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Effect of the otago exercise program on the lower extremity muscle strength in older women

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Abstract---An increased risk of falls in the elderly is associated with decreased muscle mass and strength in the lower limbs. The Otago Exercise Regimen (OEP) is a moderately challenging walking, flexibility, strengthening, and balancing exercise regimen. The Otago Exercise Program has been demonstrated to reduce the incidence of falls in elderly individuals by improving balance and muscular strength. This research sought to ascertain how the Otago Exercise Program influenced the lower limb muscular strength of older women. The research was done from October 2020 to May 2021. 26 individuals, split into a treatment group and a control group (13 people each). The moderate intensity Otago Exercise Program was administered to the treatment group for eight weeks, lasting 30 minutes three times each week. In this study, the parameter that assessed the muscular strength in the lower extremities was examined using the 30 second sit-to-stand (30STS) test. Two measurements are made: once prior to and once following the eight-week OEP period. The value of the 30STS increased significantly for both the treatment

group and the control group ($p = 0.000$ and $p = 0.040$, respectively), and there was a significant difference in the value of the 30STS between the groups ($p = 0.000$). The lower limb muscular strength of older women increases after eight weeks of the Otago Exercise Program.

Keywords---Older women, *Otago Exercise Program*, 30 second sit to stand.

Introduction

The majority of people over 65 who require hospital care due to falling incidents, with the percentage reaching over 30% and rising to 50% for those over 80 (Accident Compensation Corporation, 2004). Elderly mortality from falls have increased in the United States, from 8.613 deaths in 2000 to 25.189 deaths in 2012 (Hartholt et al., 2019). In a survey of 6.698 senior adults in Indonesia, falls that resulted in injuries happened 12.8 percent of the time over a two-year period. According to the study, the chance of falling increased by 11.5 percent for men and by 14 percent for older women (Pengpid & Peltzer, 2018). The frequency of falls in the elderly can have catastrophic consequences, from minor wounds to impairments and even fatalities (Nuruzzaman et al., 2020). According to a study by Rubenstein and Josephson from 2006, the key factor contributing to the prevalence of falls in the elderly is a decline in the muscle strength of the lower limbs. The incidence of falls in the elderly and a decline in the lower extremities' muscle mass and strength were found to be significantly correlated (Moreland et al., 2004). Elderly people experience a decline in lower extremity muscle strength as they get older, which increases their risk of falling (Rikli & Jones, 1999).

The frequency of falls among the elderly has been reduced by a variety of initiatives. One of the most crucial elements in reducing the elderly's risk of falling is physical activity (Chang et al., 2004; Gillespie et al., 2012). It has been demonstrated that setting training goals to increase balance, flexibility, and muscle strength can lower the number of falls among elderly residents of the community (Valentina, Kurniawati & Maramis, 2021; Gillespie et al., 2012). The Otago Exercise Program (OEP) is a multi-component exercise regimen created expressly to lessen the risk of falling in the elderly by improving balance and lower-extremity muscular strength (Binns & Taylor, 2011). The Otago Exercise Program adjusts to everyday functional movements to maximize an elderly person's capacity for performing functional motions (Chung, Yoo & Lee, 2013). The Otago Exercise Program is a safe, effective, practical, low-cost and can reduce the incidence of falls in the elderly by as much as 35 percent (Campbell et al., 1997).

It is crucial for elderly people to maintain their lower extremity muscle strength through physical activity, and it is also necessary to develop an accurate technique of measuring this strength, particularly for elderly people who live in the community. The best method for evaluating the strength of the muscles in the lower extremities is the 30-second sit-to-stand test (30STS) (McCarthy, Horvat, Holtsberg, & Wisenbaker, 2004). The 30STS test is a functional assessment of

lower extremity muscle strength that can be used to quickly and easily assess an elderly person's risk of falling (Rikli & Jones, 1999). Jones et al. (1999) compared the outcomes of the senior patients' 30STS test and 1 RM leg press strength test. The power of the hip extensor, knee extensor, and ankle plantarflexor were all measured. Results of the 30STS test and the leg press test in the elderly were found to have a moderate-high correlation. The 30STS test, which has a high correlation of test-retest reliability and is a useful technique of assessing the strength of the lower extremity muscles in the elderly in Japan, was then shown in a study by Nakatani et al. (2020).

There hasn't yet been any investigation of the Otago Exercise Program's impact on senior people's lower extremity muscle strength in Indonesia. Therefore, the purpose of this study is to determine how the Otago Exercise Program affects the muscle strength in the lower extremities.

Methods

Study design

This study used a randomized control trial design. This study was conducted at the Hargodedali Nursing Home and the Usia Anugerah Nursing Home for the Elderly in Surabaya. This study was carried out for the period October to May 2021.

Sampling method

The participant in the study was an Indonesian elderly woman who lived in a nursing home. There were 26 elderly women who met the study inclusion criteria. There were 13 participants in each of the two groups: the treatment group and the control group (figure 1). The following requirements had to be met in order to qualify for participation were elderly residents of the Hargodedali Nursing Home and the Usia Anugerah Nursing Home, female, age ≥ 60 years, a score on the Montreal Cognitive Assessment Indonesian Version (MoCA-Ina) of ≥ 26 , ability to understand and follow instructions, independent ambulation without the aid of a walker, stable hemodynamics, have sufficient visual and hearing. The following were listed as exclusion criteria, participation in other regular physical activity programs, severe cardiorespiratory disorders, muscle pain and lower extremity joint pain with Wong-Baker Face Scale (WBFS) > 4 and/or clinical signs of swelling, redness, and feeling warm, and having a chronic illness that results in long-term disability.

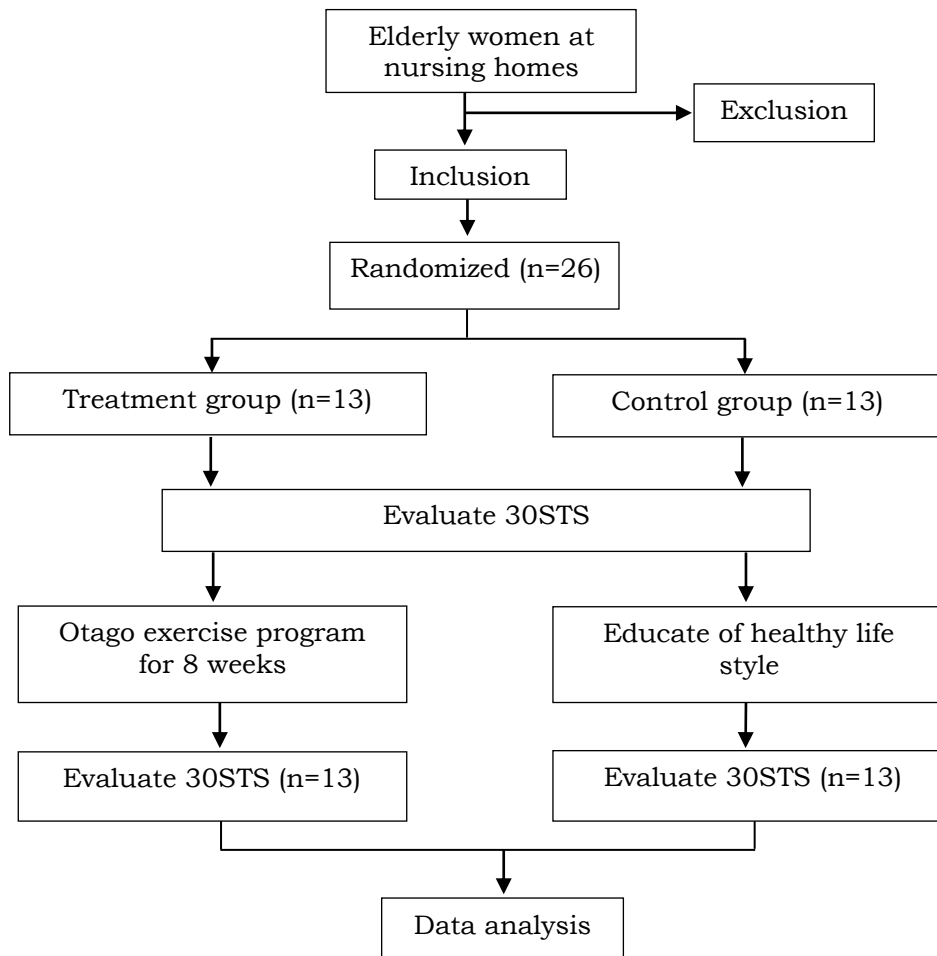


Figure 1. Subject recruitment

Intervention

The treatment group was required to participate in the Otago Exercise Program (OEP) three times per week for eight weeks. Each training session lasted around 30 minutes. The Otago Exercise Program consists of a walking program, 12 different forms of balancing exercises, and five different types of strengthening exercises. Based on the Otago Exercise Program protocol, several exercise forms were used (Campbell *et al.*, 2003). The number of repetitions, the weight of the load on the ankles, and the degree of balance training were all gradually raised based on the subject's skills during the exercise. Ankle cuff weights with loads of 0.5 kg, 1 kg, and 2 kg were employed in this investigation. The strengthening session began with the individual receiving a 0.5 kg weight. The burden was progressively raised. The individuals could only tolerate an ankle cuff that weighed 2 kg. The walking program is provided twice a week for 30 minutes each, and it may be repeated on different days with strengthening and balancing exercises by breaking it up into many sessions each day. The activities were

supervised by two instructors. One instructor showed the OEP movements, while the other was in charge of making sure the exercise was safe and correcting faulty subject movements. The control group at the nursing home was not given any treatment but was nevertheless permitted to go about their normal activity.

Outcomes measures

The parameter evaluated in this study was the strength of the lower extremity muscles. Measurements are carried out 2 times, before and after 8 weeks of administration of the Otago Exercise Program. Assessment to determine the strength of the lower extremity muscles using the 30 second sit to stand (30STS) test. Measurements are carried out 2 times with a break of 45-60 seconds between the first and second measurements, then the highest value is taken. An increase in the value of 30STS indicates an improvement in the muscle strength of the lower extremities in the subject. The initial evaluation is carried out 1 day before the start of the first session of the Otago Exercise Program, and the final evaluation is carried out 1 day after the Otago Exercise Program last session.

Statistical analysis

Data were analyzed using SPSS version 23 (IBM Corp., Armonk, NY, USA). The Saphiro Wilk test was performed to determine whether the data was normal. The independent sample *t*-test was used to compare the baseline characteristics of the participants in the treatment and control groups. A paired *t*-test was used to examine the difference in 30 STS values between the two groups before and after exercise. Using independent sample *t*-tests, differences in the change in 30STS values across groups (delta) were compared. $p < 0.05$, the difference is deemed statistically significant.

Ethical Clearance

Study participants were informed about the exercise and the associated risks before signing the study consent form. The Health Research Ethics Committee of the Faculty of Medicine at Universitas Airlangga Surabaya approved this study for ethical feasibility (No. 247/EF/KEPK/FKUA/2020).

Results

Without a single dropout, participants in the treatment group were able to complete an OEP that lasted eight weeks. After engaging in exercise for 8 weeks, no subjects in this study were reported to have any injuries.

The average age of the participants was 74.81 ± 7.6 years with a median value of 74 (71.3 - 81) years. The average age of the participants in control and treatment group was 74.31 ± 6.21 years and 75.31 ± 9.01 years, respectively ($t = 0.229$; CI 95% = -6.994 - 5.559; $p = 0.745$). The average weight of participants was 47.53 ± 9.93 kg, with a median value of 44.4 (39.7 - 55.72) kg. There was no significant difference in participant weight between treatment (45.72 ± 9.04 kg) and control group (49.33 ± 10.79 kg; $t = 1.223$; 95% CI = -12.094 - 3.094; $p = 0.365$). The average participants' height was 147.88 ± 6.84 cm, with a median value of 147 (142.25 - 153) cm. The participants' average height in the treatment and control

group was 148.85 ± 5.91 cm and 146.94 ± 7.78 cm, respectively ($t = 0.709$; 95% CI = $-3.672 - 7.519$; $p = 0.485$). The participant's body mass index (BMI) value was 21.59 ± 3.44 kg/m² (treatment group = 20.55 ± 3.33 kg/m² vs. control group = 22.61 ± 3.35 kg/m²; $t = 1.572$; 95% CI = $-4.767 - 0.645$; $p = 0.129$). (Table 1). Meanwhile, the median BMI of participants was 21.22 (19.8 – 23.75) kg/m².

Table 1. Characteristic of participant

Characteristic	Otago exercise program		95% CI	<i>p</i>
	Treatment	Control		
Age	74.31 ± 6.21	75.31 ± 9.01	$-6.994 - 5.559$	0.745
Weight	45.72 ± 9.04	49.33 ± 10.79	$-12.094 - 3.094$	0.365
Height	148.85 ± 5.91	146.92 ± 7.78	$-3.672 - 7.519$	0.485
BMI	20.55 ± 3.33	22.61 ± 3.35	$-4.767 - 0.645$	0.129

Note: BMI = body mass index; *significant <0.05

Prior to and during the administration of OEP, the value of 30STS in the treatment group differed significantly (10.31 ± 1.88 times vs. 7.92 ± 1.93 times; $t = 9.886$; 95% CI = $1.859 - 2.910$; $p = 0.000$). A significant difference in the value of 30STS before and after the individual was observed was seen in the control group (7.92 ± 1.75 times vs. 7.31 ± 1.54 times; $t = 2.309$; 95% CI = $0.035 - 1.196$; $p = 0.040$). The treatment group that participated in the Otago Exercise Program for 8 weeks had a delta value of 2.38 ± 0.87 times, compared to the control group's delta value of 0.62 ± 0.96 times for the 30STS test results. The rise in the 30STS test value varied significantly between the groups ($t = 4.922$; 95% CI = $1.027 - 2.511$; $p = 0.000$). (Table 2). After the Otago Exercise Program was administered for 8 weeks, the magnitude of the effect size was assessed using Cohen's *d*. Results for the treatment group's effect size were 1.25 while those for the control group's impact size were 0.36.

Table 2. The effect of Otago exercise program on 30STS

Group	Otago exercise program		95% CI	<i>p</i>
	Pretest	Posttest		
Treatment group	7.92 ± 1.93	10.31 ± 1.88	$1.859 - 2.910$	0.000
Control group	7.31 ± 1.54	7.92 ± 1.75	$0.035 - 1.196$	0.040

Note: Comparison of Δ 30STS in treatment group and control group was *p*-value of 0,000; *significant <0,05

Discussion

The findings of this study are consistent with those of Rubenstein et al. (2000), who found that after receiving multi-component exercises consisting of strength, balance, flexibility, and walking exercises three times per week for 12 weeks, male elderly subjects showed a significant improvement in lower extremity muscle strength. Additionally, the study also found a decrease in the incidence of falls in research subjects. In 2014 research by Zhuang et al., 56 senior residents of Shanghai underwent multi-component training for 12 weeks, and results showed a substantial improvement in lower limb muscular strength as measured by the 30STS test. Lower extremity and trunk muscles are the primary targets of

strength training. The 30STS test, which measures the strength of the lower extremities' muscles, and the strength of the hip extensor, knee extensor, and ankle plantar flexor muscle groups were shown to be positively correlated, according to the study. These muscles are crucial for carrying out regular tasks including rising up from a seated position and climbing stairs. In different research by Nayasista et al. (2022), senior adults who underwent multicomponent exercise for 8 weeks showed increased muscular strength compared to those who had only aerobic activity.

In addition, Hruda et al. (2003) found that performing simple and progressive strengthening exercises for the lower extremity muscles for a period of 10 weeks significantly increased the strength of the lower extremity muscles as measured by the 30STS test in a study of 25 elderly patients residing in treatment facilities. Other research by Islam et al. (2004) found that following 12 weeks of balance, strength, and sensory training, aged participants in Nagoya, Japan, showed a significant improvement in lower limb muscular strength as measured by the 30STS test.

According to the study's findings, administering the Otago Exercise Program for 8 weeks increased the lower extremity muscles' strength as measured by the 30STS scale. Although the period of exercise in this study was different from that in other studies, exercise for 8 weeks, with a frequency of 3 times per week, can already have an effect on boosting the lower extremities' muscular strength. It is conceivable that the establishment of neural adaptations, which result in higher motor neuron recruitment, are what lead to an increase in muscle strength. In the first several weeks of practice, the largest transformation happens. Exercise modifies the way that muscle fibers are organized and boosts neural activity, both of which contribute to increased muscular strength. By enlisting additional motor units, the nervous system increases the amount of force and effort required to combat already-held inmates. Because of the brief duration of therapy, the majority of the strength gains associated with functional activity are more the result of neural adaptation than muscle hypertrophy. The increase in initial strength and the increase in muscle tension production after exercise are the results of a more efficient neural recruitment process (Cifu, 2016; Kisner & Colby, 2012; Kocic et al., 2018). Other views of Theodorakopoulos et al. (2017) mention that strengthening exercises increase muscle strength via the plasticity of the neuromuscular system, so that muscles can adapt to certain intensity physical activity. This can occur even in elderly people without the need for strenuous intensity training or exercise using weight machines. According to this study, even though the Otago Exercise Program involves moderate intensity exercise, the study subjects' lower limb muscular strength increased (Campbell & Robetson, 2003).

The existence of an OEP exercise component with movements comparable to the 30STS test, specifically standing and sitting motions, may also be the reason of the increase in lower extremity muscular strength measured with the 30STS test following delivery of the program. On OEP, the movement from sitting to standing is gradually increased without the aid of the hands after the initial session of the exercise. The study participants in the treatment group's test scores on 30 STS were indirectly improved by this standing-sitting activity (Binns & Taylor, 2011).

In this study, it is intended that by increasing the study participants' lower extremity muscular strength, the incidence of falls in the elderly might be decreased. This is consistent with the comprehensive study by Moreland et al. (2004), which came to the conclusion that there is a link between lower extremity muscular weakness and an increased risk of falling in the elderly.

In the control group, there was a considerable improvement in the lower extremity muscular strength, which contradicted the findings of the prior study. In the opinion of the researcher, this could have happened because the control group was still engaged in daily activities, causing the physical condition to be maintained, and the 30STS assessment was repeated, resulting in the subjects in the control group being able to perform better than they had at the start of the study when the final test of the 30STS value was carried out. The fact that the sitting-standing action is one of the functional motions performed on a regular basis is another factor that makes it simpler for people in the control group to complete the 30STS test. Another factor is the length of the evaluation; 8 weeks is a rather short period of time to see the physiological changes brought on by aging, thus the participants are still collected in largely the same circumstances throughout the research (Sherrington et al., 2019).

This finding is consistent with a study by Kocic et al. (2018) that looked at 77 senior residents of care facilities who were >65 years old. The Otago Exercise Program was administered to the individuals for six months, during which time a chair stand test revealed a considerable improvement in lower limb muscular strength. According to del Campo Cervantes et al. (2019) research, following 12 weeks of strengthening activities, the hand grip strength and chair stand test scores of 19 senior participants increased.

The Otago Exercise Program was given strengthening exercises to the knee extensor muscle group and the ankle plantar flexor, where both muscle groups play a significant role in sitting to standing movements, apart from the hip flexor muscle group. This resulted in an increase in lower extremity muscle strength with the 30STS test in this study (Liu et al., 2015). The Otago Exercise Program, which combines balancing and strengthening exercises, can improve lower-extremity muscular strength in aged people without increasing muscle mass (Hasan et al., 2016; Kocic et al., 2018). The major goals of the moderate-intensity Otago Exercise Program are to improve balance and lower-extremity muscular strength. Its intensity is deemed insufficient to build muscle mass in senior participants, however. It is well recognized that a variety of variables, such as dietary consumption, vitamin D intake, and physical activity while not engaging in strenuous activity, affect the muscle mass in the aged. One of the key inflammatory variables that might influence the age and muscular strength in the elderly is interleukin-6. None of these elements were investigated in this research (Mahendra et al., 2022; Hasan et al., 2016).

In this study, Cohen's *d* was used to determine the value of the magnitude of the impact size following the delivery of the Otago Exercise Program for 8 weeks. The Otago Exercise Program was administered to this group, and the findings of the effect size in the treatment group of 1.25 revealed that it had a significant impact on boosting the strength of the lower extremity muscles. The lower extremity

muscles' ability to become stronger was very slightly affected in the control group, where the effect size was 0.36. It can be concluded that the Otago Exercise Program, when administered with moderate intensity, can increase the strength of the lower extremity muscles. Although there is an increase in muscle strength in the control group, according to calculations made from the study's effect size, this increase in muscle strength only has a very small impact on the lower extremities. Therefore, the Otago Exercise Program is strongly advised for senior people as a regular exercise both in the community and/or care facilities to reduce the likelihood of falls in the elderly.

The inability to regulate the research subjects' physical activity outside of the exercise regimen was one of the study's many flaws. There is no covert opposition to exercise programs among researchers or study participants. The quantitative value of the muscular strength of the lower extremities was not known since the measurement of such strength was only done using a 30-sit to stand test.

Conclusion

Increased muscular strength in the lower limbs in older women after 8 weeks of the Otago Exercise Program administration

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Conflict of Interest

All authors declared no conflict of interest

Author Contribution

All authors equally contributed to preparing this article.

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