesterol are widely used as indicators for screening nutrition status. Some reports have explained relationships between indicators for nutrition status in blood and physical fitness factors or physical composition (Kwon, et al., 2005; Suzuki, 2004, Baumgartner, et al., 1996). The present study showed a significant positive correlation only between hemoglobin/total cholesterol cholesterol and energy consumption (Table 4). Chin, et al., (2003) demonstrated decrease of daily physical activity rate to be the best indicator for frailty and described its relation to nutrition.

Figure 1  Relationships between energy consumption, physical fitness score, cross sectional area of tight extensor and protein intake.

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intake and nutrition status. The result obtained in the present study partly supports the view of Chin, et al., in the point that activity related to part of the indicators for nutrition status. Other parameters did not have a constant correlation (Table 4). Although previous studies (Kumagai, 2004; Kwon, et al., 2005) showed relationships of albumin values to age-related deterioration in walking ability and physical fitness level, the present study did not yield such result. The mean of the subjects’ albumin values was 4.5 g/dl, which by far exceeded the reference value of malnutrition, 3.8 g/dl. Previous studies acknowledging a relationship between albumin value and physical fitness studied malnutrition and low physical fitness in elderly. These might be factors which caused our contradictory outcome against other studies.

Despite the relationships between dietary nutrition intake and some physical fitness factors, albumin value of our targeted marker as an indicator for nutrition status did not relate to intake. It may explain why nutrition intake does not always directly reflect nutrition status of independent and well nourished elderly as observed in our study. Thought, it is important to determine their nutrition status by blood marker, it is more important to give guidance to see whether proper dietary intake status, especially protein intake, is maintained.
Our study found that our independent elderly female subjects over 60 years of age maintained a good level of nutrition status. In addition, it was suggested that for the subjects with such a good nutrition status, nutrition intake and condition might be the important factors which relate to physical fitness factors and physical composition.

5. Summary

The purpose of this study was to make a cross-sectional examination with community-dwelling independent elderly women on the relationships between daily dietary nutrition intake/nutrition condition and physical fitness factors/physical composition.

As a result, a significant positive correlation was observed between protein intake and energy consumption ($p<0.01$, $r=0.17$, $n=170$). Despite no significant correlation between intake energy and physical fitness score, a significant correlation was displayed between physical fitness score and protein intake ($p<0.05$, $r=0.21$, $n=131$) as well as between physical fitness score and fat intake ($p<0.05$, $r=0.25$, $n=131$). Blood markers obtained as indicators for nutrition condition did not display any relationships to physical fitness.

The results suggested that dietary nutrition intake might have a relationship to physical fitness factors in independent elderly women.

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References


Name: Yoko Sakato
Affiliation: Graduate School of Comprehensive Human Sciences, University of Tsukuba

Address: 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8577 Japan

Brief Biographical History:
1994- Master's Program in Health and Sport Science, University of Tsukuba
1996- Public office, Taiyo village
2004- Doctoral Program in Sport Medicine, University of Tsukuba

Main Works:

Membership in Learned Societies:
• The Japanese society of physical fitness and sports medicine
• The Japan society of physical education, health and sport sciences
• The Japan society of exercise and sports physiology
• The Japan dietetic association
• The Japanese society of nutrition and dietetics
• The Japanese society of public health