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Original Article

Chair rising exercise is more effective than one-leg standing exercise in improving dynamic body balance: A randomized controlled trial

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Abstract

A randomized controlled trial was conducted to compare the effect of a one-leg standing exercise and a chair-rising exercise on body balance in patients with locomotive disorders. Thirty ambulatory patients (mean age: 66.6 years) were randomly divided into two groups (n=15 in each group): a one-leg standing exercise group and a chair-rising exercise group. All the participants performed calisthenics of the major muscles, a tandem gait exercise, and a stepping exercise. The exercises were performed 3 days per week, and the study period was 5 months. Physical function was evaluated at baseline and at one-month intervals. No significant differences in the baseline characteristics were observed between the two groups. After the 5-month exercise program, the timed up & go, one-leg standing time, and tandem gait time improved significantly in the one-leg standing exercise group, while the walking time and chair-rising time in addition to above parameters improved significantly in the chair-rising exercise group. The improvements in the walking time, chair-rising time, and tandem gait time were significantly greater in the chair-rising exercise group than in the one-leg standing exercise group. The present study showed that the chair-rising exercise was more effective than the one-leg standing exercise for improving walking velocity and dynamic body balance.

Keywords: Fall, Exercise, Muscle Power, Body Balance, Chair Rising

Introduction

Fall-related injuries, including head injuries and fractures, are serious problems among the elderly, as they often lead to prolonged or even permanent disability. Thus, the prevention of falls and, therefore, of the injuries associated with them would reduce disability, improve quality of life, and reduce the costs of health care. American College of Sports Medicine position stand have shown that although no amount of physical activity can stop the biological aging process, there is evidence that regular exercise can minimize the physiological effects of an otherwise sedentary lifestyle and increase active life expectancy by limiting the development and progression of chronic disease and disabling conditions[1]. Thus, exercise aimed at improving physical function must be initiated as early as possible after 50 years of age.

The impairment of muscle strength and muscle power of the lower extremities, balance/postural control, and walking ability has been recognized as important risk factors for falls[2]. These parameters are known to become progressively more impaired with aging[3], increasing the risk of falls among the elderly. Muscle strength of the lower extremities, balance, and walking ability can be improved with appropriate exercise[4]. Muscle strength should be distinguished from muscle power; muscle strength is defined as the maximal force that a muscle can produce against a given resistance, while muscle power (force x velocity) is defined as the product of force and speed[2,5]. The former is related to bone strength, whereas the latter is related to falling[2,5-7]. Thus, the improvement of muscle power, rather than muscle strength, is likely to be important

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for preventing falls. Although exercise is generally accepted to be effective for the prevention of falls among the elderly[8,9], theoretically, the improvement of muscle power in the lower extremities, body balance, and walking ability is important for preventing falls.

A one-leg standing exercise, in terms of static body balance training, is reportedly useful for reducing the cumulative number of falls among the elderly[10]. Because a chair-rising exercise, in terms of muscle power training, may train the quadriceps and gluteus medius muscles, this exercise would improve not only muscle power, but also body balance. Both exercise regimens are utilized in combination for fall-prevention exercise programs[11]. However, which exercise is more useful for improving body balance remains uncertain. A randomized controlled trial was conducted to compare the effect of one-leg standing and chair-rising exercises on physical function in patients with locomotive disorders.

Subjects and Methods

Subjects

Thirty ambulatory patients (1 man and 29 women) with osteoarthritis or spondylosis who visited the Takakuwa Orthopaedic Nagayama Clinic (Hokkaido, Japan) between July 2010 and February 2011 were recruited. The inclusion criteria were an age of more than 50 years, a fully ambulatory status, and the ability to measure the parameters described below; the exclusion criteria were the use of vitamin D3 for osteoporosis[12], severe gait disturbance requiring an ambulatory aid, a severely rounded back because of osteoporotic vertebral fractures, an acute disease phase, and severe cardiovascular disease. The mean age of the participants was 66.6 years (range: 52-76 years). The physical activity level at baseline was considered to be comparatively low in all the participants, since none of them had been laborers or had been engaged in any regular or leisure-time sporting activities.

Each subject was numbered according to the sequence in which they were enrolled in the study. Then, the subjects were divided into two groups (n=15 in each group): the one-leg standing exercise group (OLS group) and the chair-rising exercise group (CR group). The study period was 5 months. The primary endpoint was physical function. The secondary endpoints included falls and fall-related injuries. Informed consent was obtained from each of the subjects prior to their participation in the study. The protocol was approved by the Ethical Committee of Takakuwa Orthopaedic Nagayama Clinic.

Assessment of physical function and fall incidence

After the assessment of age, body weight, height, body mass index, history of falls in the past 1 year, and fall-related fractures after 50 years of age, physical function was evaluated by measuring the 5-m walking time, the timed up & go (3 m), the chair-rising time (5 times), the one-leg standing time, and the 3-m tandem gait time. Walking time is an index of walking ability. The timed up & go test is an index of both muscle power plus dynamic body balance. The chair-rising time (5 repetitions of rising from a chair as quickly as possible with arms crossed over the chest) is an index of muscle power[2]. The one-leg standing time is an index of static body balance. The tandem gait time is an index of dynamic body balance. The 5-m walking time, the timed up & go (3 m), the chair-rising time (5 times), and the 3-m tandem gait time were each determined by obtaining the mean value of two measurements. The one-leg standing time was determined by obtaining the mean value for the right and left sides.

Exercise program

The daily exercise program consisted of a one-leg standing exercise (1 min x 3 sets in each leg per day) in the OLS group and a chair-rising exercise (10 times x 3 sets per day) in the CR group. All the participants performed calisthenics of the back muscles, iliopsoas, hamstrings, and calf muscles, tandem standing (3 min with each leg forward x 2 sets per day), a tandem gait exercise (10 steps x 5 sets per day), and a stepping exercise (in which the subject stepped forward, back, to the right, and to the left x 10 times for each step per day)[11]. All the exercises were performed three days per week and required about 30 minutes to perform. The Guidelines of the French Society of Geriatrics and Gerontology recommend rehabilitation exercises with a professional to extend the rehabilitation benefits[13]. Thus, one session per week was supervised by physical therapists, and the other two sessions were performed at home. Although a meta-analysis study clarified that multifactorial intervention with an exercise component tended to have a larger effect than the exercise intervention alone[14], we educated participants by providing a 20-min lecture once a week. The incidence of fall and fall-related fractures as well as the above-mentioned parameters were assessed every month after the start of the trial.

Statistical analysis

Data are expressed as the means ± standard deviation (SD) in the tables and the means ± 95% confidence intervals (CIs) in the figures. The unpaired t-test and the Fisher exact test were used to compare the characteristics and physical function of study subjects at baseline as well as the percentage changes in physical function parameters and the incidence of falls between the two groups. A one-way analysis of variance (ANOVA) with the Fisher protected least significant difference (PLSD) test was used to compare physical function between baseline and other time points (1, 2, 3, 4, and 5 months). A one-way ANOVA with repeated measurements was used to analyze the longitudinal changes in physical function parameters within a group. A two-way ANOVA with repeated measurements was used to compare the longitudinal changes in the physical function parameters between the two groups. All the statistical analyses were performed using the Stat View J-5.0 program (SAS Institute, Cary, NC, USA). The significance level was set at $P \leqq 0.01$ for all the comparisons.

	OLS group	CR group
Number of subjects	15	15
Gender, Male/Female	1/14	0/15
Age (years)	66.9±6.6	66.3±6.4
Height (m)	1.53±0.07	1.51±0.04
Body weight (kg)	64.9±11.0	64.0±7.8
Body mass index (kg/m^2)	27.7±3.4	28.1±2.8
Number (%) of fallers during the past 1 year	6 (40.0)	5 (33.3)

Data are expressed as the means ± SD. The unpaired t-test and Fisher exact test were used to compare data between the two groups. No significant differences in any parameters were observed between the two groups. OLS: one-leg standing exercise, CR: chair rising exercise.

Table 1. Baseline characteristics of study subjects.

	Unit	OLS group	CR group
5-m walking time	Sec	5.20±1.34	5.75±1.40
Timed up & go (3 m)	Sec	8.92±2.21	8.14±1.15
Chair rising time (5 times)	Sec	9.59±2.18	10.43±2.43
One-leg standing time	Sec	33.21±28.19	33.51±18.49
3-m tandem gait time	Sec	4.99±1.73	5.40±1.58

Data are expressed as the means ± SD. The unpaired t-test was used to compare data between the two groups. No significant differences in any parameters were observed between the two groups. OLS: one-leg standing exercise, CR: chair rising exercise.

Table 2. Physical function at baseline.

	OLS group	CR group	P values
5-m walking time	-12.4±31.4	-38.4±20.0	0.01
Timed up & go (3 m)	-9.0±11.1	-13.4±6.8	N S
Chair rising time (5 times)	-6.8±17.8	-22.5±9.1	0.01
One-leg standing time	138.1±168.1	72.9±56.6	N S
3-m tandem gait time	-14.4±19.1	-35.3±22.3	0.01

Data are expressed as the means ± SD. The unpaired t-test was used to compare data between the two groups.OLS: one-leg standing exercise, CR: chair rising exercise, NS: not significant.

Table 3. Percentage changes in physical function parameters after 5 months.

Results

Characteristics and physical function of study subjects at baseline

Table 1 shows the baseline characteristics of the study subjects. No significant differences in age, height, body weight, and body mass index were observed between the two groups. In addition, no significant difference was seen in the percentage of subjects who had experienced falls during the past 1 year. None of the subjects had experienced fall-related fractures after 50 years of age. The main diseases that could have possibly affected physical activity in the participants were knee osteoarthritis (n=10), hip osteoarthritis (n=3), and spondylosis (n=2) in the OLS group and knee osteoarthritis (n=13) and hip osteoarthritis (n=2) in the CR group. Table 2 shows the baseline physical function of the study subjects. No significant differences in any of the baseline physical function parameters were observed between the two groups. Because the study was strictly conducted by physical therapists, the adherence, i.e., the compliance and persistence, with the exercises was 100%. All the participants completed the 5-month trial.

Effect of exercise on physical function

Figures 1, 2, and 3 show the percentage changes in the physical function parameters: the 5-m walking time (Figure 1), the timed up & go (3 m) and the chair-rising time (5 times) (Figure 2), and the one-leg standing time and 3-m tandem gait time (Figure 3). A one-way ANOVA with repeated measurements showed that the timed up & go, the one-leg standing time, and the tandem gait time improved significantly from the baseline value in the OLS group (P=0.0002, P<0.0001, and P<0.0001, respectively), while the walking time, the timed up & go, the chair-rising time, the one-leg standing time, and the tandem gait time improved significantly from the baseline value in the CR group (all P<0.0001). A two-way ANOVA with repeated measurements showed that the improvement of the walking time, timed up & go, chair-rising time, and one-leg standing time, and 3-m tandem gait time according to a time factor were significant

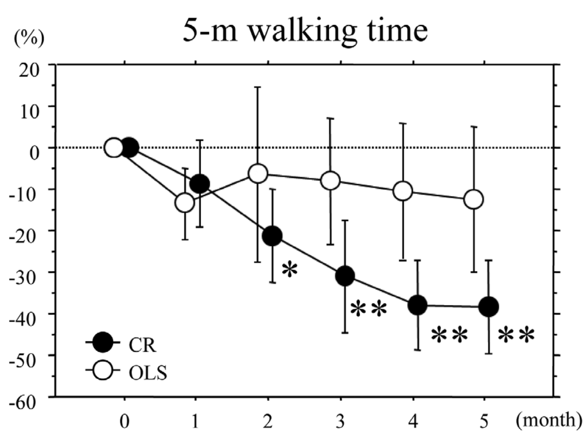

Figure 1. Changes in 5-m walking time. Data are expressed as the means ± 95% confidence intervals (CIs). An analysis of variance (ANOVA) with the Fisher protected least significant difference (PLSD) test showed that the walking time decreased significantly after 2 months in the CR group, but did not change significantly in the OLS group. A one-way ANOVA with repeated measurements showed that the walking time improved significantly from the baseline value only in the CR group (P<0.0001). A two-way ANOVA with repeated measurements showed that the improvement of the walking time was significantly greater in the CR group than in the OLS group (P<0.0001). *: P<0.001, **: P<0.0001 vs. baseline by an ANOVA with the Fisher PLSD test. OLS: one-leg standing exercise, CR: chair rising exercise.

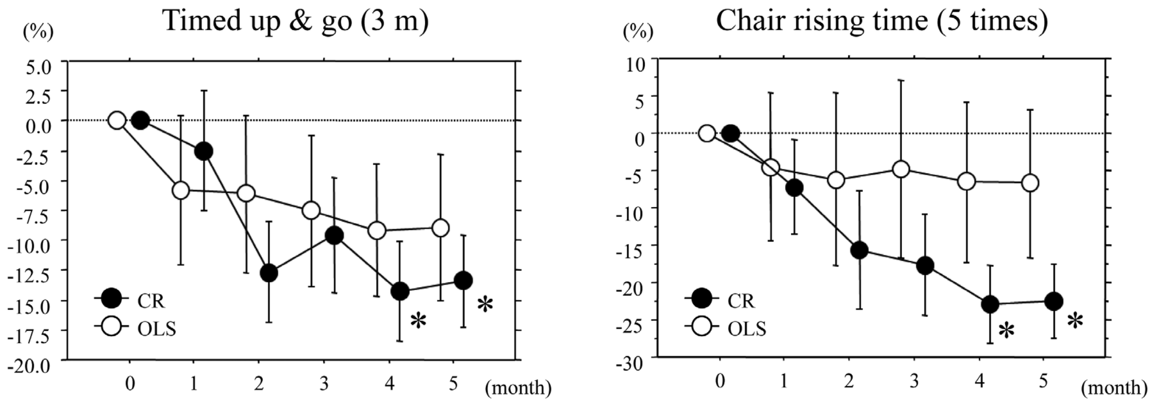

Figure 2. Changes in timed up & go (3-m) and chair rising time (5 times). Data are expressed as the means ± 95% confidence intervals (CIs). An analysis of variance (ANOVA) with the Fisher protected least significant difference (PLSD) test showed that the time up & go and chair rising time decreased significantly after 4 months in the CR group, but did not change significantly in the OLS group. A one-way ANOVA with repeated measurements showed that the timed up & go improved significantly from baseline in the OLS group (P=0.0002), while the timed up & go and chair rising time improved significantly from the baseline value in the CR group (both P<0.0001). A two-way ANOVA with repeated measurements showed that the improvement of the chair rising time was significantly greater in the CR group than in the OLS group (P=0.0008). *: P<0.01 vs. baseline by an ANOVA with the Fisher PLSD test. OLS: one-leg standing exercise, CR: chair rising exercise.

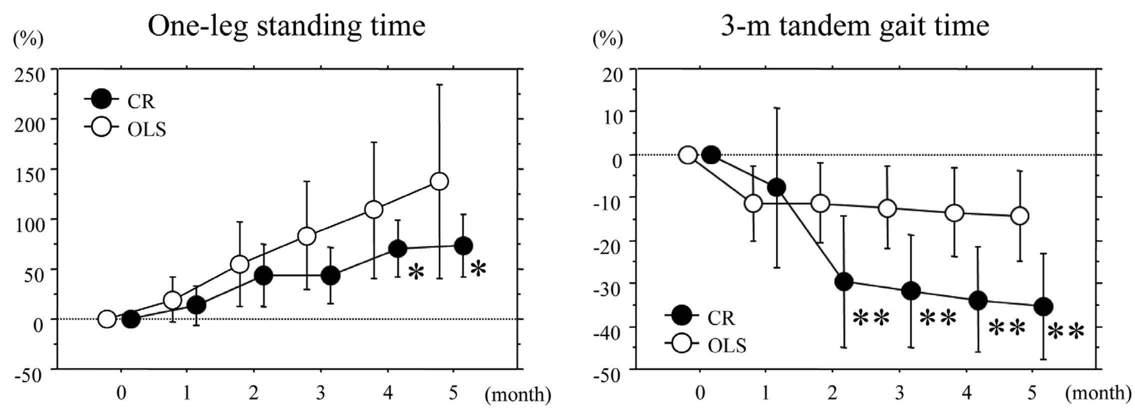

Figure 3. Changes in one-leg standing time and 3-m tandem gait time. Data are expressed as the means ± 95% confidence intervals (CIs). An analysis of variance (ANOVA) with the Fisher protected least significant difference (PLSD) test showed that the one-leg standing time increased significantly after 4 months and the tandem gait time decreased significantly after 2 months and in the CR group. However, this analysis did not show any significant changes in either the tandem gait time or the one-leg standing time in the OLS group. A one-way ANOVA with repeated measurements showed that the one-leg standing time and tandem gait time improved significantly from the baseline value in the OLS and CR groups (all P<0.0001). A two-way ANOVA with repeated measurements showed that the improvement of the tandem gait time was significantly greater in the CR group than in the OLS group (P=0.0003). *: P<0.01, **: P<0.0001 vs. baseline by an ANOVA with the Fisher PLSD test. OLS: one-leg standing exercise, CR: chair rising exercise.

in all subjects (all P<0.0001), and that the improvement in the walking time, chair-rising time, and tandem gait time according to a treatment factor was significantly greater in the CR group than in the OLS group (P<0.0001, P=0.0008, and P=0.0003, respectively).

Table 3 shows the percentage changes in the physical function parameters after 5 months of exercise. Changes in the walking time (-38.4% vs. -12.4%), the chair-rising time (-22.5% vs. -6.8%), and the tandem gait time (-35.3% vs. -14.4%) were significantly greater in the CR group than in the OLS group. The changes in the one-leg standing time were the greatest among the physical function parameters (+138.1% in the OLS group and +72.9% in the CR group). Meanwhile, the changes in the timed up & go were the smallest among the physical function parameters (-9.0% in the OLS group and -13.4% in the CR group).

Fall incidence and adverse events

One patient in the OLS group experienced a fall during the 5-month study period but only suffered a mild contusion. None of the patients in the CR group fell. The incidence of falls did not differ significantly between the two groups. No serious adverse events, such as severe injuries or adverse cardiovascular effects, were observed. The exercise program was safe and was well tolerated.

Discussion

Although a meta-analysis revealed that programs that included balance training, contained a higher dose of exercise, and did not include walking training had the greatest effect on reducing falls[15], exercise aimed at improving not only body balance but also muscle power is important for preventing falls. The one-leg standing exercise is a static body balance training method, while the chair-rising exercise is a muscle power training method, both of which were convenient and well tolerated in subjects with locomotive disorders. In particular, muscle power, as evaluated using the chair-rising test, plays a crucial role in the aging process[16]. The chair-rising exercise (muscle power training) may train the quadriceps and gluteus medius muscles and improve joint movement of the lower extremities, possibly improving body balance. The focus of the present study was: 1) whether the chair-rising exercise would improve not only muscle power but also body balance in patients with locomotive disorders; and 2) whether the improvement of body balance, if any, would be more significant in the CR group than in the OLS group.

We examined the benefits to the study participants of the one-leg exercise (OLS group) or the chair-rising exercise (CR group) in combination with calisthenics for the major muscles, a tandem gait exercise, and a stepping exercise. The timed up & go, one-leg standing time, and tandem gait time improved in the OLS group, while the walking time and chair-rising time in addition to above parameters improved in the CR group (one-way ANOVA). Jacobson et al.[17] reported that a static balance exercise resulted in the improvement of the 30-sec chair test repetition, the 8-foot up and go test, balance assessments, and leg function in frail elderly individuals. Kuptniratsaikul et al.[18] also reported that a simple balancing exercise improved the timed up & go and chair stand in elderly patients with a history of frequent falls. One possible explanation for the discrepancy between our study and those by Jacobson et al.[17] and Kuptniratsaikul et al.[18] regarding the effect of balance exercise on chair rising time may be the difference in study subjects, i.e., the patients with locomotive disorders in the present study and the frail elderly individuals in the previous studies. However, our study showed consistence results regarding the beneficial effect of balance exercise on the timed up & go and body balance.

Although walking exercise has been speculated to play a role in improving walking ability and thereby preventing falls, we did not apply a walking exercise to improve walking ability in terms of walking velocity because the effect of walking exercise on the incidence of falls is controversial. In a cohort study among postmenopausal women, Feskanich et al.[19] showed that walking for at least 4 hours per week was associated with a 41% lower risk of hip fracture, compared with walking less than 1 hour per week. On the other hand, Gillespie et al.[20] showed in a systematic review that brisk walking increased the risk of upper limb fractures among elderly women. Sherrington et al.[15] suggest in an updated meta-analysis that high risk individuals for falls should not be prescribed brisk walking programs. Based on the hierarchy of the evidence, we believe that the result of the systematic review is more reliable. Therefore, we applied only a stepping exercise, which can be considered safe from the point of view that exercise therapy should be safe. However, walking velocity was not improved from the baseline in the OLS group (one-way ANOVA), suggesting the non-beneficial effect of stepping exercise on walking velocity in patients with locomotive disorders.

The one-leg standing time was improved from the baseline value in the CR group (one-way ANOVA), similar to the results in the OLS group (two-way ANOVA). Furthermore, the tandem gait time and the walking time were more significantly improved from the baseline values in the CR group than in the OLS group (two-way ANOVA). These results suggest that the chair-rising exercise was more effective in improving walking velocity and dynamic body balance than the one-leg standing exercise. A randomized controlled trial also showed that power training improved balance, particularly using a low load, high velocity regimen, in older adults[21]. Because muscle power is defined as the product of force and speed[2,5], muscle power training can reasonably improve walking velocity. Muscle power might also play a role in improving dynamic body balance and subsequent static body balance.

The timed up & go, which mainly consists of chair-rising, walking, turning, and sitting, is known to be a reliable and valid test for quantifying functional mobility[22]. The timed up & go results improved similarly in both groups. The improvement after 5 months of exercise (-9.0% in the OLS group and -13.4% in the CR group) was smaller than that of the walking time in both groups (-12.4% in the OLS group and -38.4% in the CR group) and that of the chair-rising time in the CR group (-22.5%). Its improvement was also smaller than that of the tandem gait time (-14.4% in the OLS group and -35.3% in the CR group). These results suggest that our exercise program may not be useful for turning actions, especially for patients with locomotive disorders such as osteoarthritis of the hip and knee or spondylosis.

The exercise program in the present study was performed three days per week. The intensity and frequency of the exercise program were thought to be reasonable for our study subjects (mean age, 66.6 years) to perform without any fatigue and difficulty for 5 months. Although compliance with exercise is an important factor for preventing falls among the elderly, the compliance was 100% in our study. In particular, the chair-rising exercise was not only effective for improving muscle power and dynamic body balance, but was also well tolerated, and no serious adverse events, such as fall-related injuries or adverse cardiovascular effects, were observed in any of the subjects during the exercise program, suggesting the usefulness and convenience of the chair-rising exercise in improving physical function.

The limitations of this study should be discussed. First, the study period was relatively short (5 months). Long-term exercise is needed to reduce the lifetime risk of falls and fall-related injuries. However, because our exercise program proved easy for our subjects with locomotive diseases to continue without any difficulty, we believe that it could be continued under the instruction of general practitioners. Second, the number of study subjects was too small to obtain significant results regarding the incidence of falls, even though statistically significant results regarding physical function were obtained. Third, because there was no control group where the participants performed neither the one-leg standing exercise nor the chair rising exercise, the effect of both exercises on body balance may not clearly be distinguished from that of the tandem gait exercise. Thus, further studies are needed to overcome the study limitations.

In conclusion, the present study examining patients with locomotive disorders showed that the one-leg standing exercise improved static body balance from the baseline value, while the chair-rising exercise was useful for improving walking velocity, dynamic body balance, and muscle power, compared with the baseline values. The chair-rising exercise may be more effective than the one-leg standing exercise for improving walking velocity and dynamic body balance.

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