Abstract. The objective of the present study was to clarify the effects of physical fitness elements on rising from the supine to sitting position in the elderly. Subjects were 18 elderly persons (12 men and 6 women) who lived at home. Rising from the supine to sitting position was analyzed by measuring the amount of time required for rising and observing body movements. Dynamic balance was assessed by measuring maximum forward and lateral reach of the arm in the sitting position. Trunk muscle strength was also assessed by measuring trunk bending while sitting in a chair. Furthermore, flexibility was assessed by measuring finger-floor distance (FFD) while standing on the feet and bending the upper body forward. The average minimal rising time was 2.7 ± 0.9 seconds. There were two distinctive movement patterns for rising, and the results of one-way ANOVA showed that FFD was the only significant principal effect. Multiple regression analysis of the relationship of minimal rising time to maximum lateral reach and maximum trunk muscle strength showed a determination coefficient of r^2=0.795 (p<0.01). The results of the present study indicate that flexibility affects movement patterns, and that lateral reach and trunk muscle strength are the determination factors for the amount of time required for rising from the supine to sitting position.

Key words: Performance, Sit up, Physical fitness

INTRODUCTION

Of the various activities that make up daily living activities, basic activities such as walking, standing and rising, have been analyzed both qualitatively and quantitatively. Rising and standing movements have been primarily examined in qualitative research, and the development of movement as well as movement patterns in children has been mostly analyzed and classified. In quantitative research, several studies have analyzed energy efficiencies, muscle activities, and gravity center fluctuations, while others have compared elderly persons who live at home and those who live at nursing homes. However, there have been very few studies analyzing the basic
movement patterns of the elderly both quantitatively and qualitatively\(^6\). Of the various basic movements, rising is associated with various movement patterns, and the differences among these movement patterns have not been fully clarified. Therefore, the present study investigated the relationship between physical fitness elements and movement patterns for rising from the supine to the sitting position.

**SUBJECTS AND METHODS**

Subjects were 18 elderly persons who lived at home. Elderly persons who were receiving treatment at medical institutions, those with lumbar pain, or those who could not tolerate the predetermined measurements were excluded from the present study. Table 1 shows the subject profiles. The objectives of the present study were explained to each potential subject, and after obtaining written consent, measurements were made.

*Classification of rising movement patterns*

Movement patterns for rising from the supine to sitting position were observed, and trunk physical fitness elements such as sitting balance, flexibility, trunk muscle strength and rising time, were measured.

Movement patterns for rising were classified according to Sarnacki’s classification system\(^10\) (Table 2). The reliability of this classification system for four areas of the body (left arm, right arm, neck-trunk, legs) has been confirmed \((1.00 \geq \kappa \geq 0.71)^6\). In the present study, the neck-trunk criteria were used to assess movements of the trunk region.

*Minimum rising time*

Rising from the supine to sitting position was assessed and the length of time required for rising was measured based on the methods established by Ford-Smith et al.\(^{11}\) For each subject, two video cameras, a standard examination table (hereinafter referred to as a bed, width 0.7 m, length 1.9 m, and height 0.62 m), and one stool (height 0.44 m) were used: One video camera was placed on the right side of the bed (height 0.8 m, 2.0 m away from the edge of the bed), while the other camera was positioned at the foot of the bed (height 0.8 m, 1.85 m from the edge of the bed). The stool (height 0.40 m) was placed on the bed on the right side of the subject at the midpoint along the long axis of the bed. At the start, the subject was instructed to match the height of the anterior superior iliac spine to the center of the long axis of the bed. Then, while lying on the bed in the supine position, the subject rolled to the right to sit on the bed so that the legs were dangling on the side, and then took a magazine placed on the stool. The subject was instructed to carry out this action as quickly as possible to measure a minimal rising time. Several trial runs were done before actually measuring the rising time for a total of five times.

Observed movements of the neck-trunk region were assessed in sections and classified according to the definitions shown in the classification table. The above-mentioned measurement was repeated five times, and a movement pattern that was reproduced at least three times was analyzed. Using a stopwatch, the length of time it took for the subject to rise from the supine to sitting position and touch

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**Table 1. Subjects**

<table>
<thead>
<tr>
<th></th>
<th>Men (n=12)</th>
<th>Women (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>76.5 ± 3.8</td>
<td>74.8 ± 3.7</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>161.3 ± 5.6</td>
<td>146.3 ± 3.9</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>59.2 ± 9.1</td>
<td>50.4 ± 7.2</td>
</tr>
</tbody>
</table>

Mean ± SD.

**Table 2. Movement patterns**

<table>
<thead>
<tr>
<th>Body position</th>
<th>Movement patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvis leading</td>
<td>The lower trunk rotates to the side. In other words, rotation is lead by the pelvis.</td>
</tr>
<tr>
<td>Lateral roll</td>
<td>The head and trunk rotate to the side. In other words, the shoulder girdle and pelvic girdle rotate simultaneously.</td>
</tr>
<tr>
<td>Roll off</td>
<td>The center of gravity is transferred to the right gluteal region to sit on the edge of a bed.</td>
</tr>
<tr>
<td>Come to sit</td>
<td>While having the gluteal region as an axis, the relative positioning between the trunk and the legs is maintained to sit on the edge of a bed.</td>
</tr>
</tbody>
</table>

*: The movement pattern categories have been renamed from Sarnacki’s original titles\(^10\). Sarnacki’s original referred to the right and left sides of the body as near and far sides, respectively.
The magazine on the stool was measured. The break between two measurements was not defined.

**Maximum forward reach and Maximal lateral reach**

With regard to physical fitness elements, balance was assessed by measuring forward and lateral arm reach in the sitting position. One arm (the right arm for the 17 right-handed subjects, and the left arm for the 1 left-handed subject) was raised and moved forward and to the side. At the start of measurement, the arm was raised in the direction of reaching. For forward reach measurements, shoulder flexion was at 90 degrees, while for lateral reach measurements, shoulder abduction was at 90 degrees. The elbow was extended, the fingers were completely bent, and the forearm was pronated 90 degrees. The opposite arm hung naturally at the side of the body (Fig. 1). The subject was instructed to reach a maximum distance within 5 seconds, and the difference between start and end position was measured.

**Maximum finger-floor distance (FFD)**

Flexibility was assessed by measuring the finger-floor distance while instructing the subject to stand on the feet and bend the upper body forward.

**Maximum trunk muscle strength**

According to the methods of Kubo et al.\(^\text{12}\), trunk muscle strength was assessed by measuring trunk traction induced by isometric exercises while sitting in a chair.

Physical fitness elements were compared between the two movement patterns by one-way ANOVA and then multiple comparison assay (Fisher’s PLSD). The relationship between rising time and physical fitness elements was analyzed using correlation coefficients and multiple regression analyses. All statistical significances were set at P<0.05.

**RESULTS**

**Classification of rising movement patterns**

Table 3 shows the results of the rising movement pattern classification. The neck-trunk movements were divided into two patterns: In the roll-off pattern (R pattern), the body weight was shifted in the direction of rising to the ipsilateral ischial bone to rise from the supine to sitting position. In the present study, the subjects were asked to roll to their right, and as a result, body weight was shifted to the right side of the ischial bone. While 11 subjects exhibited the R pattern (6 men and 5 women), 7 subjects exhibited the C pattern (6 men and 1 woman) (Table 3).

**Comparison of physical fitness elements**

Table 4 shows the results of physical fitness measurements: sitting balance, flexibility, trunk muscle strength, and rising time. The results of variance analysis comparing the two rising movement patterns showed that FFD was the only significant principal effect, while other physical fitness elements, such as sitting balance, trunk muscle strength, average rising time, or minimal rising time, were not. There were no significant

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*Table 3. Results: Movement patterns*

<table>
<thead>
<tr>
<th>Body position</th>
<th>Elderly (n=18)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men (n=12)</td>
<td>Women (n=6)</td>
<td></td>
</tr>
<tr>
<td>Neck-trunk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pelvis leading</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Lateral roll</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Roll off</td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Come to sit</td>
<td>6</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

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Fig. 1. Sitting balance. Balance was assessed by measuring forward and lateral arm reach in the sitting position.
differences in physical characteristics such as height and body mass index (BMI).

The results of a multiple regression analysis of minimal rising time (dependent variable) in relation to sitting balance, flexibility and trunk muscle strength (explanatory variables) revealed a significant correlation between rising time and maximum lateral reach ($r = -0.632, p < 0.01$) and maximum trunk muscle strength ($r = -0.518, p < 0.05$). Multiple regression analysis of maximum lateral reach and maximum trunk muscle strength showed a significant difference with a determination coefficient of $R^2 = 0.795$ ($p < 0.01$). Therefore, minimum rising time appears to correlate to trunk muscle strength and lateral arm reach.

**DISCUSSION**

*Comparison of physical fitness elements between the two movement patterns*

Considering age-induced changes and physical fitness elements in the elderly, the neck and trunk are likely places where osteoarthritis occurs, and restricted spinal movement is influenced by muscle strength, balance and flexibility. In the present study, movements of the neck and trunk region during rising in the elderly were observed, and their relationships to physical fitness elements were investigated. The results showed that there were two movement patterns, and there was a significant difference in FFD, a flexibility parameter, between the two movement patterns. This relationship to physical fitness elements is different from other basic movements, such as standing or walking.

To date, the effects of age-induced changes on physical functions have mostly been evaluated by analyzing walking and standing. One study has investigated the relationship between physical fitness elements and age-induced changes in step width, and the results showed a correlation with maximum knee muscle strength. Step width indicates the distance between the feet during walking, while FFD represents the distance that the neck can be moved towards the pelvis, in other words neck-to-pelvis movement. Therefore, changes in rising movements are caused by a reduction in the neck-to-pelvis movement. Consequently, a reduction in the neck-to-pelvis movement causes a shift from the R pattern, where the body weight is shifted in the direction of rising to the ipsilateral ischial bone, to the C pattern, where the body weight is placed on both sides of the ischial bone during the entire rising movement.

*Comparison of minimal rising time and physical fitness elements*

Clarifying the relationship between rising time and physical fitness elements is very important when promoting the physical strength of the elderly. The results of the present study show a correlation between rising time and physical fitness elements such as lateral sitting balance and trunk muscle strength. The elements involved in rising can be roughly divided into two stages. In the first stage of rising from the supine position, the neck is raised, and then the trunk is bent. In the second stage, the body weight is supported by the arms and then the ischial bone. During the first stage, trunk muscle strength is important, while during the second stage, lateral balance is important. Therefore, to rise from the supine and sitting position, it is important to maintain and strengthen trunk muscle strength and lateral balance.

**CONCLUSIONS**

The purpose of this study was to examine the effects of trunk muscle strength, flexibility and dynamic balance on the activity of getting up from a bed among community-dwelling elderly persons. The results suggest that the required time for getting

<table>
<thead>
<tr>
<th></th>
<th>Minimum rising time* (sec)</th>
<th>Maximum forward reach (cm)</th>
<th>Maximal lateral reach (cm)</th>
<th>Maximum trunk muscle strength (kg)</th>
<th>FFD** (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>2.8 ± 1.0</td>
<td>39.9 ± 8.3</td>
<td>30.4 ± 7.5</td>
<td>15.2 ± 5.2</td>
<td>0.2 ± 8.3</td>
</tr>
<tr>
<td>Women</td>
<td>2.5 ± 0.7</td>
<td>40.9 ± 5.9</td>
<td>30.0 ± 4.9</td>
<td>11.0 ± 4.2</td>
<td>7.3 ± 6.0</td>
</tr>
</tbody>
</table>

*: Minimum rising time: Time required (seconds) to rise from the supine to sitting position. **FFD: Maximum finger-floor distance (cm).
up from a bed for community-dwelling elderly persons may depend on the lateral dynamic balance of the trunk and muscle strength for supporting the trunk. Therefore, this study gives a clear indication of determination of getting up performance, and contributes to the treatment strategy for improvements of basic activities.

REFERENCES