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Improving Range of Motion through Leg Extension Exercise and Static Bike Exercise for Osteoarthritis Genu

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Abstract

Aging is identical with decreased functional abilities, such as prolonged standing, walking, squatting, running, or other activities. These decreases in functional ability can be caused by a degenerative disease, namely osteoarthritis (OA) genu resulting in a limited motion in the knee joint caused by a decrease in range of motion. Treatments for OA Genu cases include leg extension exercise and static bike exercise to maintain and to increase the range of motion (ROM) of knee joints. This study was a Quasi Experimental study. The study lasted for five weeks from May-June 2022. The samples of this study were 24 people. The results of the study found that the ability to perform movement extension and knee flexion of both groups increased. Both groups obtained p value = 0.625 for extension and p value = 0.062 for flexion. The p value of extension and flexion is p>0.05. Results showed that, after the intervention in both groups, the osteoarthritis patients at Siloam Hospitals Bali had improved the ROM of knee flexion and extension. Based on the difference value before and after treatments, the percentage of increase in range of motion extension and flexion of the static bike group was slightly higher than the leg extension exercise group. It concludes that leg extension exercise and static bike exercise are equally good in increasing ROM of osteoarthritis patients. Leg extension exercise and static bike exercise can be used as alternative exercises to improve the ability to bend and to straighten knee joints experiencing limitations or stiffness.

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INTRODUCTION

Aging causes a decrease in the system of the body. The decline in the system of the body is identical to the condition of the elderly. Elderly is the final stage of the aging process characterized by the decreased function of the body systems. Conditions of elderly cause degenerative and non-degenerative problems. One of the degenerative diseases that usually occur in the aging process is osteoarthritis (Pratama, 2019). The prevalence of osteoarthritis genu is 11.9% in Indonesia and 19.3% for the Bali area, where the highest incidence rate occurs at the average age of ≤ 75 years (Badan Penelitian dan Pengembangan Kesehatan, 2018). Osteoarthritis Genu is a limited movement in the knee joint. The disease is chronic, progressive, non-inflamed, and characterized by erosion of joint cartilage and the formation of new bone on the joint surface. Complaints often experienced by people with osteoarthritis genu are limitations in making movements in the knee area. This limitation can inhibit the functional ability of patients with osteoarthritis genu (Cudejko et al., 2018). The impact of osteoarthritis genu in elderly is limited joint movement in carrying out daily activities, such as walking for a long time, climbing stairs, squatting, running, and kneeling. The range of motion (ROM) of a joint plays a role in carrying out daily activities, especially the knee joints. Physiotherapy has an important role in handling limited ROM. Physiotherapy using an exercise therapy can increase the range of motion (ROM) in the elderly experiencing osteoarthritis genu. Life expectancy in Indonesia continues to increase for both men and women, namely 70.1 years in the 2010-2015 period and estimated to increase up to 72.2 years in the 2030-2035 period in the elderly suffering from osteoarthritis genu (Pusat Data dan Informasi, 2022). It is important to maintain the elderly to remain active and perform functional abilities, such as daily activities. The treatment that can be given to maintain the ability of the knee joint is an exercise focusing on the genu area. Physiotherapy treatments, namely leg extension exercise and static bike exercise, can improve joint movements so that it can improve the functional ability of the elderly (Ismail, 2021).

Physiotherapy treatment using the leg extension exercise is relevant with the research conducted by Vincent (2019), entitled Eccentric and Concentric Resistance Exercise Comparison for Knee Osteoarthritis, showing that leg curl (leg extension exercise) effectively increased leg strength. Knee flexion and knee extension muscle strength can modify function and pain symptoms in muscle contraction type. The mode is determined by the preference, goals, tolerance to the contraction type, and equipment availability. The result was evidenced by a p value <0.001 (Vincent et al., 2019).

Providing physiotherapy interventions using static bikes is in line with the research conducted by Abdurrachman (2019) entitled Effects of Cycling Exercise on Reducing Pain in Osteoarthritis. Cycling exercise intervention could be an endurance exercise as it could strengthen muscles and improve cardiovascular and respiratory health. Cycling exercise could reduce pain followed by increased joint mobility and reduced stiffness in the knee joint. The results showed that the cycling exercise intervention on pain reduction in osteoarthritis felt by the elderly gained $\rho = 0.000$ or $\rho < \alpha$ (0.05) (Abdurrachman et al., 2019).

The research conducted by Endang Mien Mas'ud (2021), entitled The Effect of Straight Leg Raise Exercise with Static Bicycles on Increasing Quadriceps Muscle Strength in Knee Osteoarthritis Patients, gave straight leg raise (SLR) and static bike training interventions, showing a significant change in the increased quadriceps muscle strength in the subjects experiencing weakness in muscle strength due to knee osteoarthritis. The results found that there was a significant effect of giving straight leg raise ($p = 0.002$) and static bicycles ($p = 0.005$) trainings on increasing quadriceps muscle strength. The results showed that there was no significant difference between the two groups in the increase of quadriceps muscle strength ($p = 0.481$). The results showed that straight leg raise and static bicycle trainings increased muscle strength and there was no difference between the two exercise groups (Mas'ud et al., 2021).

Based on the description of previous studies, there is no research focusing on ROM. Meanwhile, ROM is vital for carrying out daily activities in elderly, such as walking, sitting, squatting, and standing. When experiencing limitations or stiffness in the knee joint, it will be difficult for the elderly to carry out activities, leading to a decrease in the productivity of the elderly. A study, conducted by Endang Mien Mas'ud (2021), compared the SLR and Static Bicycle training on the

strength of the quadriceps muscles in osteoarthritis patients. Meanwhile, researchers were interested to find out whether giving Leg Extension Exercise and Static Bike Exercise could increase ROM in Genu Osteoarthritis patients. Therefore, this study focused on the ability to move the knee joint, namely flexion and extension, to increase ROM of patients with knee osteoarthritis by providing the Leg Extension Exercise and Static Bike Exercise interventions in Bali.

METHODS

This study used an experimental method with the two group pre-test and post-test group research design. Group I (control group) received leg extension exercise treatment, while Group II received static bike treatment. The followings are the hypothesis of the study:

1. Leg extension exercise could improve range of motion of osteoarthritis genu patients at Siloam Hospitals, Bali.
2. Static bike exercise could increase range of motion of osteoarthritis genu patients at Siloam Hospitals, Bali.
3. Leg extension exercise and static bike exercise had an effect on increasing the range of motion of patients with osteoarthritis genu at Siloam Hospitals, Bali.

The study was conducted in the Medical Rehabilitation room of Siloam Hospitals Bali from April-June 2022. The population were elderly with an osteoarthritis genu diagnosis at Siloam Hospitals Bali who had met the inclusion criteria and were willing to be sampled in this study.

The sample selection in this study included inclusion, exclusion, and drop out criteria. Inclusion criteria consisted of elderly aged 60-90 years, had been diagnosed with osteoarthritis genu by a doctor and based on medical records, did not use assistive devices, and were willing to voluntarily be the research sample from the beginning to the end of the study by signing informed consent. Exclusion criteria included elderly who were suffering from pain, such as fractures, stroke, cataracts, severe hearing loss, Parkinson's, dementia, and vertigo, using walking aids, having knee surgery (total knee replacement and reconstruction surgery), and had experienced knee injuries. Drop out criteria included the sample withdrew; the sample deteriorated after being given exercise; and when the patient suddenly falled ill or was injured for some reasons.

Participant

In this study, the sample size formula used Pocock's (2008) formula. The formula is usually used for case control research (Pocock, 2008). Based on previous research conducted by Adegoke BO, et al., (2019), it obtained an average value of μ1 = 114 and a standard deviation of σ = 41.8, while the average value of μ2 = 166 obtained based on the expectation of an increase of 20% from the previous study (Adegoke et al., 2019).

$$n = \frac{\sigma^2}{(\mu_2 - \mu_1)^2} \; x \; f(\alpha, \beta)$$

$$n = \frac{2(41{,}8)^2}{(166 - 114)^2} \; x \; 7{,}9$$

$$n = 10{,}208$$

n : Number of Samples
s : Standard Deviation
α : Error Rate I (set 0.05) Confidence Interval (1-β) = 0.95 or 95%
β : Error Rate II set at 0.20 or 20%
μ1 : Average value of treatment group I
μ2 : Average value of treatment group II
f(a,b) : Confidence Interval 7.9

Based on the results of sample calculations, the initial number of sample was 10,208 or rounded up to 10 people. The number of sample was added 20% to prevent the sample that failed or dropped out, then 12 people were selected. The results of the calculation concluded that each group consisted of 12 people. The first group involved 12 people and the second group involved 12 people with a total sample of 24 people.

Materials and Apparatus

The measuring instrument used in this study was a Goniometer to determine the degree of difference in the knee joint before and after the treatment. Goniometry is usually used to measure the ability to move active and passive joints. Goniometer is a device that has a unit of measurement in degrees and has an angle of 360 ° for goniometer standards. The range of motion in normal knee joint for flexion is 0 – 120°, while for extension is 0 - 30° (Gandbhir & Cunha, 2023).

Procedures

The study was conducted directly in the Siloam Medical Rehabilitation room, Siloam Hospitals Bali.

Researchers explained the purpose and the procedures of the research before carrying out the research and provided opportunities for respondents to give questions regarding the research. Researchers asked for consent to the subject. When the subjects were willing to involve, they were expected to sign informed consent. Researchers filled in sample information data and conducted interviews to obtain data on the characteristics of subjects regarding their age, gender, and occupations.

There were three main processes in the data collection process, namely pre-test, treatments, and post-test. Pre-test was the measurement of range of motion with goniometer before treatment and the results were recorded. In the treatment, Group I control (leg extension exercise) was provided with leg extension exercise using leg extension tools. This exercise was carried out 8-12x repetitions for 5 weeks, twice per week, expected to increase the range of motion of osteoarthritis genu patients. When doing extension movements, the position of the legs was held for 10 seconds and rested for approximately 5 seconds for each repetition. Group II intervention (static bike exercise) was provided with static bike exercise with a duration of 10-15 minutes, for 5 weeks, twice per week. During this exercise, the position of the body was straight and not bending. When pedaling the bicycle, the sample used the sole of the foot to pedal and the heel to help apply pressure so that the pedalling could be done optimally. The post-test was measurement evaluation of range of motion results after 5 weeks of treatment using Goniometer to determine the value of range of motion of the knee joint. After all the data and measurements were obtained, researchers analyzed the data and compiled the results of the study.

Design or Data Analysis

The data obtained from the results of the study were processed using SPSS 16.0 software, then researchers used several statistics, including:

1) descriptive statistical analysis to describe the age, sex, and occupation data taken before the initial intervention,
2) normality test using the Saphiro Wilk Test because the number of samples of the study was less than 50 people, the data are said to be normally distributed if the p value (Sig) ≥ α 0.05 and the data are not normally distributed if the p value (Sig) ≤ α 0.05,
3) homogeneity test, using Levene Test, to determine data variations, the meaning limit used α = 0.05), while the result was p ≥ 0.05 so that the data were homogeneous,
4) the hypothesis test of Group I to determine the effectiveness of the treatment in Group I by giving leg extension exercise, using nonparametric test, namely Wilcoxon Signed Rank Test, because the data were not normally distributed,
5) the hypothesis test of Group II to determine the effectiveness of the treatment in Group II by giving static bikes, using nonparametric test, namely Wilcoxon Signed Rank Test, because the data were not normally distributed,
6) the hypothesis test between Group I and Group II to know the more effective treatment, when the data were not normally distributed, the test carried out was the nonparametric test, namely the Mann-Whitney Test (the significant level was set at Alpa (α) 0.05).

RESULT

The study was conducted on the elderly in the Medical Rehabilitation room of Siloam Hospitals Bali. The characteristics of respondents based on age, gender, and occupations in the treatment group can be seen in Table 1.

Table 1. Characteristics of Respondents

Characteristic	Frequency (f)	Percentage (%)
Age Group		
60-65	13	54,2%
66-70	6	25,0%
71-75	5	20,8%
Gender		
Woman	15	62,5%
Man	9	37,5%
Occupation		
Self-employed	7	29,2%
Merchant	7	29,2%
Housewives	6	25,0%
Farmer	4	16,7%
Sum	24	100%

Table 2. Normality Test Results

Variable	Before the Intervention		After the Intervention	
	p	Description	p	Description
Group I Extensions	0,012	Not Normal	0,000	Not Normal
Group I Flexion	0,249	Normal	0,018	Not Normal
Group II Extensions	0,010	Not Normal	0,000	Not Normal
Group II Flexion	0,147	Normal	0,186	Normal

Table 3. Results of Homogeneity Test

Variable	p	Description
Before the Intervention Group I and II Extensions	1,000	Homogenous
After the Intervention Group I and II Extensions	1,000	Homogenous
Before the Intervention Group I and II Flexion	1,000	Homogenous
After the Intervention Group I and II Flexion	1,000	Homogenous

Table 4. Average Improvement Before and After Interventions

Group	Before Intervention	CI* 95%		After Intervention	CI* 95%		p
	Mean±SD	Upper	Lower	Mean±SD	Upper	Lower	
Group I Extension	3,42±3,80	1.00	5.83	1,17±2,16	-0,21	2.54	0,027
Group I Flexion	117,08±10,62	110.33	123.83	129,67±5,94	125.89	133.44	0,002
Group II Extension	3,50±3,20	1.46	5.54	0,75±1,76	-0.37	1.87	0,017
Group II Flexion	109,75±9,01	104.03	115.47	125,00±5,72	121.37	128.63	0,002

CI* = Confidence Interval

The normality test used the Shapiro Wilk Test, while the homogeneity test used the Levene's Test. The results of the analysis are presented in table 2 and table 3.

To test the average increase before and after the intervention in Group I and Group II, the Wilcoxon test was used to determine the difference of the average increase before and after the intervention. The test results can be seen in Table 4.

Based on Table 4, the results of the average increase were analyzed using Wilcoxon test before and after the intervention. In Group I, extension gained a value of $p = 0.027$ ($p < 0.05$), while flexion obtained a value of $p = 0.002$ ($p < 0.05$), meaning that there was a significant difference of the increase before and after the intervention in the treatment group. Hypothesis testing of Group II used the Wilcoxon test. In Group II, extension gained p value = 0.017 ($p < 0.05$), while flexion obtained p value = 0.002 ($p < 0.05$), meaning that there was a significant difference of the increase before and after interventions in the treatment group.

Comparison of Before and After Improvement in Both Groups

To test the comparison of the average increase before and after treatment between Group I and Group II, the nonparametric test was used. The results can be seen in Table 5.

Table 5. Mann-Whitney Test Results

	Group	n	Mean±SD	p
After intervention	Group I Extension	12	1.17±2.16	0.625
	Group II Extension	12	0.75±1.76	
	Group I Flexion	12	129.6±5.9	0.062
	Group II Flexion	12	125±5.7	

Based on Table 5, the average difference of extension improvement after the intervention obtained p value = 0.625 ($p > 0.05$). It indicates that there was no significant difference of ROM of extension improvement between Group I and Group II. In Groups I and II Flexion, p value = 0.062 ($p > 0.05$) was obtained after the

intervention in both group. This means that there was no significant difference in both group after the intervention for increasing range of motion in osteoarthritis patients at Siloam Hospitals Bali. Based on Table 5, Group I (leg extension exercise) and Group II (static bike exercise) are equally good in improving ROM in osteoarthritis patients.

The percentage of improvement in functional ability scores after intervention in Group I (leg extension exercise) and Group II (static bike exercise) can be seen in Table 6.

Table 6. Percentage Improvement of Range of Motion

Analysis Result	Group I Extension	Group I Flexion	Group II Extension	Group II Flexion
Before Intervention	3,42	117,08	3,50	109,75
After Intervention	1,17	129,67	0,75	125,0
Difference	2,25	12,59	2,75	15,25
Percentage	65,7%	10,7%	78,5%	13,8%

Based on Table 6, the percentage improvement of Group II (static bike exercise) was higher than the percentage improvement of Group I (leg extension exercise).

DISCUSSION

Characteristics of Respondents

Based on the characteristics of respondents in this study, most of the respondent age was 60-65 with a total of 13 elderly experiencing osteoarthritis problems. The causes of osteoarthritis are age, sex (female), obesity, physical activity, genetic factors, race, joint trauma, chondrocalcinosis, lack of movement, and metabolic diseases, such as diabetes. Osteoarthritis is common in adults over the age of 40 (Brophy & Fillingham, 2022). It is in line with Mega Anjeli's research (2021), studying the relationship between age and knee osteoarthritis at the Tegal Rejo Health Center, that showed that the highest number of respondents was found in the elderly age group of 60-65 years (45%). Researchers state that osteoarthritis often occurs in the elderly phase, causing a decrease in the body ability and system, such as decreased bone density, decreased muscle strength, and decreased synovial fluid in the knee joint leading to osteoarthritis conditions to occur in elderly.

Based on the sex categories, women more exposed osteoarthritis. Researchers found that there was an alignment between the results of the study with existing theories. Women are more dominant affected by Osteoarthritis (OA) because the estrogen hormone owned by women. Osteoarthritis (OA) is the most common form of arthritis, affecting 1 of 3 people over the age of 65 and more common in women than men (Anjeli, 2021). This occurs due to the decrease of estrogen hormone in menaupose women and a decrease in bone and joint density. While the function of the estrogen hormone itself is to help synthesize chondrocytes in the bone matrix. If the estrogen hormone decreases, chondrocyte synthesis also decreases so that the synthesis of proteoglycans and collagen also declines but lysosomal activity increases, causing osteoarthritis to occur in many women (Miftahul Zannah et al., 2023).

Based on occupations, the average sample was in the medium-heavy occupational category. The load on the knee joint can be caused by daily activities, such as lifting things, walking, and going up and down stairs which can cause excessive pressure on the joint. On average, elderly, who work as self-employed, traders, farmers, and housewives, perform activities that put weight on the knees. This will cause changes in the knee joint (Juriansari et al., 2020).

Leg Extension Exercise for Increasing Range of Motion

Based on the result, leg extension exercise improved range of motion before and after interventions. Leg extension exercise is a dynamic exercise performed with the resistance or constant load and changes in muscle length principles. Researchers gave leg extension exercise because it has an effect on muscle mass and muscle strength that can increase the size of the muscle spindle, so that it increases the strength of muscle contraction and relaxation. This condition can reduce spasm so that stiffness or limitation in the joints decreases. It is proven by the increase of ROM after giving the leg extension exercise.

Based on Nugraha (2017), this training mechanism can provide an increase in the size of muscle mass, making it possible to create power in activities that are higher than before. Muscle strength is influenced by

two important and decisive elements, namely strength and speed. This exercise results in an increase in muscle spindle size which will ultimately increase the power or strength of the intended muscle contraction, increase the number of contractile proteins, myosin filaments, and capillary density, and increase the strength of connective tissue and ligaments. (Nugraha, 2017)

In line with Utami's research (2019), leg extension exercise has a contraction and relaxation phase. During the contraction phase, the increased stress of origo and insertio muscles that approach each other will push venous blood. When entering the relaxation phase, the capillarity of the muscles increases 15-20 times compared to when it is in the resting phase, helping the process of increasing metabolism so that there is a removal of metabolic waste and lactic acid as the cause of spasm. This metabolism results in decreased muscle stiffness, reduced knee pain, increased muscle strength, and better joint stability, thereby increasing functional ability in osteoarthritis genu (Utami, 2019).

Static Bike Exercise for Increasing Range of Motion

Based on the result of the study, static bike exercise increased range of motion before and after intervention. Static bike exercise is a form of aerobic exercise aimed to strengthen muscles and flexibility of the knee joint. Researchers chose this intervention because aerobic exercise focusing on the knee joint can result in increasing flexibility, muscle strength, and synovial fluid and decreasing pain to reduce limitations in the knee joint. It is proven by the increase of ROM after giving the static bike intervention.

Supported by the theory and research conducted by Brosseau (2017), aerobic exercise is a form of physical activity carried out systematically and functionally in a low impact aerobic exercise. This exercise is a type of activity that requires oxygen as an energy source. Besides, this exercise can increase propioseptic stimulation in the knee joint (Brosseau et al., 2017). The increases occurred due to proprioceptive stimulations are the increase in joint flexibility, coordination of motion, and sense of motion in the joint.

Research conducted by Abdurrachman (2019) on cycling exercise intervention as endurance training with a low-impact type is also in line with the results of the study. Elderly patients with osteoarthritis who performed endurance training could increase their muscle strength and cardiovascular and respiratory health (Abdurrachman et al., 2019). Even, doing cycling exercise will have an effect in increasing synovial fluid and reducing the secretion of inflammatory cytokines in the joints, so that pain will be reduced followed by increased joint mobility (Zhang et al., 2013). Osteoarthritis is a disease that has not been cured until now, thus the treatment given for osteoarthritis cases is focused on preventing disability and minimizing the worsening condition of the patient.

Leg Extension Exercise and Static Bike Exercise for Increasing Range of Motion

Based on the results of the study, both groups were equally good at increasing ROM in the knee joint. This condition could be because both groups performed exercises that focused on flexion and extension movements of the knee joint which might have an effect on increasing flexibility and muscle strength in the area around the knee and decreasing spasm and knee pain associated with decreased stiffness or limitation of the knee joint. It is proven by the increase in ROM after giving the leg extension and static bike exercises.

It is in line with the research conducted by Endang Mien Mas'ud (2021), providing straight leg raise (SLR) and static bike training, showing that there was no significant difference of the effect in the two treatment groups. A significant effect was found on increased quadriceps muscle strength of subjects who experienced muscle strength weakness due to knee osteoarthritis (Mas'ud et al., 2021). This mechanism can be achieved because straight leg raise exercises stimulate muscles to actively contract freely. Straight leg raise is an open kinetic chain, an active motion exercise involving one or more muscles and joints without movement in the proximal segment. The longer the leg stretches, the greater the workload on the muscle allowing it to contract maximally (Kisner et al., 2017; Shultz et al., 2015). Likewise, static bike exercises can increase muscle strength and reduce pain in the knees. This mechanism occurs because exercise with a static bike reduces the compression load on the knee joint but puts the load on the muscle to contract. Low intensity cycling can improve aerobic functions and capacities and reduce pains. Cycling exercise intervention given to knee osteoarthritis respondents can increase propioseptic stimulation in the knee joint which can improve joint stability. The increased stability allows the joint to improve

motion coordination of the joint and make changes to muscle contractions that stimulate the Golgi Tendon Organ (GTO), carrying information of mechanical changes and passing it on to afferent fibers. Exercises that strengthen the agonist and antagonist muscles simultaneously are physiological exercises for the lower limbs. The improvement of flexibility and muscle strength will support the ability to carry out daily activities (Luan et al., 2021)

Both interventions provide benefits for muscle tissues by stimulating the Golgi Tendon Organ (GTO) which carries information of mechanical changes passed on to afferent fibers so that stability and muscle tone can be maintained. This result is also supported by the results of research by Mangione (1999), showing that static cycling exercises did not cause acute pain so that functional ability could increase, leading to increased muscle strength and joint range of motion. Likewise, the results of Gezginaslan (2018) research showed that leg extension exercises could increase muscle strength and improve joint proprioception. Thus, both straight leg lifting exercise and static bike exercise could affect the quadriceps muscle strength of patients with knee osteoarthritis (Gezginaslan, 2018; Kisner et al., 2017; Mangione et al., 1999; Shultz et al., 2015).

CONCLUSION

Based on the results of the research, it concludes that leg extension exercise and static bike exercise could increase range of motion in osteoarthritis patients at Siloam Hospitals Bali. Leg extension exercise is as good as static bike exercise in increasing range of motion in osteoarthritis patients. Based on the results of the study, the provision of leg extension exercise and static bike exercise had the same effect in increasing the range of motion. Both exercises had similar increases in ROM. Viewed from the difference values, there was a slight difference, where the static bike exercise had slightly higher values in the percentage of ROM increase value. The intervention might provide stimulation to the GTO, causing tone in the lower limb muscles trained in the elderly with OA Genu condition.

The suggestion for future research is that the research should narrow the OA category by including the grade of OA Genu category, because the grade of OA distinguishes the severity or absence of OA conditions experienced by patients. Researchers can then provide a combination of intervention, such as with physiotherapy modalities, or interventions involving many leg muscle groups.

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