Original article

The Effectiveness of Toe Flexion and Extension Exercise for Fall Prevention in Community-Dwelling Older Females

Terumi KAWAI[1], Masahiko KANAMORI[2], Hiroko WASHIZUKA[3], Miho YOSHII[4], Keiko TERANISHI[5]

地域在住女性高齢者に対する転倒予防のための足趾屈伸運動の介入効果

河相てる美[1]・金森昌彦[2]・鷲塚寛子[3]・吉井美穂[4]・寺西敬子[5]

Abstract

The purpose of this study is to investigate whether exercises for toe flexion and extension are effective in improving Toe function (TF) and the locomotive syndrome (LS).

The survey conducted the following TF tests (toe-grip strength, toe-gap force and 10-second toe test), one leg balance test and LS test (two-step test, stand-up test and GLFS-25 scores). The participants were 209 community-dwelling aged females. Participants were instructed to perform flexion and extension exercises of toes in three sessions per day, with ten repetitions per session. After three months they were again tested with the TF and LS tests.

After the continuous exercises performing flexion and extension of the toes over a three-month period, we divided participants into two groups (exercise-continuing and non-continuing groups), and analyzed the obtained data. In the continuing group, the significant improvement was shown in TF tests ($p<.001$), stand-up tests ($p<.01$) and GLFS-25 scores ($p<.05$), compared with pre-intervention scores. The non- continuing group showed no changes in these scores.

Toe flexion and extension exercises may contribute to the prevention of falls for older individuals.

Keywords: community-dwelling older people, toe function, locomotive syndrome, toe flexion and extension exercise

和文要旨

本研究の目的は，足趾の屈伸運動が，足趾の機能（TF）とロコモティブシンドロームの程度を改善させ得るか否かについて検討することである。調査項目として，転倒リスク簡易評価指標，足趾の機能として，足趾握力，足趾挟力，足趾10秒テスト，またロコモの評価として開眼片脚起立時間および２ステップテスト，立ち上がりテスト，ロコモ25を測定した。対象は地域在住の女性高齢者209人である。椅子座位にて足趾の屈曲と伸展の運動を１日３回，１回につき10回毎日実施することを各個人に依頼した。３か月間足趾の屈伸運動実施後，参加者を運動継続した群と継続しなかった群に分けて，分析した。継続群において，介入後の値は介入前の値に比べて，足趾握力，足趾挟力，足趾10秒テスト（$p<0.001$）と立ち上がりテスト（$p<0.01$）・ロコモ25（$p<0.05$）の測定項目が有意に改善した。一方，非継続群では変化はなかった。高齢者に対する足趾の屈伸運動は，高齢者の転倒予防にも寄与できる可能性がある。

Key words: 地域在住高齢者　足趾機能　ロコモティブシンドローム　足趾屈伸運動

(Received 2023.8.26 / Accepted 2023.10.5)

[1]Clinical Nursing, Toyama Prefectural University, Faculty of Nursing, Toyama, Japan, [2]Department of Human Science, Graduate School of Medicine and Pharmaceutical Sciences for Research, University of Toyama, Toyama, Japan, [3]Fundamental Nursing, Toyama Prefectural University, Faculty of Nursing, Toyama, Japan, [4]Department of Fundamental Nursing, Graduate School of Medicine and Pharmaceutical Sciences for Research, University of Toyama, Toyama, Japan, [5]Kanazawa Medical University School of Nursing, Ishikawa, Japan

Introduction

Objective

A previous systematic review indicated that there are numerous causes of falls, including internal factors, such as diseases and age-related changes in physical functions, as well as external factors, such as the living environment and footwear[1]. Older individuals who fall may sustain fractures, which may require surgery as an inpatient and or institutionalization, leading to decreased functionality in daily life[2, 3]. In addition, complications often make such conditions worse. In light of these circumstances, studies on fall prevention based on the concept of sarcopenia have been conducted in many countries apart from Japan. The Sarcopenia Working Group of Europe[4] and Asia[5] has defined sarcopenia as decreased skeletal muscle mass and strength. The criteria used to determine sarcopenia is based on the results of a physical function assessment comprising walking speed (under 0.8 m/sec), grip strength, and skeletal muscle mass[5]. While walking speed decreases with age in both males and females, the decrease is particularly observable in females[6].

The advent of the super-aging society indicates that, despite being able to control medical diseases to some extent, problems with the organs of locomotion—such as the bones, joints, muscles, and nerves—that occur as a result of aging, reduce locomotor functioning. This leads to an increase in the number of people whose independence in daily life has decreased. In Japan, there are awareness programs in place to educate the public about this situation, characterized as the "locomotor syndrome" (LS) [7]. Measures that have been shown to be considerably effective in preventing falls among community-dwelling older people include group exercise programs, Tai Chi, and rehabilitation through home nursing[8].

LS was first assessed using the Musculoskeletal Ambulation Disability Symptom Complex (MADSC) criteria, which includes: under 15 seconds in the one leg balance test (OLBT), and the 3-minute Timed-Up-and-Go test (TUG) is more than 11 seconds[9]. Subsequently developed tests for assessing the LS include the stand-up test, the 2-step test, and the 25-question geriatric locomotive function scale (GLFS-25)[10]. The LS level has been shown to be related to decreased locomotor functioning; as a result, the tests for LS have been reported to be useful[11, 12].

We have conducted a series of studies focusing on toe-functions (TF) and balance ability (BA) for preventing falls for older individuals[13, 14]. The results suggest that developing toe strength is important as toes directly contact the ground or floor. Our previous interventional studies involved toe exercise training. These studies were designed to improve the strength of the feet using a towel (sometimes known as "towel curl")[15] We also found that training involving flexing and extending the toes led to improved toe strength among university students[16]. However, to the best of our knowledge, there are no studies in the literature on the effectiveness of toe exercises performed by community-dwelling older individuals. Because the average life expectancy is higher in a woman, countermeasures for the locomotive syndrome are important. In the present study, we investigated whether interventional, consisting of exercises involving toe flexion and extension—the main movements of the toes—are effective in improving TF and LS for community-dwelling older women.

Participants and Methods

Definition of terms

1) TF is defined by the following three elements: i) toe grip strength (the gripping ability of the toes), ii) toe gap force (the ability to hold something between the toes; motor dexterity), and iii) toe extension and flexion strength (agility).

2) BA is defined by the following three elements: i) static balance (the ability to stand on one leg with the eyes open), ii) vertical dynamic balance (the ability to stand up from the seated position in a chair), and iii) horizontal dynamic balance (the ability to align the feet after taking two long strides).

Participants

The participants were community-dwelling older women (aged 65 years and older). A description of the study was provided to members of Seniors Clubs and similar organizations, and written consent was obtained from the participants. The participants were individuals who were able to walk independently, had no problems related to cognitive functioning, and were able to understand and provide responses to questions. Among the 256 individuals who consented to participate in this study and underwent initial measurements, 209 subsequently underwent the second measurements after receiving the toe flexion and extension exercise training intervention. We divided the patients into two groups: 107 in a continuing group including 64 who performed the exercises every day and 43 who sometimes missed

Table 1 Background characteristics of the participants

	Continuing group (n = 107)	Non-continuing group (n = 102)
Age (year)	75.4 ± 5.8	75.2 ± 1.7
Height (cm)	149.2 ± 5.6	148.8 ± 5.5
Weight (kg)	52.8 ± 8.1	53.4 ± 9.3
BMI	23.7 ± 3.5	24.1 ± 4.1

Mean ± standard deviation
BMI : Body-Mass Index

but did the exercises five days a week, and 102 as a non-continuing group including 66 who did not do the exercises and 36 who discontinued the exercises after sometimes doing the exercises in the first month. The background characteristics of the participants are shown in Table 1. The study period was from January 2016 to March 2018.

Fall risk assessment

Risk assessments were conducted using the Fall Risk Index[17]. The questions were as follows: "Q1: Have you had a fall during the past year?" "Q2: Do you walk slower than you used to?" "Q3: Has your back become rounder than before?" "Q4: Do you use a walking stick/cane?" and "Q5: Do you currently take five or more different drugs?". Question 1 was assigned 5 points and Questions 2 to 4 each 2 points, for a possible total score of 0–13 points. A score of 6 was the cutoff, with scores of 5 or less indicating a low risk of falls, with scores of 6 or higher indicating a high risk of falls.

Fig. 1a
Toe grip strength meter (Takei, Co., Japan)

Fig. 1b
Toe gap force meter "Checker-kun" (Nissin Sangyo, Co., Japan)

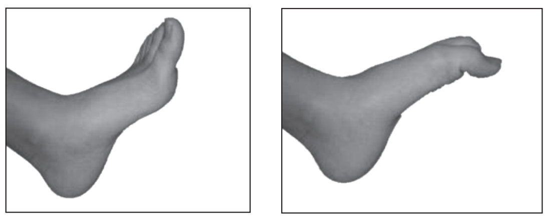

Fig. 1c Toe flexion and extension exercises

TF assessment

Toe grip strength

Toe grip strength was measured using a toe grip strength meter (Takei Co., Japan) (Fig. 1a). Each participant sat in a chair with knees flexed at a 90° angle. The feet were in a fixed position, and the toes were placed on a bar[18]. The traction force exerted by the toes was measured using this bar. Of the two measurements each with the left and right feet, the maximum values were used as representative.

Toe gap force

Toe gap force was measured using a toe gap force meter "Checker-kun" (Nissin Sangyo, Co., Japan) (Fig. 1b). Each participant sat in a chair with knees flexed at a 90° angle, and the pressure between the first and second toes was measured[19, 20].

10-second toe test

The test was conducted with participants seated in a chair with both knees and ankles at a 90° angle. The flexion and extension of all the toes within the range of the participant motion were counted as one. The number of times the participant could complete the exercise in 10 seconds was visually observed for both the left and right feet[21].

LS assessment

OLBT

OLBT was checked to assess the BA with static balance. With the eyes open and both hands placed on the hips, raising one foot and moving it approximately 5 cm in the forward direction, the time it took for this foot to return to contact the floor was measured for both the left and right legs. The upper limit a measurement was 120 seconds[22].

Stand-up test

Stand-up test was carried out to asserts the BA with vertical movement. Using the top of a series of steps 40, 30, 20, and 10 cm in height, each participant stood up from a seated position on each step. Measurements were made using the method devised by Muranaga[23]. First, participants sat on a 40 cm high step with arms crossed, rose on two legs without any lowering of the body, and maintained the posture for 3 seconds. Standing on the 40 cm step on two legs, they raised either the left or right leg, with the knee slightly bended, keeping the leg off the floor, standing with the arms crossed and without any lowering of the body, and maintained this posture for 3 seconds. After performing this with both legs, the participants who successfully completed this on one leg with the 40 cm step moved to 10 cm lower steps, stepwise, and the height of the lowest step where participants were able to stand on one leg (with both legs) was regarded as a test result. The participants who were not able to stand on the 40 cm step on one leg were moved to lower steps in 10 cm steps, and the lowest step where they were able to stand on both legs was used as the test result. We assigned 0 points where participants could not stand on both legs on the 40 cm step, 1 point for both legs on the 40 cm step, 2 points for both legs on the 30 cm step, 3 points for both legs on the 20 cm step, 4 points for both legs on the 10 cm step, 5 points for one leg on the 40 cm step, 6 points for one leg on the 30 cm step, 7 points for one leg on the 30 cm step, 8 points for one leg on the 20 cm step, and 8 points for one leg on the 10 cm step. These results were treated as ordinal data.

2-step test

The 2-step test was measured to asserts the BA with horizontal movement, and conducted as follows: A mat specifically developed for use in the 2-step test was prepared, and a starting line was determined[24]. Each participant took two steps using long strides beginning from the starting line, after which they aligned their feet. The length of the two strides was measured using the tips of the toes at the final position as the point measured. Measurements were taken in the range within which the participant did not lose balance. The participants were instructed not to jump.

GLFS-25

The GLFS-25 is a self-administered questionnaire comprising 25 questions. Each question was allotted a score between 0 (indicating normalcy) and 4 (indicating the most severe disorder) points[25]. Thus, the most severe condition was indicated by a total score of 100 points. Four of the items cover issues, such as “physical pain experienced over the past month” and 21 items are related to “your normal daily life over the past month.”

Intervention method

Toe exercise interventional training consisted of flexion and extension exercises focused on the main toe movements (Fig. 1c). Participants were instructed to sit in a chair and perform flexion and extension exercises of the toes for three sessions per day with ten repetitions per session. The participants were provided with calendar-type check charts on which they recorded whether they did the exercises or not. They were asked to complete these charts on their own. After three months they submitted their charts to the researchers who then checked the implementation status of the exercises.

Statistical analysis

To understand the particulars for the participants, we examined the background of the participants by descriptive statistics using the variables of age, height, weight, and body mass index (BMI). Performing a cross tabulation of the high and low scores of fall risk assessments with the continuing and non-continuing groups, we analyzed the relationship by a chi-square test. For the values of measurement items of the pre- and post-toe flexion and extension exercise training intervention of the continuing and non-continuing groups, we conducted a paired t test on normally distributed continuous data, and a Wilcoxon signed-rank test on other data. Here, the measured items were as follows: toe grip strength, toe gap force, 10-second toe test, 2-step test, GLFS-25, and the duration of OLBT.

Next, we performed an analysis of covariance using the values of the post-intervention toe flexion and extension exercise training as independent variables, and the values of the pre-intervention as adjusting factors (two age groups: a. 65 years to 74 years and b. 75 years and older). The significance level was set to less than

5% in two-sided tests. We used IBM SPSS Statistics (Ver.24) for data processing and statistical analyses.

Ethical considerations

This study was approved by the Ethics Committee of the institutions the authors belong to (No.: Fukutan H27-11; Rin 28-87). The participants were provided with both written and oral explanations of the objectives and details of the study. The participants received the following information verbally: their participation was voluntary; anonymity would be preserved; their identities would be encoded to prevent identification; their data would not be utilized for any purpose other than this study; and they could withdraw from or discontinue participation in the study at any time during the course of the study without suffering any negative consequences. The participants provided written consent to participate in the study and for publication of the results of the study. This study was approved by the Ethics Committee of Toyama College of Welfare Science (Fukutan H27-11), and by the Ethics Committee, University of Toyama (Rin 28-87).

Results

Fall risk assessment

The results of the cross-tabulation regarding continued participation in the study and the risk of falls are shown in Table 2. The Chi-square test did not show any significant differences.

TF assessment

Toe grip strength

In the continuing group, the pre- and post-intervention toe grip strength values were 5.2 ± 0.2 kg and 5.8 ± 0.2 kg, respectively. The mean difference was 0.6 ± 0.1 kg. This indicated that there was a significant improvement in the toe grip strength after intervention as compared to that prior to intervention ($p < .001$). In the non-continuing group, the pre- and post-intervention toe grip strength values were 5.1 ± 0.2 kg and 5.2 ± 0.2 kg, respectively, indicating that there was no significant change (Fig. 2a). Comparison of the continuing group and the non-continuing group showed that despite considering age and the pre-intervention values, the post-intervention value was significantly higher with a difference of 0.6 kg over the non-continuing group ($p < .001$).

Toe gap force

In the continuing group, the pre- and post-intervention toe gap force values were 2.3 ± 0.1 kg and 2.6 ± 0.1 kg, respectively; the mean difference was 0.3 ± 0.1 kg. The post-intervention value was significantly higher than the pre-intervention value ($p < .001$). In the non-continuing group, the pre- and post-intervention toe gap force values were 2.2 ± 0.77 kg and 2.26 ± 0.8 kg, respectively, indicating that there was no change (Fig. 2b). Comparing the continuing and non-continuing groups using an analysis of covariance, the post- intervention values of toe gap force were statistically significantly higher with a difference of 0.3 kg than that of pre-intervention ($p < .001$).

10-second toe test

In the continuing group, the pre- and post-intervention 10-second toe test results were 16.6 ± 0.4 times and 18.0 ± 0.4 times, respectively; the mean difference between the groups was 1.40 ± 0.2 times, and the post-intervention result showed a significant improvement over the pre-intervention result ($p < .001$). In the non-continuing group, the pre-and post-intervention 10-second toe test results were 16.10 ± 0.4 times and 16.40 ± 0.4 times, respectively, indicating no change (Fig. 2c). Comparing the continuing and non- continuing groups using analysis of covariance, the post- intervention values of the 10-second toe test were statistically significantly higher, with a difference of 0.3 kg, than that of pre-intervention ($p < .001$).

Based on the above results, the post-toe flexion and

Table 2 Results of the cross-tabulation regarding continued participation in the study and the risk of falls (n = 209)

	Continuing group (n = 107)	Non-continuing group (n = 102)	Chi-square test *p*-value
Fall risk (5 or less)	69 (65.4%)	66 (64.7%)	n. s.
Fall risk (6 or more)	38 (35.5%)	36 (35.3%)	

n. s.: not significant

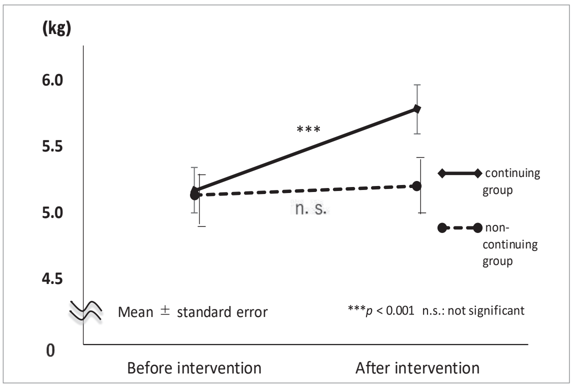

Fig. 2a Toe grip strength

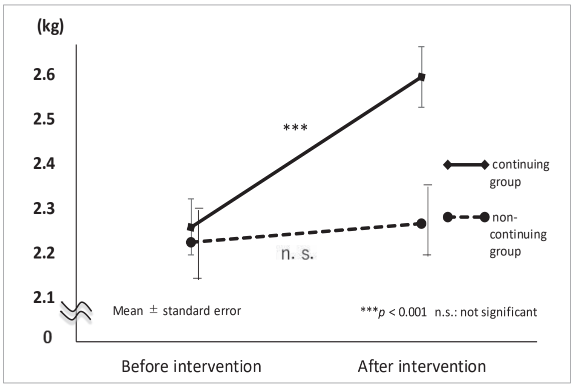

Fig. 2b Toe gap force

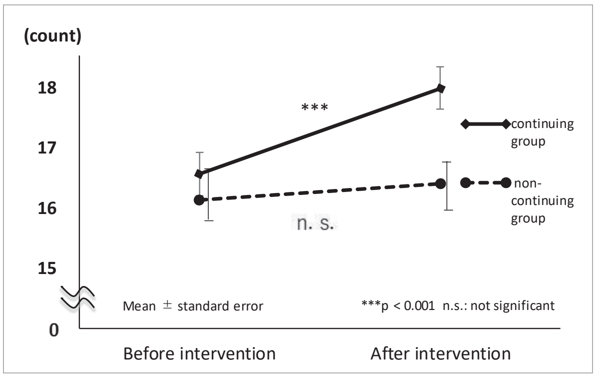

Fig.2c 10-second toe

extension exercise training intervention values showed significant improvements in the toe grip strength, toe gap force, and 10-second toe test items as compared to the pre-intervention values only in the continuing group; the non- continuing group showed no changes in these items. Comparing the continuing and non-continuing groups using the analysis of covariance, the post-intervention values of toe grip strength, toe gap force, and 10-second toe test were statistically significantly higher than those of the pre-intervention values ($p < .001$).

LS assessment

OLBT

In the continuing group, the pre- and post-intervention OLBT values were 37.2 ± 2.9 minutes and 38.9 ± 3.2 minutes, respectively, indicating no significant change. In the non-continuing group, the pre- and post-intervention OLBT values were 36.8 ± 3.3 minutes and 37.1 ± 3.4 minutes, respectively, indicating no change. Comparing the continuing and non-continuing groups using the analysis of covariance, there were no statistically significant differences between the pre- and post- intervention values.

Stand-up test

In the continuing group, the pre- and post-intervention stand-up test values were 3.9 ± 0.1 and 4.1 ± 0.1, respectively. The difference in the mean values was 0.2 ± 0.04, indicating that the post-intervention value showed a significant improvement over the pre-intervention value ($p < .01$). In the non-continuing group, pre- and post-intervention stand-up test values were 3.9 ± 0.1 and 4.0 ± 0.1, respectively, indicating no change (Fig. 3a).

2-step test

In the continuing group, the pre- and post-intervention 2-step test values were 1.19 ± 0.02 and 1.2 ± 0.02, respectively, indicating no change. Moreover, there was no change in the pre- and post-intervention 2-step test values in the non- continuing group change. Comparing the continuing and non-continuing groups using the analysis of covariance, there were no statistically significant differences between the pre- and post- intervention values.

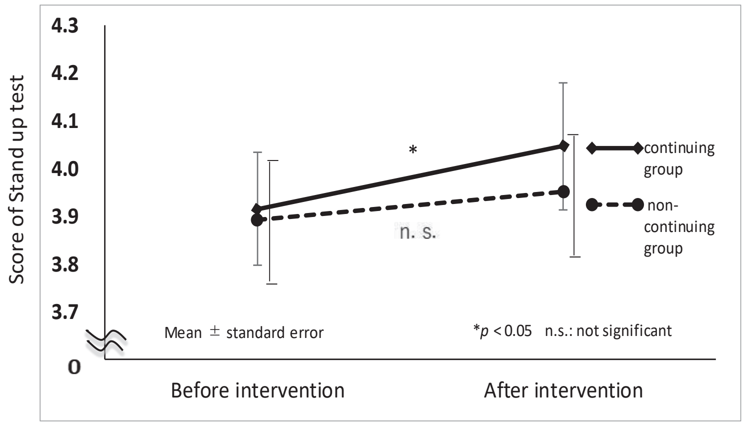

Fig.3a Stand Up test

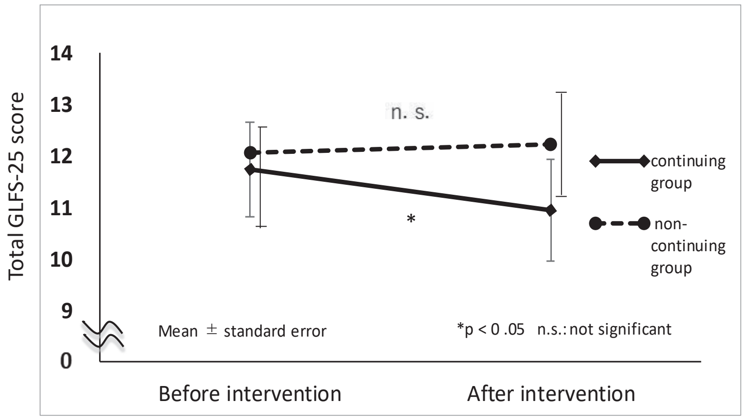

Fig.3b GLFS-25

GLFS-25

In the continuing group, the pre- and post-intervention GLFS-25 scores were 11.8 ± 0.9 and 11.0 ± 1.0, respectively. The difference in the mean scores was 0.8 ± 0.4, indicating that the post-intervention score showed a significant improvement over the pre-intervention score ($p < .05$). In the non- continuing group, the pre- and post-intervention GLFS-25 scores were 12.1 ± 1.03 and 12.2 ± 1.1, respectively, indicating no significant change (Fig. 3b). Comparing the continuing and non-continuing groups using the analysis of covariance with the post-intervention GLFS-25 scores, the continuing group showed improvements of 1 point over the non-continuing group even if the age and the pre-intervention scores were taken into consideration ($p < .05$).

Based on the above results, the post-toe flexion and extension exercise training intervention values of the continuing group showed significant improvements in the stand-up test values and GLFS-25 scores; the non-continuing group showed no changes in these items. In the comparison of the two groups, the post-intervention GLFS-25 scores of the continuing group were statistically significantly lower than that of the non- continuing group.

Discussion

Toe movements include flexion and extension as well as spreading[26]. These movements can be assessed by having participants perform “rock-paper-scissors” movements with their toes. However, as this requires motor dexterity, we suspected that it would be difficult to include this in training for older people. Thus, in the present study on older individuals, we examined the effectiveness of intervention consisting of flexion and extension exercises of the toes. The results of continuously performing flexion and extension exercise training of the toes over a three-month period, the post-intervention results in the continuing group for the toe grip strength, toe gap force, 10-second toe test, stand-up test, and GLFS-25 showed significant improvements over the pre-intervention results. However, there were no changes in the non-continuing group.

TF refers to the function of the muscle groups related to toe movement and that of the muscle groups related to maintaining the plantar arch. When standing, TF helps maintain balance by allowing the toes to grip the ground; while walking, TF facilitates shock absorption during the initial contact phase of gait, supports loads, and plays a role in single-leg support. It has been reported that older individuals with weak TF or foot deformities have a high risk of falls[27]. It has also been reported that individuals who sustained a fall over the past six months had significantly lower toe lift angles than that in those who did not[28]. There is an association between fall risk and toe grip strength. Thus, it may be possible to utilize this in the prevention of falls[29]. There is a positive correlation between the toe grip strength and the strengths of the tibialis anterior, abductor hallucis, and flexor digitorum brevis muscles[30]. Exercises to strengthen these muscles may contribute to fall prevention. A large amount of muscle activity occurs during the towel gathering exercise, which involves gripping a towel with the toes and resembles the toe flexion movement taught during training[31]. Toe flexion and extension exercises in the present study can be performed anytime and anywhere, even without the use of a towel or similar item. Therefore, it places little burden on older individuals. Swiftly flexing and extending the toes requires motor dexterity.

Although toe gap force also requires motor dexterity, there are no specific muscles playing a dominant role in this movement, as muscles, such as the lumbricals and the interossei complement each other while performing this movement. It has been reported that those who have sustained falls have lower interdigital pressure than those who have not[20]. (Yamashita & Saitou, 2002). A quantitative assessment of toe gap force and the risk of falls have found that when toe gap force is 2.4 kg or lower, the risk of falls is high[19]. (Yamashita, et al., 2008). The results of the present study indicate the possibility that an improvement in the mean toe gap force to 2.5 kg or higher reduced the risk of falls. The 10-second toe test requires toe agility, as flexion and extension movements of the toe are repeated. A systematic review has shown evidence that increased toe flexion strength is associated with good posture as well as balance, which indicates that there is a significant relation between toe flexion strength and posture as well as with balance[32]. Improved toe agility, therefore, can be expected to be effective in improving toe flexibility.

In the present study, we assessed BA using the LS test. The stand-up test reflects not only BA related to vertical movement function but also lower extremity muscle strength and the ability to perform activities of daily living[33]. The 2-step test assesses BA related to horizontal movement, lower extremity muscle strength, and comprehensive walking skills, such as flexibility[34]. The results of the present study suggest that toe flexion and extension exercises may strengthen the muscle groups associated with toe movements and maintenance of the plantar arch, and may thus result in more stable stand-up test results. In addition, there is a possibility that the risk of falls decreases as a result of improvements in the GLFS-25 results. The GLFS-25 has been correlated with walking speed[35]. Therefore, improvements in GLFS-25 results are likely to lead to improved walking speed. The toe flexion and extension exercise can be performed even when confined to bed, so it can be performed by patients who require bedrest as well as by those who are recovering after surgery. The TF improvements as a result of toe flexion and extension exercise are likely to be effective in preventing falls after the conclusion of the bedrest period.

However, we did not observe improvements in the OLBT or the 2-step test. Both of these tests require gross muscle strength and flexibility in multiple joints because OLBT measurements are taken while the participant supports their body with a single leg, and the 2-step test requires that the participant supports their body weight on a single leg while taking each step. Therefore, improvement in these types of balance skills requires more than the toes alone; it also requires training for the lower back and extremities as a whole.

During the planning stage for this study, we aimed to conduct a controlled two-arm study. However, there were problems with this design, including problems regarding how to confirm whether the interventional exercises were performed appropriately and whether or not the participants were able to maintain their level of awareness regarding their participation in the study. In this study, we utilized a calendar-type check sheet for the purpose of determining whether the participants performed the interventional training. However, the fact that this depends upon self-reporting means that there were limitations in the extent to which we could confirm that the participants did perform the interventional training. In the future, we would like to obtain more verifiable results by having participants perform the exercises at an exercise facility for older individuals or a similar institution. However, when considering that approximately 40% of the participants in this study were able to continue in their performance of the exercise, it is clear that it would be difficult to collect data in a prospective controlled two-arm study. The present study was single-arm interventional study. However, by analyzing the results after establishing subgroups within the single group, we were able to improve the reliability of this study. Nevertheless, in the future, performing either a prospective controlled two-arm study or a randomized study would verify the effectiveness of toe flexion and extension exercise training.

Conclusions

In this study, we examined the effectiveness of interventional training with exercises involving toe flexion and extension, which are the main toe movements, in community-dwelling older women. Our study findings may be summarized as follows:

1) Our comparisons of pre-intervention and post-intervention data indicated that there were significant improvements in the TF, stand-up test, and GLFS-25.

2) Toe flexion and extension exercises increased the overall strength of the toes, and also improved balance ability with vertical movement (stand-up test) as well as GLFS-25 scores. Thus, it is suggested that these exercises may contribute to the prevention of falls among older individuals.

3) In terms of the applicability to nursing practice, and as toe flexion and extension exercises can be performed during bedrest, it is possible for patients who are confined to their beds to perform these exercises. In conclusion, we hope that these exercises will be included in fall prevention rehabilitation programs.

Acknowledgments

The authors are grateful for the cooperation of the participants for giving their consent to the participation in study and those who readily consented to investigation cooperation in performing this study. We thank Professor emeritus Naruse Y. at the University of Toyama, Japan, who provided the valuable advice support in performing the statistical analysis.

References

1) Deandrea S., Lucenteforte E. and Bravi F.: Risk factors for falls in community-dwelling older people: A systematic review and meta-analysis. J Epidemiol, 21(5), 658-668, 2010.
2) Rubenstein L. Z.: Falls in older people: epidemiology, risk factors and strategies for prevention. Age Ageing, 35-S2: ii37-ii41, 2006.
3) Peel N. M.: Epidemiology of falls in older age. CJA, 30: 7-19, 2011.
4) Cruz-Jentoft A. J., Baeyens J. P. and Bauer J. M.: Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in older people, Age Ageing, 39(4): 412-423, 2010.
5) Chen L. K., Liu L. K. and Woo, J.: Sarcopenia in Asia: consensus report of the Asian Working Group for Sarcopenia. J Am Med Dir Assoc, 15(2): 95-101, 2014.
6) Seino S., Shinkai S. and Fujiwara Y.: Reference values and age and sex differences in physical performance measures for community-dwelling older Japanese: a pooled analysis of six cohort studies. PLOS one, 9(6): e99487, 2014.
7) Japanese Orthopaedic Association : New concept of locomotive syndrome, 2007.
8) Gillespie L. D., Robertson M. C. and Gillespie W. J.: Interventions for preventing falls in older people living in the community, Cochrane Database Syst Rev. (9), 2012.
9) Japanese Orthopaedic Association : Locomotive syndrome, 2-13. Tokyo, Japan: Bunkodo, 2010.
10) Japanese Orthopaedic Association : Locomo challenge promotion society! Locomo brochure, 5-8. Tokyo, Japan, 2013.
11) Ogata T., Muranaga S. and Ishibashi, H.: Development of a screening program to assess motor functioning the adult population: a cross-sectional observational study. J Orthop Sci, 20(5): 888-895, 2015.
12) Yoshimura N., Muraki S. and Oka, H.: Association between new indices in the locomotive syndrome risk test and decline in mobility: third survey of the ROAD study. J Orthop Sci, 20(5): 896-905, 2015.
13) Kawai T., Miyagi Y. and Sakai M.: Raising awareness about locomotive syndrome in the daily life of the elderly. JJNR, 41(4): 723-732, 2018 (in Japanese).
14) Kawai T., Nakada T. and Kanamori M.: Locomotive syndrome evaluation and toe motor functions related to risk of falling in community-dwelling elderly men. J health sciences of mind and body, 16(2): 49-62, 2020 (in Japanese).
15) Kohashi T. and Shono T.: Exercise intervention that community-dwelling elderly individuals can perform at home to improve foot morphology and prevent falls-discussion based on the relationship between improvement of toe and flat foot grounding with toe flexor muscle strength training and fall prevention effects-. The latest social welfare study, 14: 55-67, 2019 (in Japanese).
16) Nagatani N., Washizuka H. and Sakai, M.: Effects of trainings on the toe's function. Synergetic Welfare Sci, 10(1): 37-42, 2015 (in Japanese).
17) Okochi J., Toba K. and Takahashi T.: Simple Screening test for risk of falls in the elderly. Geriatr Gerontol Int 6(4): 223-22, 2006.

18) Arai T., Fujita H. and Hosoi T.: Toe flexor muscle strength as a measure of motor function in community-dwelling elderly people. Jpn Phys Ther Assoc, 38(7): 489-496, 2011 (in Japanese).

19) Yamashita K., Ino S. and Kawasumi M.: Quantitative evaluation of fall risk from viewpoint of lower limb muscular strength. Healthy medical Research institute furtherance memoirs, 23: 133-143, 2008 (in Japanese)..

20) Yamashita K. and Saitou M.: Evaluation of the Aged against Tumbling by Toe-Gap Force. T. S I CE, 38(11): 952-957, 2002 (in Japanese)..

21) Motoe K., Kanamori M. and Nagatani N: Toe's power evaluation in the nursing physical assessment (The 1st report) -Setting of the normal value for the healthy subjects-. J Nurs Soc Toyama, 12(2): 101-112, 2012.

22) Ministry of Education in Japanese : New fitness test implementation guideline for 65-79 aged people, 2014.

23) Muranaga S.: Evaluation of the muscular strength of the lower extremities using the standing movement and clinical application. J Showa Med Assoc, 61(3): 362-367, 2001.

24) Muranaga S. and Hirano K.: Development of a convenient way to predict ability to walk, using a two-step test. J Showa Med Assoc, 63(3): 301-308, 2003.

25) Seichi A., Hoshino Y. and Doi T.: Development of a screening tool for risk of locomotive syndrome in the elderly: the 25-question Geriatric Locomotive Function Scale. J Orthop Sci, 17(2): 163-172, 2012.

26) Suzuki T.: Anatomy of feet]. Yamazaki, N. (Ed.). Dictionary of feet (pp. 10-11). Tokyo, Japan: Asakura book store, 1999.

27) Mickle K. J., Munro B. J. and Lord S. R.: Toe weakness and deformity increase the risk of falls in older people. Clin Biomech, 24(10): 787-91, 2009.

28) Takatori K. and Matsumoto D.: Relationships between simple toe elevation angle in the standing position and dynamic balance and fall risk among community-dwelling older adults. PM&R: 7(10): 1059-1063, 2015.

29) Tsuyuguchi R., Kurose S. and Seto T.: Toe grip strength in middle-aged individuals as a risk factor for falls. J Sports Med Phys Fitness, 58(9): 1325-1330, 2018.

30) Yamada Y. and Sudo A.: Relationship between toe-gripping exercises and lower limb muscular activity. Jpn Phys Ther Assoc, 33(1): 183-186, 2018 (in Japanese).

31) Yamada Y. and Sudo, A.: Muscle activities of the muscles surrounding the ankle in toe-grip exercises. Jpn Phys Ther Assoc, 33(6): 905-909, 2008 (in Japanese)..

32) Quinlan S., Yan A. F. and Sinclair P.: *Gait & posture*, 81, 56-66, 2020.

33) Arai T., Fujita H. and Maruya K.: The stand-up test a measure of decreased motor function and physical activity in community-dwelling elderly people. JJOS, 3(4): 377-386, 2017 (in Japanese).

34) Japanese Orthopaedic Association : Locomo challenge promotion society! Locomo brochure, 6. Tokyo, Japan, 2015.

35) Asahi R., Fujita H. and Arai T.: Relationship between results of the short test battery for locomotive syndrome and gait speed in community-dwelling aged people. JJOS, 2(3): 255-265, 2016 (in Japanese).