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The Effects of The Combination Training by Self-Weight Load Exercises and Dynamic Stretching on Locomotive Abilities in the Middle-Aged

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ABSTRACT

There is a large difference between the healthy and normal life expectancies. Musculoskeletal deterioration and movement disorder are some of the main factors which makes the difference larger. One of main causes for the movement disorder is motor dysfunction due to muscle weakness and a reduced flexibility. Muscle function is improved by strength and/or flexibility trainings. So, it is expected that motor dysfunction can be improved by practicing trainings mentioned above. The present study was designed to investigate the possibilities of self-weight load strength training with dynamic stretching as one of the safe and effective training methods for preventing and/or improving musculoskeletal deterioration and movement disorder. Six middle-aged men (Age 54.3 ± 7.8 yrs) and six middle-aged women (Age 53.5 ±4.0 yrs) participated in the present study. The participants trained for 8 weeks with frequency of three times/week. The training was consisted of forward lunge, one leg squat and a dynamic stretching for hip joints. The stand-up test and 2-step test were performed before and after the eight-week training. The results obtained were analyzed using paired T-tests. 2-step distance was improved by 7.8% after the training (254.6±28.4 cm vs, 237.1±28.4 cm, $P < 0.001$). Stand-up test was improved by 1.2 points (6.0±1.0 points vs. 4.8±1.3 points, $P < 0.001$). In the present study we confirmed that stand up and walking abilities, which relate to musculoskeletal deterioration and movement disorder, were improved by combination of self-weight load lower extremity strength exercises (forward lunge and one leg squat) and dynamic stretching.

Keywords: Musculoskeletal deterioration, movement disorder, self-weight strength training, dynamic stretching, heathy and normal life expectancies

INTRODUCTION

Japan has one of the longest life expectancies in the world with the average Japanese person living to age eight-two, however, it also has a serious problem which relates to the life expectancies. There is a large difference between the healthy life expectancy and the normal life expectancy. The difference for men is about nine years and for women is about twelve years [1] and it tells that many old people have difficulties to live independently (without others' help) for more than ten years average. One of the main factors which makes the difference larger is due to musculoskeletal deterioration in the elderly and movement disorder, which are related to so-called locomotive syndrome [2]. Locomotive syndrome is defined as the state where nursing care is most likely required due to reduced locomotive ability and included in life-related diseases or geriatric syndrome [3]. It is said that there are two main causes on locomotive syndrome. One is locomotor disorders cause by osteoarthritis, osteoporosis, and rheumatoid arthritis and the other is musculoskeletal dysfunction caused by muscle weakness and a reduced flexibility [4]. It is well-known that muscle function is improved by strength and/or flexibility trainings. So, it is expected that musculoskeletal deterioration in the elderly and movement disorder caused by aging, which often can be seen in the patient with locomotive syndrome, would be prevented or improved by the trainings mentioned above. We need to carefully consider training methods, intensity, frequency, and amount of it when we want to obtain enough benefits from the training. In addition, high intensity training is not desirable for the elderly from the point of safety. It is known that forward lunge without any equipment can improve hamstring and quadriceps strength and their functions [5.6]. In addition, squat even without load (self-weight load) is thought to improve lower extremities, mainly gluteus maximus and quadriceps [7]. Thus, the present study was designed to investigate the possibilities of self-weight load training with combination of lower extremity dynamic stretching as one of the safe and effective training methods for preventing and/or improving locomotive abilities.

PARTICIPANTS AND RESEARCH METHODS

Participants

Six late middle-aged men (Age 54.3 ± 7.8 years, Height 167.0 ±3.2 cm, Weight 67.2 ±7.5 kg, Body Fat, 19.1 ±4.6 %) and six late middle-aged women (Age 53.5 ±4.0 years, Height 159.2 ±5.4 cm, Weight 59.5 ± 10.5 kg, Body Fat, 30.0 ±4.4 %) without having any record of articular diseases participated in the present study. Before participating, the participants were informed of all experimental procedures, the possible risks, and their voluntary withdrawal from the procedures at any time. Formal consent was obtained from all the participants. All experimental procedures were approved by the Experiment Ethics Committee of Osaka Sangyo University (number; 2020-03) and were conducted in accordance with the Declaration of Helsinki.

Methods

Pre-and-post eight-week training, two exercise tests (the stand-up test, 2-step test) and the 25-question Geriatric Locomotive Function Scale (GLFS-25), which is designed to check degrees of musculoskeletal deterioration and locomotive ability impairment [8.9], were carried out. The training was consisted of three types of exercises (dynamic stretching, forward lunge, and one leg squat). Two sets of dynamic stretching with fifteen repetitions per set were performed to increase flexibility around the hip joints (Fig.1).

Fig. 1 Hip joints dynamic stretching.

Three sets of forward lunges were carried out for each leg with ten times repetitions per set（ Fig.2.

Fig. 2 Forward lunge.

Three sets of one leg squat from the chair, whose height was set 10cm lower than value obtained in the pre-training stand-up test, were performed with ten repetitions per set. (Fig. 3).

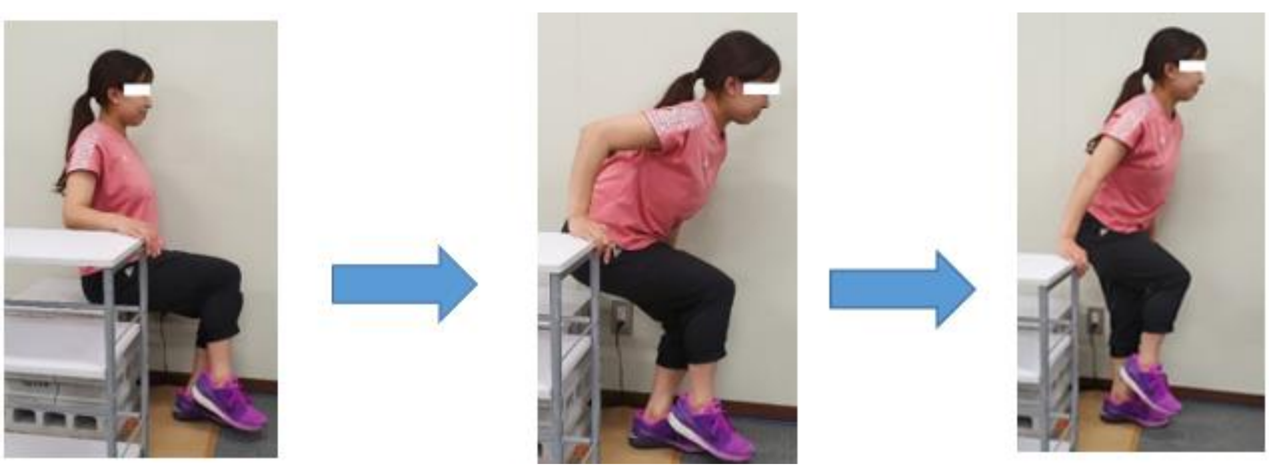

Fig. 3 Single leg Squat.

The participants held a table with a hand to get support for standing up and did not have to stand up completely as long as they put weight on the leg when practicing one leg squat. The training period was eight weeks, and the training frequency was three times/week. The results obtained were analyzed using the paired T-test. The significance level was established by $P < 0.05$.

Stand-Up Test:

Stand up test is the one which was designed to measure lower extremity muscle strength [8.9] (Figure 4). First, the participants sit on the bench with the height of 40cm and stood up from it with both legs and keep standing at least for three second. If the participant succeeded in the first trial, the participant went up to the second trial where the participant was required to stand up by one leg and keep standing for three second at the same chair height. In the second trail the participant was also required to succeed with both single legs to go up to the next trail. If the participant succeeded in the second trail, the chair height was lowered by 10 cm when the participant succeeded and proceeded to the next trial from the third trail. The trial has been continued until the participant failed or succeeded in standing up from the height of 10 cm chair by both single legs. If the participant failed the second trail, the participant went to both legs stand up trial from the height of 30cm chair. From the third trial the chair height was lowered by 10 cm. The trial has been continued until the participant failed or succeeded in standing up from the height of 10 cm chair by both legs.

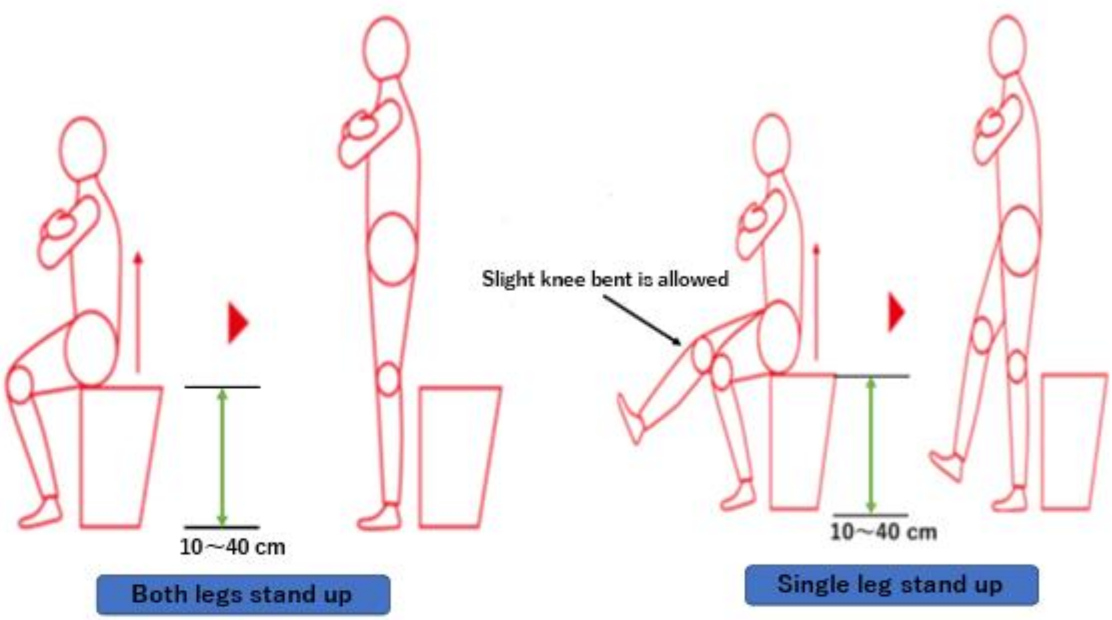

Fig. 4 Stand-up test.

The participants got a point according to their successful level as following and points are used for data analysis.

1 point ---- Succeeded in 40 cm height stand up by both legs.
2 points ---- Succeeded in 30 cm height stand up by both legs.
3 points ---- Succeeded in 20 cm height stand up by both legs.
4 points ---- Succeeded in 10 cm height stand up by both legs.
5 points ---- Succeeded in 40 cm height stand up by both single legs.
6 points ---- Succeeded in 40 cm height stand up by both single legs.

7 points ---- Succeeded in 40 cm height stand up by both single legs.
8 points ---- Succeeded in 40 cm height stand up by both single legs.

2-Step Test:

The 2-step test is the one for comprehensively evaluating walking ability including muscle strength, balance ability, and flexibility of the lower extremities [8.9] (Figure 5). The procedure of the test was as following.

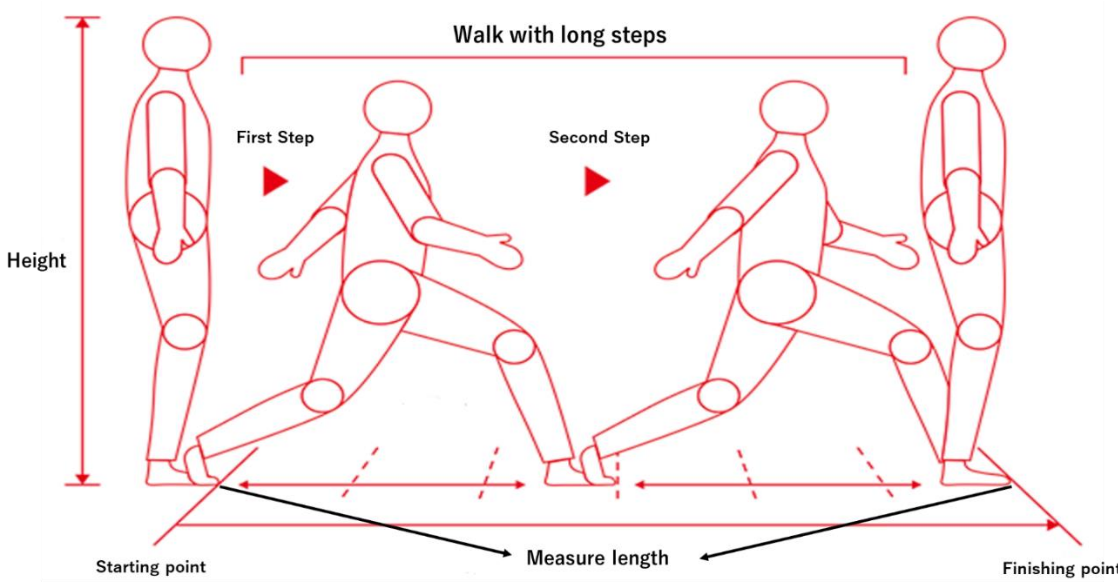

Fig. 5 2-step test.

First, the participant place the toes of both feet on the starting line. Second, take two strides as far as he/she can and bring his/her feet together. If the participant loses his/her balance, it is considered as a failed attempt. Third, measure the length of the two strides, which is from the line where the participant first stood to the tip of his/her toe where the participant landed. The participant tried the test twice and use the better one as his/her record. Then, calculate the 2-step value with the following formula. 2-step value = 2-step distance / height.

GLFS-25:

GLFS-25 is a self-reported comprehensive measure that consists of 25 questions that refer to experiences over the past month [10]. The scale addresses four dimensions using 25 questions (four questions regarding pain, sixteen questions regarding Activities of Daily Living (ADL), three questions regarding social functions, and two questions regarding mental health status). These 25 questions were graded using a 5-point scale from no impairment (0 points) to severe impairment (4 points). Overall points and total points for each dimension were calculated.

RESULTS

The score of the stand-up test after the eight-week training was significantly higher than that of pre-training (pre-training 4.8±1.3 points vs. post-training 6.0±1.0 points, $P < 0.001$) (Fig.6). The 2-step distance after the training was also significantly higher than that before training (pre-training 237.1 ± 28.4 cm vs. post-training 254.6 ± 28.4 cm, $P < 0.001$). 2 step values for post-training was significantly higher than that of pre-training (1.45 ± 0.18 vs. 1.56 ± 0.18, $P < 0.001$) (Fig.7). For GLFS-2 there was no significant difference in overall GLFS-25, physical pain sand ADL dimensions, however, social function (pre-training 1.0 ± 1.0 vs. post-training 0.3 ± 0.5, $P < 0.05$), and mental health status (pre-training 1.0 ± 1.1 vs. post-training 0.2 ± 0.4, $P < 0.05$) dimensions showed significant improvement.

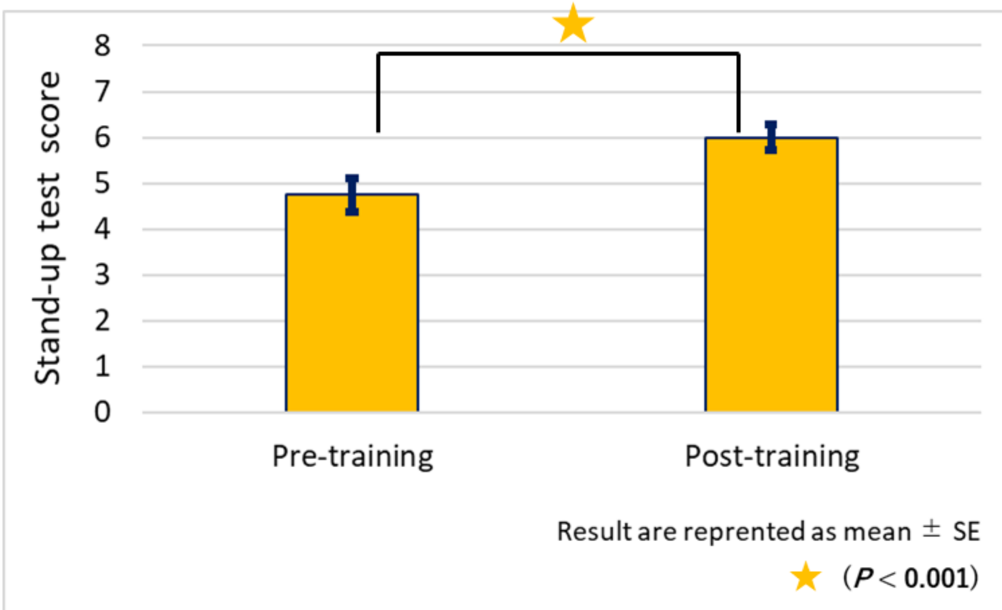

Fig.6 The effects of the combination training on lower extremity strength.
The score of the stand-up test after the eight-week training was significantly higher than that of pre-training ($P < 0.001$).

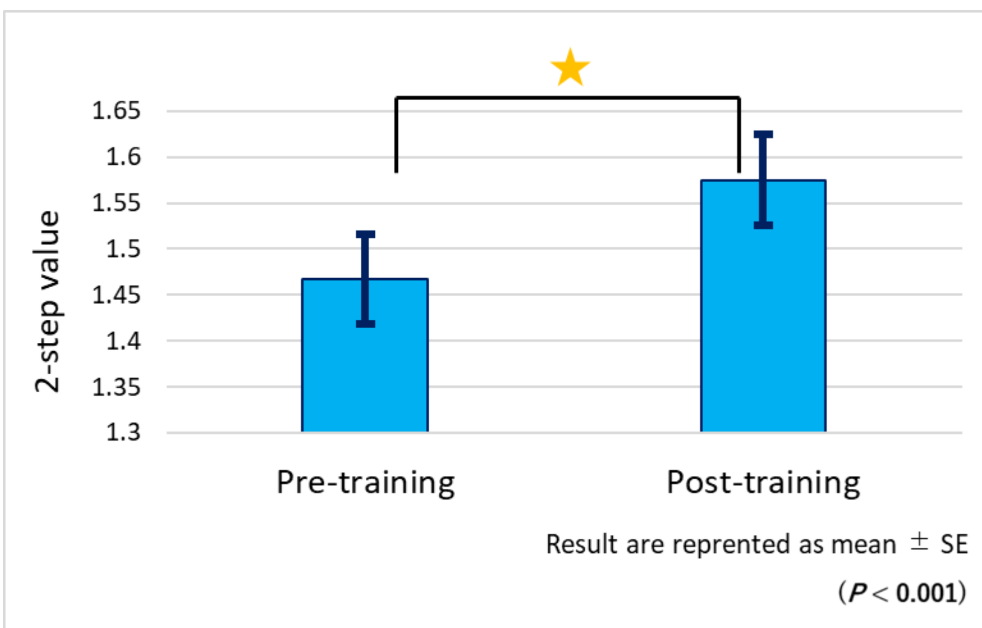

Fig.7 The effects of the combination training on walking ability.
2-step value = 2-step distance / height. 2 step value for post-training was significantly higher than that of pre-training ($P < 0.001$).

DISCUSSIONS

Post-training stand-up test values were improved by an average of 1.2 points compared to pre-training ones ($p<0.001$). The stand-up test is a test that measures the muscle strength of the lower extremities [8]. When standing up from a chair, the vastus medialis and vastus lateralis muscles act on knee extension, and the hamstrings and gluteus maximus act on hip extension [7.11]. It is necessary to train the muscles mentioned above in a well-balanced manner in order to perform the stand-up motion smoothly. The forward lunge is thought to comprehensively improve the muscle strength of the lower extremities such as rectus femoris and gluteus maximus [7.11] and squat is thought to mainly improve gluteus maximus and quadriceps [7.11]. Since the height of chairs was not more than 40 cm, the gluteus maximus muscle is thought to be a main muscle [12], which was involved in stand-up test. Therefore, we speculate that stand-up test value was improved by the combined training effects of forward lunge and one-leg squat utilizing self-body weight.

In the present study, the post-training 2-step test value (1.56 ± 0.18) was improved by 7.6% compared to the pre-training value (1.45 ± 0.18) ($P < 0.001$). The 2-step test is the one for comprehensively evaluating walking ability including muscle strength, balance ability, and flexibility of the lower extremities, and it is closely related to stride length [8.9]. The dynamic stretching performed in this study was to increase flexibility around the hip joint, and the forward lunge was considered to comprehensively improve lower extremity muscle strength. To date, it is considered that the test value has improved due to mutual effects of the dynamic stretching and forward lunge.

For GLFS-2 social function (Pre-training 1.0 ± 1.0 vs. post-training 0.3 ± 0.5, $P < 0.05$), and mental health status (Pre-training 1.0 ± 1.1 vs. post-training 0.2 ± 0.4, $P < 0.05$) dimensions showed significant improvement although there was no significant difference in overall GLFS-25, physical pain and ADL dimensions. Stand-up test is the one which was designed to measure lower extremity muscle strength and 2-step test is the one for comprehensively evaluating walking ability including muscle strength, balance ability, and flexibility of the lower extremities. We detected that improvement in the values of the two tests in the present study. So, we expected that ADL dimension would show improvement as lower extremity muscle strength, leg balance and motor ability of lower extremities (cf: chair stand test time) were strongly associated with ADL dependency [13]. However, we could not detect significant changes in these values. We assume this may be due to linkage between pain and ADL dimensions. For example. we tend to feel difficulty in ADL when we feel pain in the part of body which we move. The improvement in social function and health status dimensions is interesting. We assume the improvement in stand-up test and 2-step test may give confidence to the participants about social function (cf: participation in local events and socialization with friends) and health status (cf: anxiety of falling down, and anxiety about not being able to walk) dimensions of GLFS-25 and it might positively affect the results although we cannot explain the reasons clearly.

The data of the present study were obtained only by the middle-aged participants who had no record of articular disease. So, we must take a careful consideration when we apply the training used in the present study for the elder and people who has articular diseases.

CONCLUSION

In the present study we confirmed that self-weight load strength exercises (forward lunge and one leg squat) with hip joints dynamic stretching can be one of the safe and effective training methods for preventing and/or improving musculoskeletal deterioration and movement disorder which relate to locomotive syndrome.

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