The Modified Otago Exercises Prevent Grip Strength Deterioration Among Older Fallers in the Malaysian Falls Assessment and Intervention Trial (MyFAIT)

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Background and Purpose: Exercise-based interventions, such as the Otago Exercise Program (OEP), are effective in preventing falls in the older adult. Previous studies evaluating the OEP have determined falls, lower limb strength, or balance outcomes but with lack of assessment of hand grip strength. The objective of this study is to evaluate the effect of OEP on hand grip strength alongside mobility and balance outcomes.

Methods: This was a single-center, prospective, and single-blind randomized controlled trial conducted at the University Malaya Medical Centre. Patients older than 65 years presenting to the hospital emergency department or geriatric clinic with 1 injurious fall or 2 falls in the past year and with impaired functional mobility were included in the study. The intervention group received a modified OEP intervention (n = 34) for 3 months, while the control group received conventional care (n = 33). All participants were assessed at baseline and 6 months.

Results: Twenty-four participants in both OEP and control groups completed the 6-month follow-up assessments. Within-group analyses revealed no difference in grip strength in the OEP group (P = 1.00, right hand; P = .55, left hand), with significant deterioration in grip strength in the control group (P = .01, right hand; P = .006, left hand). Change in grip strength over 6 months significantly favored the OEP group (P = .047, right hand; P = .004, left hand). Significant improvements were also observed in mobility and balance in the OEP group.

Conclusions: In addition to benefits in mobility and balance, the OEP also prevents deterioration in upper limb strength. Additional benefits of exercise interventions for secondary prevention of falls in term of sarcopenia and frailty should also be evaluated in the future.

Key Words: balance, grip strength, mobility, older fallers, Otago Exercise Program (OEP)

INTRODUCTION

Falls are common health issues seen in older adults globally, defined as “inadvertently coming to rest on the ground, floor, or other lower level, excluding intentional changes in position to rest in furniture, wall, or other objects.”1 With the expected rapid increase in the older population, falls will impose an increasing burden on the health care system. According to the World Health Organization report,1 28% to 35% of older adults 65 years of age and older experience falls every year and make up more than 50% of injury-related hospitalizations. They also account for 40% of all injury deaths although the rates vary between countries. Falls have numerous negative consequences, including dependence, fear of falling, loss of confidence, immobilization, and depression, leading to a reduction in social function and interactions. Falls are also associated with high morbidity and mortality in the ageing population.2

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All authors have made an intellectual contribution to this research. M.P.T., M.M., and K.H. were responsible identifying the research questions, design of the study, and overseeing the implementation of the study. P.J.T. and M.S. contributed to the development of support materials and recruitment of participants. L.K.L. and L.A.M. were responsible for study implementation and data collection. M.P.T. and L.K.L. conducted data analysis and interpretation. All authors were responsible for drafting the manuscript and have read and approved the final version.

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are multiple risk factors associated with falls. Fall prevention strategies identify and target modifiable risk factors to reduce falls. Strategies such as exercise have shown to be successful as a single or as part of a multifactorial intervention in community-dwelling populations for fall reduction. The Otago Exercise Program (OEP) is an effective fall prevention exercise program that can be implemented to improve lower limb weakness and balance. It is an individually tailored home exercise program that consists of strengthening and balance exercises and a walking program.3 Previous studies have demonstrated the efficacy of this program in reducing the number of falls and fall-related injuries.4-8 A meta-analysis showed that OEP demonstrates the greatest benefit in people older than 80 years and with a history of falls. This exercise program significantly reduced both the risk of death and fall rates over a 12-month period.3 Previously published studies in falls prevention have focused exclusively on lower limb strength and balance after exercise interventions. However, strength and balance exercise also have a wider benefit, in particular, as a possible intervention to treat or prevent sarcopenia,9,10 which is an established risk factor for falls.11 One of the markers for diagnosis of sarcopenia and frailty is hand grip strength.12-14 Thus, this study aimed to examine the effectiveness of the OEP in older adults with recurrent or injurious falls on hand grip strength, alongside mobility and balance outcomes.

METHODS

This was a substudy of the Malaysian Falls Assessment and Intervention Trial. The details of the study protocol have been published elsewhere.15 All participants were recruited from the University Malaya Medical Centre, specifically from the primary care clinic, geriatric clinic, and emergency and trauma department. Community-dwelling adults aged 65 years of age and older with a history of 2 or more falls or 1 injurious fall in the past 12 months were eligible to participate in the study.

All participants received a structured multifaceted assessment including an assessment of gait, balance, and muscle strength. Those with strength and balance problems were invited to participate in the OEP study arm as part of the overall interventions. Participants also had to meet the following criteria: able to walk at least 3 m and a Timed Up and Go (TUG) test score greater than 13.5 seconds or 11 to 13.5 seconds with fear of falling (Short Falls Efficacy Scale-International score of 11 or greater), as this threshold is associated with higher risk for fall.16 Ethical approval was obtained from University Malaya Medical Centre Medical Research Ethics Committee (registration number MREC 925.4), and written informed consent was obtained for those who agreed to participate. This was a single-blind (assessor) randomized controlled study. Older adults with clinically diagnosed dementia (according to the International Classification of Diseases, Tenth Revision [ICD-10] definition), severe physical disabilities preventing the ability to stand, or major psychiatric illness were excluded. Participants were assigned to either the intervention group or the control group using a computer-generated random number sequence. Treatment allocation was kept in sealed envelopes and stored in a secured location. Participants recruited from July 2012 to December 2013 were included in this substudy.

Participants in the intervention group participated in the OEP and other interventions according to their clinical indication, whereas participants in the control group were given health advice with continued conventional care by their medical practitioners and other health professionals. All participants were assessed again at 6 months by a blinded, independent assessor. Additional assessments were performed on the participants in the intervention group at 3 months, after completing the OEP.

The outcome measures for both groups at baseline and 6 months were the following:

1. Grip strength. This measurement was performed using a Jamar hydraulic hand dynamometer (Patterson Medical, Warrenville, Illinois). The participants were seated with the elbow flexed to 90° and in a neutral position, and the wrist in slight extension. They were instructed to squeeze the dynamometer as hard as they could. Both hands were assessed in turn, allowing 3 attempts each with 5 seconds of rest in between and the average of 3 scores. The dynamometer units were in kilogram (intraclass correlation coefficient [ICC] > 0.85).17 Normative reference values for grip strength are 27.2 to 35.1 kg (right), 24.4 to 31.3 kg (left) in men 70 to 74 years of age, and 22.3 to 27.2 kg (right), 20.2 to 24.9 kg (left) in men 75 years of age and older. While for women, the reference cutoffs for normal are 19.5 to 23.2 kg (right) and 18.1 to 21.5 kg (left) for those 70 to 74 years of age, and 16.9 to 19.9 kg (right) and 15.0 to 17.8 kg (left) for those 75 years of age and older.18 The standard error of the measurement (SEM) is 1.9.19

2. Timed Up and Go (TUG). This is a test of functional lower limb mobility. Participants started with their backs against the back of the chair, with arms resting on the armrests. They were timed when they were asked to rise from a standard chair (approximately 46 cm in height) with armrest, walk at a comfortable speed for 3 m, turn, walk back to the chair, and sit down again. Timing stopped when the participant's back was positioned against the back of the chair after sitting down (ICC > 0.90).20 The participants were allowed to use their usual walking aids. Each participant was given 3 trials and the average result of 3 trials was used. Normal reference ranges are 7.1 to 9.0 seconds (60-69 years), 8.2 to 10.2 seconds (70-79 years), and 10.0 to 12.7 seconds (80-89 years).21 The minimal detectable change is 1.84 seconds.22

3. Functional Reach test (FR). This test assesses dynamic bilateral stance balance. The meter rule is first fixed at shoulder height. The participants were instructed...
to stand next to the wall with 1 shoulder close to the wall. With the arm closest to the wall raised to 90° of shoulder flexion, participants were required to reach forward as far as possible without falling over. The maximum distance a participant is able to reach forward with his dominant arm while maintaining both feet 10 cm apart is measured (ICC = 0.81). Each participant was given 3 trials and the average result of 3 trials was used. The reference range for FR is 27.60 to 31.27 cm.

Additional outcome measures for the OEP group (not measured in the control group) at 3 and 6 months were as follows:

1. Five Times Sit to Stand test. This is a test of functional lower limb strength in which the participant is asked to stand up and sit down as quickly as possible from a standard chair (47 cm height) 5 times continuously with arms folded across the chest (ICC > 0.89). The participants were allowed to have their arms at their side if they were unable to stand up with their arms folded, for instance, if there was history of stroke or fracture. Normal reference values are 11.4 seconds (60-69 years), 12.6 seconds (70-79 years) and 14.8 seconds (80-89 years). Minimal detectable change is 2.5 seconds.

2. Berg Balance Scale. This test consists of 14 static and dynamic activities related to everyday living (ICC = 0.98). The test has a score range of 0 to 56, with higher scores indicating better performance. Minimal detectable change score range of 45 to 56 is 4 points.

3. Step test. This is a test of dynamic single-limb stance balance. It measures the number of steps a participant makes for each leg when stepping up and down from a 7.5-cm block as quickly as possible (ICC > 0.90). The score is the number of steps completed in the 15-second duration for each leg. A score of 16 steps and more is considered normal.

**Modified OEP Intervention**

The OEP consists of 17 strengthening and balance exercises. The strengthening exercises included strengthening of the knee extensors, knee flexors, hip abductors, ankle plantar flexors, and ankle dorsiflexors. The balance exercises consist of knee bends, backward walking, walking and turning around, sideways walking, tandem walking, tandem standing, one leg stand, heel walking, toe walking, heel toe walking backward, sit to stand, and stair climbing. Participants were instructed to begin the exercises with 5 minutes of flexibility exercises. The exercises (flexibility, strengthening, and balance) took about 30 minutes to complete and were performed at least 3 times a week. The walking component of the original Otago exercises was not included.

A trained physiotherapist performed a baseline assessment on each participant to prescribe individual exercise programs from the OEP manual. The participants were then given an exercise manual with large print pictures of the exercises. They were also given ankle weight cuffs, weighing 0.5 to 1 kg for lower limb strengthening exercises. The therapist assessed all participants from the intervention group in the hospital monthly to make progressive adjustments according to the OEP exercise manual. The total duration of the OEP was 3 months. Participants were advised to pursue regular physical exercises such as walking or Tai Chi upon completion of the program.

**Adherence to the OEP**

The participants were considered compliant to the OEP if they performed the exercises at least 3 times each week for the 3 months’ duration of the exercise program. Adherence to the OEP was monitored using a calendar given to participants at the start of the OEP. Participants were advised to document the frequency and duration of exercises performed at home. The calendar was returned monthly during hospital visits within the first 3 months.

**Sample Size**

The sample size was calculated using the G*Power 3.1 software. A total sample of 46 provided 80% power to detect an effect size of 0.75 between groups, which constitutes a large effect size. The effect size is obtained by dividing the mean difference with the standard deviation. When considering within-group comparisons (before and after interventions), a sample size of 27 will provide 80% power to detect an effect size of 0.50 that constitutes a moderate effect size.

**Statistical Analysis**

The data were analyzed using SPSS software, version 21. A mixed-model analysis of variance was used to examine interaction effects between groups in functional mobility, strength, and balance over time. The differences between the pre- and posttest scores within the same group were determined and compared using the paired t test. The baseline characteristics were expressed as mean and standard deviation. A nonparametric test, Wilcoxon signed rank test, was employed to assess significant differences of outcomes measures if the assumption of normality was not met or if equal variances were not assumed. A P value of less than .05 was considered statistically significant. For within-group comparisons, multiple comparisons were conducted between baseline and 3 months and between 3 and 6 months. We, therefore, applied the Bonferroni correction and considered a P value of .025 or less as statistically significant.

**RESULTS**

A total of 67 participants were recruited into this study with 34 participants in the intervention group and 33 participants in the control group. Figure 1 shows the flowchart of the recruitment process. Nineteen participants were lost to follow up. Only 48 (72%) completed the 6-month assessment. The baseline characteristics of the participants are...
shown in Table 1. The 2 groups of participants were comparable in baseline characteristics and assessment scores.

**Within-Group Comparisons**

**Grip strength**
When the groups were analyzed separately, right and left grip strength among participants in the intervention group were maintained throughout the 6 months’ follow-up period. Both right and left grip strength in the control group were significantly lower at 6 months compared with baseline ($P < .05$).

**Lower limb function**
Berg Balance Scale, Five Times Sit to Stand test and Step test performance were available only for the intervention group as they were part of the OEP prescription assessment. These assessments were conducted at 3 months and 6 months for the intervention group. Participants in the intervention group showed significant improvements in functional mobility and balance based on the TUG, Berg Balance Scale, and right and left Step test pre- and post-intervention scores (Table 2) from baseline to 6 months. There was no difference in TUG or FR test from baseline to follow-up among the control participants.

**Between-Group Comparisons**
Results from mixed-model analysis of variance (Table 2) indicated a significant within-subject main effect for time and significant interaction between time and group for both right- and left-hand grip strength. There was also significant interaction between time and group for FR test but no significant within-subject effect for time. No significant interaction and effect of time for TUG were observed. These results revealed significantly greater deterioration in right- and left-hand grip strength among the control group than among the intervention group at 6 months. Compared with the control group at 6 months, the intervention group showed a statistically significant improvements in balance with a higher FR score (Table 3). No significant changes in functional mobility were observed in the control group.

**Adherence to the OEP**
Sixteen participants (67%) in the OEP group adhered to the exercise where they completed the exercises prescribed 3 or more times per week, 2 participants (8%) completed the exercises 2 or more times per week, and 1 participant (4%) completed the exercises at least once per week. Five participants (21%) did not return the monthly calendars and were unable to be contacted after 6 months.
DISCUSSION
In this study, home-based OEP was prescribed for community-dwelling older adults with a previous history of recurrent or injurious falls. The benefits in functional mobility and balance observed after 6 months were consistent with other studies. Mixed-model analysis of variance showed that significant interaction existed between groups and, over time, a greater deterioration in grip strength in the control group than in the intervention group. The minimal detectable change and SEM values indicate that TUG in the intervention group and left-hand grip strength in the control group showed true statistical change beyond the measurement error. This also suggested a meaningful change in the patient’s performance.

This was a substudy of a larger intervention study. We were, therefore, required to be selective with our choice of assessments. While frailty is often measured using far more in-depth assessments tools like the Fried or Rockwood scores, it was not possible to incorporate these measures in this substudy without any preliminary findings to justify their inclusion. Our study has first revealed that in individuals with abnormal gait and balance who were not prescribed exercise interventions after recurrent or injurious falls, deterioration in grip strength was observed within 6 months. This suggested that these individuals are at serious risk of sarcopenia and increased frailty. Two plausible explanations may explain this finding. First, individuals who are developing sarcopenia or becoming increasingly frail develop falls in the course of their deterioration. Second, individuals who suffer falls may develop fear of falling and hence limit their physical activity and in turn experience reduced social contact and negative psychological effects. Sarcopenia and increased frailty then ensue.

The OEP appears to be able to maintain grip strength in our intervention group, with between-group comparisons demonstrating a significant difference in deterioration in grip strength in the control group in comparison with the intervention group. As the OEP was designed to reduce the risk of falls by improving lower limb girdle strength, limited improvements in upper limb performance is expected. Compared with the OEP group who used their hands for support while performing some of the prescribed strengthening exercises, the control group did not have any specific exercises that included the usage of their hands for support, and it is possible that this minimal usage of the hands still

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*Abbreviation: OEP, Otago Exercise Program.*

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<th>Table 2. Within-Group Comparisons of Mean Scores at Baseline and Follow-Up Among Participants in the Intervention and Control Groups</th>
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*a Multiple comparisons with Bonferroni correction.
*b Statistically significant difference.
makes a difference in frail older individuals. However, it is more likely that the participation in an exercise program postfall is able to prevent the development of sarcopenia and frailty through the systemic effects of exercise in this group of highly vulnerable individuals.

A 3-month duration for the OEP was initially chosen in this study because of time constraints and patient preference, compared with the 6-month duration previously reported. Nevertheless, the participants in this study were required to come for a monthly visit to the hospital for an exercise program adjustment within the 3-month duration. We observed good exercise adherence rate of 67% for the OEP group, indicating that the OEP is well accepted in the local community setting. This finding has major local implications, as this is the first study to evaluate a modified OEP among the older Malaysian population. The possible reasons for the good adherence rate could be the simple and short duration of this exercise intervention.

Previous studies incorporating exercise programs of 3 months in duration have shown a positive impact on strength and balance improvements in older adults. A Korean study examining the effects of 12 weeks of resistance and balance exercises reported positive results on balance and strength using outcome measures such as one leg stand test, figure-of-eight running test, and TUG. A separate 12-week program consisting of 3 sessions a week of 90 minutes of strength, endurance, and balance exercises showed improvements in endurance and gait using the 6-minute walk test and a reduction in fall rate. A minimum of 50 hours in an exercise program over a period of 3 months was also shown to be associated with effective fall prevention.

Studies that incorporated the OEP program for community-dwelling older adults for the duration of less than a year have, however, shown mixed results. Binns and Taylor found no improvements in strength or balance using gait velocity, TUG, chair stand test, and Step test. Liu-Ambrose et al. also reported that 6-month OEP had no effects on risk of physiological falls or functional mobility with TUG but showed a 47% reduction in fall incidence. On the contrary, improvements in chair stand and 4-stage balance tests have been shown to occur after 6 months of OEP. Another study that incorporated an expanded OEP into the exercise intervention for older people with mild balance dysfunction reported improvements in balance and strength. Their results showed significant improvements in the FR test, Step test, hip abductor strength, and gait step width. We found significant improvements in Berg Balance Scale scores within our OEP intervention group, as well as significant improvements in FR test in the intervention group compared with the control group. Both Berg Balance Scale and FR test are clinical measures of balance that predict falls and functional status. The measures are also responsive to change with exercise in the older adult.

In this study, lower limb strength was assessed using the Five Times Sit to Stand test, for which no significant improvement was observed among the participants in the OEP group. A 3-month duration of strengthening exercises in this study could be insufficient to observe significant improvements. A longer duration of strengthening exercises in the OEP using ankle cuff weights of 0.5 kg and 1 kg has demonstrated positive results. Furthermore, the use of the Five Times Sit to Stand test was probably unable to detect subtle strength changes, although it correlates well with lower limb strength as a function-based performance test.

### Study Limitations
This study was limited by its lack of power to detect smaller changes due to the relatively small number of participants. The shorter duration of 3 months of OEP could also be inadequate to demonstrate differences in mobility improvement between the 2 groups. However, our findings that OEP preserves grip strength in those with a history of falls have brought to light an important aspect of falls management, which has not previously been considered. This study, therefore, serves as a pilot study to inform future larger studies to evaluate exercise programs for the prevention of frailty and sarcopenia among older individuals presenting with falls, using more robust measures of frailty and/or sarcopenia.

### CONCLUSIONS
A significant deterioration in hand grip strength was observed over a 6-month period in older adults with recurrent or injurious falls over the preceding 12 months, but this deterioration was prevented through inclusion in a modified OEP for 3 months. We have also demonstrated that a modified OEP of 3-month duration is effective in improving mobility and balance in community-dwelling older adults, as evidenced by improvements in functional mobility, strength, and balance outcomes. This suggests that OEP is a feasible and effective exercise intervention for older adults, providing a potential tool for preventing falls and promoting overall health and well-being.
older adults in our Malaysian setting. From the positive results shown, we thus support the modified OEP intervention of 3 months’ duration to improve hand grip strength, mobility, and balance in community-dwelling older adults with a history of falls. Our preliminary findings will inform future studies on the prevention of sarcopenia and frailty among older adults with a history of falls.

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