EFFECTS OF LOW-INTENSITY AND LOW-VELOCITY RESISTANCE TRAINING ON LOWER LIMB MUSCULAR STRENGTH AND BODY COMPOSITION IN ELDERLY ADULTS

TAKAHIRO MUKAIMOTO, ILLYOUNG HAN, TATSUKI NAKA and MAKOTO OHNO

Abstract

15 healthy elderly adults (68.6±4.5 years old) participated in this study and were chosen at random for either super low-velocity repetition training (SLT: n=7) or general low-velocity repetition training (GLT: n=8). All subjects performed machine training leg work twice a week for 6 months. Training contents of SLT and GLT were programmed as follows: SLT (Method: 4 seconds of lifting and 6 sec of lowering) and GLT (Method: 2 sec of lifting and 2 sec of lowering). Muscular strength testing was adopted during isometric knee extension using Cybex6000, and body composition was measured by DXA method. As a result, increases in peak torque values and 5 sec average torques value were significantly different in both groups, pre- and post-training (p<0.05). However, there was no significant difference between the two groups. Fat mass significantly decreased during post-training in both groups (p<0.05); however, there was no significant difference between the groups. SLT showed that increases in maximum muscular strength and endurance were similar to GLT. Thus, low-intensity and low-velocity repetition training is suggested as an effective method for elderly adults to increase lower limb muscular strength.

key word: elderly adults, muscular strength, low-velocity resistance training, low intensity

Background

Resistance training is performed by a wide age group to maintain health and for prevention of lifestyle-related diseases. Many studies have recognized that resistance training is effective to increase muscular strength and muscle mass even in aged subjects so that it might improve Quality of Life (QOL) and Activities of Daily Living (ADL).

Previous studies of resistance training in elderly adults were done by using a load of comparatively high intensity. Effects of the training to increase muscular strength and muscle mass for elderly adults is to be expected when the intensity is higher. However, the breath-holding action (valsalva maneuver) is easily caused when exercise intensity becomes high so that the possibility of inducing a sudden elevation in high blood pressure, or of causing excessive stress to muscle tendon organization increases. Westcott et al. reported that the super-slow training increased strength more than regular speed training. Thus, super-slow training is an effective method for elderly adults and exercise beginners. Consequently, for preventing or keeping risks to a minimum, slow movement (low velocity) exercise has recently been recommended.

The purpose of this study was to determine whether slow speed (low velocity) repetition training on lower limbs is effective for muscle strength and body composition in elderly adults as compared to general speed repetition training.

Methods

Subjects

Participants were fifteen healthy elderly adults who obtained exercise permission from their physician (men: n=3, women: n=12). The average age was 68.6±4.5 years old. Physical characteristics of the subjects in the training group are shown in Table 1. Before starting the training, they were
Table 1. Physical characteristics of the participants.

<table>
<thead>
<tr>
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<th>GLT (n=7)</th>
<th>SLT (n=8)</th>
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<tbody>
<tr>
<td>Age (yr)</td>
<td>67.5 ± 5.4</td>
<td>68.9 ± 4.0</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>156.3 ± 7.4</td>
<td>155.8 ± 7.6</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>57.0 ± 12.8</td>
<td>55.5 ± 8.5</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.1 ± 4.2</td>
<td>22.8 ± 2.3</td>
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Values are mean ± SD. GLT: general low-velocity training, SLT: super low-velocity training.

chosen at random for either the general low-velocity training (GLT: n=7) or the super low-velocity training (SLT: n=8) groups. Muscular strength and body composition were measured within seven days before and after the training.

Training protocols

All subjects performed machine training (leg press, leg extension, and leg curl) twice a week for 6 months. Training contents of SLT and GLT were programmed by authors as follows: SLT (Load: 65–50% of the estimated 1 Repetition Maximum (RM) Volume: 3 sets of 6–4 reps; Method: 4 seconds of lifting (concentric exercise) and 6 sec of lowering (eccentric exercise)) and GLT (Load: 80–65% of 1 RM; Volume: 3 sets of 15–10 reps; Method: 2 sec of lifting and 2 sec of lowering).

Measurement items and methods

Muscular strength of lower limbs was measured by Cybex6000C (Cybex) for isometric knee extension strength. Body composition analysis scanned the entire body using dual energy x-ray absorptiometry (DXA). Measurement analysis was used for fat mass (FM), lean tissue mass (LTM), and bone mineral content (BMC).

Statistical analyses

Wilcoxon Rank Sum Test was used to analyze the difference in value before and after 6 months of resistance training. Mann Whitney’s U Test was used to measure the difference in value between the 2 types of training (GLT and SLT) before and after 6 months of resistance training. Values less than 5% were considered significant.

Results

Isometric knee extension strength

Peak torque values of GLT was significantly in-
creased from $2.4 \pm 0.4$ to $2.7 \pm 0.5$ Nm/kg ($10.8 \pm 10.7\% \uparrow$, $p < 0.05$) and that of SLT also significantly increased from $2.4 \pm 0.3$ to $2.8 \pm 0.6$ Nm/kg ($16.1 \pm 13.7\% \uparrow$, $p < 0.05$) (Fig. 1-A). 5 seconds average torque value of GLT significantly increased from $2.2 \pm 0.3$ to $2.5 \pm 0.4$ Nm/kg ($14.4 \pm 12.8\% \uparrow$, $p < 0.05$) and that of SLT significantly increased from $2.0 \pm 0.6$ to $2.5 \pm 0.6$ Nm/kg ($24.6 \pm 21.5\% \uparrow$, $p < 0.05$) (Fig. 1-B). However, there was no significant difference between pre- and post-training on peak torque value and 5 seconds average torque values.

**Body composition**

Body composition is shown in Table 2. Body fat percentage (%) and fat mass (FM) significantly decreased in pre- to post-training ($p < 0.05$) of both GLT and SLT groups. However, there was no significant difference between pre- and post-training groups. Lean tissue mass (LTM) did not increase significantly in pre- to post-training during this period.

**Discussion**

Slow movement speed exercise with low intensity (50–65% 1RM) is the training method in which the speed of the voluntary movement is controlled and the consciousness of the firing muscle group is enhanced. In general terms, as repetition velocity of exercise becomes fast, the amount of inertia and stasis becomes large. Consequently, it is difficult to keep the power constant. Also, as the volume of inertia increases so does the risk of injury. Conversely, slower movement speeds create less inertia so that it is possible to keep muscle tension throughout the range of motion. To repeat the exercise under controlled speed tends to reduce the risk of injury and is the recommended strength training method for elderly adults\(^{16}\). In addition, the effects of keeping muscle tension working for a longer period of time during exercise is correlated to vascular occlusion training\(^{13,14}\).

The resistance training for elderly adults is generally set at an exercise intensity of 65–85% 1RM as high intensity and less than 65% 1RM as low intensity\(^{1,11,16}\). According to the results of this study, low intensity and low velocity (super low-velocity) training showed obvious increases of maximum muscular strength and muscular endurance. The training also showed an increase in muscular strength similar to high-intensity resistance training. Strength measurement adopted isometric knee extension strength, to display muscle action of both groups on the specific conditions\(^7\), and to differ exercise velocity of both groups. For active elderly adults, this long-term resistance training significantly brought decrease of FM, however, in-

### Table 2. Comparison of the body composition after the 6 months resistance training between GLT and SLT.

<table>
<thead>
<tr>
<th></th>
<th>GLT: general lo-velocity training (n=7)</th>
<th>SLT: super low-velocity training (n=8)</th>
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<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>BW (kg)</td>
<td>57.0±12.8</td>
<td>56.3±12.5</td>
</tr>
<tr>
<td>%BF (%)</td>
<td>32.6±5.9</td>
<td>30.3±6.3 *</td>
</tr>
<tr>
<td>LTM (kg)</td>
<td>36.2±7.8</td>
<td>36.9±7.5</td>
</tr>
<tr>
<td>FM (kg)</td>
<td>18.8±6.0</td>
<td>17.4±6.3 *</td>
</tr>
<tr>
<td>BMC (kg)</td>
<td>2.0±0.5</td>
<td>2.0 ±0.5</td>
</tr>
<tr>
<td>BMD (g/cm(^3))</td>
<td>1.049±0.17</td>
<td>1.044±0.16</td>
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</table>

Pre: pre resistance training, Post: post resistance training, BW: body weight, %BF: percentage body fat, LTM: lean tissue mass, FM: fat mass, BMC: bone mineral content, BMD: bone mineral density. *: $p < 0.05$, compared to pre resistance training group. NS: no significant, compared to values in general slow-pace training group. Values are mean±SD.
crease of LTM was not significantly observed. It is the hypothesis that maintaining the duration of muscle contraction accelerates the rate of muscle metabolism, even if training intensity is low. Therefore, FM of GLT and SLT decreased equally. In addition, although we do not measure the action potential of muscle with EMG, it is conceivable that the improvement of nervous system is a factor in increase of muscular strength. Consequently, super low velocity training was shown as an effective and safe method for elderly adults to increase lower limb muscular strength.

Regarding training, programmers create ideal training methods by combining various training patterns in accordance with the needs and purpose of each individual. Although no formal conclusions can yet be drawn regarding training velocity, resistance training of low intensity and low velocity is expected to be one of the ideal methods for elderly adults and rehabilitants at hospitals. An aging society is increasing quite remarkably at present so advanced study of muscle activity and training methods will be needed to improve QOL and ADL.

References