Jurnal Keterapian Fisik
Vol. 10, No. 2, November 2025
https://doi.org/10.37341/jkf.v10i2.464

Original Research

Effects of Active Assisted and Isometric Exercises Combined with Ultrasound in Knee Osteoarthritis

Ida Ayu Astiti Suadnyana[1*], I Putu Prisa Jaya[2], IA Pascha Paramurthi[3] Nyoman Dwi Sutrisnawati[4]

[1,2,3] Physiotherapy Department, Faculty of Health Sciences, Bali International University
[4] Hospital Administration Department Faculty of Health Sciences, Bali International University

ABSTRACT

Background: *Knee Osteoarthritis is a chronic degenerative joint disease of the knee cartilage which is characterized by pain and joint stiffness which has an impact on the functional activities of the elderly. Physiotherapy has an important role in reducing pain by using electrotherapy modalities (ultrasound) and also exercise therapy (active assisted exercise and isometric exercise) The aim of this study is to determine the difference in effectiveness between adding active assisted exercise and isometric exercise to ultrasound intervention in reducing pain among elderly patients with knee osteoarthritis.*

Methods: *This research was conducted at the Physiotherapy Clinic of Merdeka Medical Center from June to July 2024. The study used an experimental pre-test–post-test control group design with purposive sampling. Twenty-six elderly participants were selected and allocated into two groups of thirteen participants each. Knee pain was measured using the Visual Analogue Scale (VAS), administered before and after the intervention in both groups. Data were analyzed using SPSS. Based on the results of the paired samples t-test in groups 1 and 2.*

Results: *The p value was 0.001, indicating a significant difference between group 1 and group 2 in reducing pain. Isometric exercise combined with ultrasound reduced knee pain by 51.3% more than active assisted exercise combined with ultrasound in elderly patients with knee osteoarthritis.*

Conclusion: *Isometric exercise with ultrasound reduces knee pain in the elderly compared to active assisted exercise. Therefore, isometric exercise with ultrasound should be recommended as a preferred physiotherapy intervention to reduce pain in this population.*

ARTICLE HISTORY
Received: April 17th, 2025
Accepted: December 2nd, 2025

KEYWORDS
active assisted exercise, isometric exercise, knee osteoarthritis, pain, ultrasound;

CONTACT
Ida Ayu Astiti Suadnyana
astitisuadnyana@unbi.ac.id
Physiotherapy Department, Faculty of Health Sciences, Bali International University. Jl. Sroja, Gang Jeruk No. 9A, Tonja, Denpasar, Bali, Indonesia.

Cite this as: Effects of Active Assisted and Isometric Exercises Combined with Ultrasound in Knee Osteoarthritis. (2025). *Jurnal Keterapian Fisik*, *10*(2), 110-121. https://jurnalketerapianfisik.com/index.php/jpt/article/view/464

INTRODUCTION

Indonesia is currently entering the aging population phase, namely the proportion of the elderly population is increasing. Based on the Indonesian population census in 2023, 11.75% of the Indonesian population is categorized as elderly (Badan Pusat

Statistik Indonesia, 2023). Elderly is a natural process that occurs in someone who is entering the final stages of life.

This process occurs continuously when a person experiences several changes that affect the function and abilities of the entire body, which is called the aging process. As age increase, every part of the human body becomes more susceptible to movement and function disorders, which can reduce the quality of life of the elderly. Physical changes that occur in the elderly include changes in the nervous system, cardiovascular system, respiratory system, digestive and metabolic system, urinary system, reproductive system, and musculoskeletal system (Flint & Tadi, 2023).

Osteoarthritis constitutes a heterogeneous group of conditions that lead to joint symptoms and signs associated with impaired integrity of the articular cartilage, in addition to associated changes in the underlying bone at the joint margins. Osteoarthritis is also a global health problem that reaches 151.4 million people and 27.4 million people in Southeast Asia. In Indonesia, the prevalence of osteoarthritis is 8.1% of the total population (Gan et al., 2023). Osteoarthritis can occur in all joints but is more often seen in weight-bearing joints such as the knee (Krupa & Dinesh, 2021).

Knee osteoarthritis is a chronic degenerative joint disease of the knee cartilage characterized by clinical, histological and radiological changes. In knee osteoarthritis, patients will experience complaints in the form of joint stiffness and pain which have an impact on functional activities. Around 80% of seniors aged 60 years suffer from knee joint osteoarthritis and an estimated 1-2 million seniors experience disability due to osteoarthritis (Syamsia et al., 2020). Treatment for knee osteoarthritis includes non-operative and operative measures (arthroplasty) and involves cross-disciplines such as doctors, nurses, physiotherapy (Somaiya et al., 2024).

The role of physiotherapy in treating osteoarthritis conditions is very important, especially in reducing pain, namely with electrotherapy modalities and also exercise therapy. The electrotherapy modality used in this research is ultrasound. Ultrasound has been used as a non-invasive and safe physiotherapy for musculoskeletal conditions (Dantas et al., 2021). Giving ultrasound can increase blood circulation in the tissue, thereby reducing pain.

Ultrasound not only relieves the pain of osteoarthritis patients but has potential cartilage healing effects (Yousef et al., 2024). Furthermore, exercise therapy, namely active assisted exercise, is exercise that is carried out alone (independently) and also with the help of forces from outside the body so that the movements that occur are actively participatory. This exercise can also control muscle performance as a muscle group so that it can have an impact on reducing pain (Syah et al., 2020).

In cases of knee osteoarthritis, strengthening exercises are also needed to reduce pain. Strengthening training is an exercise that aims to increase muscle strength where this exercise will cause muscle morphological changes, namely increasing the diameter of muscle fibers (Zeng et al., 2021a).The bigger the muscle that is formed, the more mitochondria it contains.

The recommended strengthening exercise with resistance is isometric exercise on the quadriceps muscles. Increasing quadriceps muscle strength causes reduced pressure on the knee, thereby reducing pain (Basuki et al., 2024). Isometric exercises are easy and safe to do (Kangeswari et al., 2021). Therefore, researchers wish to combine exercise therapy and electrotherapy to reduce pain in patients with knee osteoarthritis so that patients with knee osteoarthritis can find appropriate, effective and efficient interventions.

The novelty of this research lies in directly comparing the effectiveness of two exercise modalities active assisted exercise and isometric exercise when each is combined with ultrasound for elderly patients with knee osteoarthritis. The aim of this study was to determine the difference in the effectiveness of adding active assisted exercise and isometric exercise to ultrasound intervention in reducing pain in elderly people with knee osteoarthritis at Poly Physiotherapy Merdeka Medical Center.

MATERIALS AND METHOD

The research design used in this study was quasi-experimental with a pre-test and post-test control group design. This design was selected because random allocation of participants was not feasible in the clinical setting, while a comparison between two intervention groups was still required. It enables evaluation of changes in pain within each group over time (pre–post) and allows control of baseline differences by comparing post-intervention outcomes between groups while taking initial scores into account, thereby providing stronger evidence of intervention effects than a simple pre–post or cross-sectional design.

This research was conducted at the Merdeka Medical Center (MMC) Physiotherapy Clinic in June-July 2024. Data collection was carried out for 6 weeks. The target population in this study was the entire elderly population with a diagnosis of knee osteoarthritis at the Poly Physiotherapy Merdeka Medical Center. The accessible population is the elderly with a diagnosis of knee osteoarthritis at the Poly Physiotherapy Merdeka Medical Center who have met the inclusion criteria and exclusion criteria and are willing to be the sample in this study.

The sample size was calculated using the pocock formula with the number of samples in each group were 13 people, where the total subjects in this study were 26 samples. The sample collection technique in this research uses a non-probability sampling technique in the form of purposive sampling, sampling based on predetermined inclusion and exclusion criteria. Non-probability sampling is a sampling technique that does not provide an equal chance for each element or member of the population to be selected as a sample for this research.

The samples in the study were knee osteoarthritis patients at the Poly Physiotherapy Merdeka Medical Center who met the following inclusion criteria such as male or female seniors aged 60-90 years, seniors who had been diagnosed with knee osteoarthritis by a doctor based on medical records (X-rays), seniors who have been diagnosed with osteoarthritis genu by physiotherapy based on physical examination, have a good cognitive, have signed informed consent. The exclusion criteria in this research is fracture, stroke, severe hearing loss, parkinson's and dementia. And the last drop out criteria was samples got worse after being given training, patients suddenly fell ill or were injured for some reason during data collection.

The independent variables in this research are ultrasound, active assisted exercise, isometric exercise and the dependent variable is pain. The procedure in this research begins with research preparation by arranging permission for a research introduction letter to the Bali International University institution and requesting permission and approval from the Head of Poly Physiotherapy MMC. Next, carrying out the research requires approval from the subjects being researched and if they are willing, the subjects are expected to sign informed consent.

Fill out the form and conduct an interview to obtain data on the subject's characteristics regarding age, gender and occupation. Next, measure pain using a visual

analogue scale (VAS) and also provide physiotherapy. Ultrasound was given with an intensity of 1.0 W/cm², a frequency of 1 MHz and a duration is 5 minutes for 6 weeks.

Ultrasound is given two times a week using continuous mode at the painful point. Active assisted exercise is given in 5 sets with 8-10 repetitions. This training is carried out for 6 weeks, where the training frequency is 2 times per week. Giving isometric exercises to increase muscle strength, done in 5 sets with 8-10 repetitions (hold for 8 seconds and rest for 4 seconds). This training was carried out for 6 weeks, where the training frequency was 2 times per week. After week 6, pain measurements were carried out again using a visual analogue scale (VAS), an instrument with well-established validity and reliability for assessing subjective pain intensity.

Data analysis in this research used a computer software program, namely SPSS. The first analysis carried out was a descriptive statistical test to analyze age, gender and occupation whose data was taken before the initial intervention was carried out. Next, a data normality test was carried out using the Shapiro-Wilk test to determine whether the data distribution was normal or abnormal. After the normality test, continue with the data homogeneity test using Levene's Test which aims to determine data variations. The significance limit used is α=0.05.

Hypothesis testing is carried out to assess pre and post tests in each group. Because the data is normally distributed, we used the paired samples t-test to test differences in results before and after treatment. And finally, a different test was carried out to assess the difference in effectiveness between group 1 and group 2 using a parametric test, namely the independent t-test.

This research has also been ethically approved by the Health Research Commission of Bali International University with letter number 01.055/UNBI/EC/V/2024. All participants received a clear explanation of the study procedures and provided written informed consent, their confidentiality and anonymity were ensured, participation was entirely voluntary with the right to withdraw at any time, and the interventions were designed to minimize any potential risks or discomfort in accordance with the principles of respect for persons, beneficence, and justice.

RESULTS

The characteristics of respondents based on age, gender and occupation can be seen in the following table:

Table 1. Distribution sample by Age, Gender and Occupation (n = 26)

Characteristic	Category	Group 1 (n = 13)		Group 2 (n = 13)	
		n	**%**	**n**	**%**
Age	60-65	8	30.7	6	23.1
	66-70	5	19.3	1	3.8
	71-75	0	0	2	7.7
	76-80	0	0	4	15.4
	Total	**13**	**100**	**13**	**100**
Gender	Men	5	19.3	6	23.1
	Woman	8	30.7	7	26.9
	Total	**13**	**100**	**13**	**100**
Occupation	Housewife	4	15.4	5	19.2
	Entrepreneur	3	11.5	3	11.5

Characteristic	Category	Group 1 (n = 13)		Group 2 (n = 13)	
		n	%	n	%
	Merchant	3	11.5	1	3.9
	Lecturer	1	3.9	0	0
	Retired	2	7.7	4	15.4
	Total	**13**	**100**	**13**	**100**

Note: n = number of observation; % = percentage

Based on Table 1, Most participants in both groups were aged 60–65 years, with fewer participants in the older age categories (30.7%). The proportion of women (30.7%) was slightly higher than men in both groups. Regarding occupation, housewives (15.4%) participants constituted the largest proportions.

As a prerequisite for determining the statistical test, it can be using normality test and data homogeneity test are carried out before and after treatment. The normality test uses the shapiro wilk test, while the homogeneity test uses Levene's test. The results of this analysis can be seen in the following table:

Table 2. Results of Normality Test and Homogeneity Test Before and After Intervention

Data Group	Shapiro Wilk Test				Levene's Test
	Group 1		Group 2		
	Statistic	p-value	Statistic	p-value	
Pre-Test	0.891	0.099	0.872	0.055	0.404
Post-Test	0.878	0.066	0.876	0.063	0.690

Based on the table 2 it can be seen from the results of the normality test using the shapiro wilk test that the probability value for the data group before the intervention in group 1 was obtained where the p-value = 0.099 (p-value > 0.05) and after the intervention the p-value = 0.066 (p-value > 0.05) while in group 2 before the intervention the p value = 0.055 (p-value > 0.05) and after the intervention the p value = 0.063 (p-value > 0.05). These results indicate that the data is normally distributed. In the homogeneity test using levene's test, the value of p-value = 0.404 (p-value > 0.05) was obtained for the group before the intervention and for the group after the intervention the value was p-value = 0.069 (p-value > 0.05) which indicates that the data before and after the intervention had homogeneous data.

To test the mean increase before and after intervention in treatment group 1 and treatment group 2, the paired-samples t-test was used which aims to determine the difference in mean increase before and after intervention. The test results can be seen in the following table:

Table 3. Within-Group Comparison of Pain Scores Before and After Intervention (n = 26)

	Before Intervention	After Intervention	MD ± SD	95% Confidence Interval		p-value*
				Lower	Upper	
Group 1	5.31	4.08	1.23 ± 0.44	0.97	1.49	<0.001
Group 2	5.38	2.62	2.77 ± 1.01	2.16	3.38	<0.001

Note: MD = Mean Different; SD = Standard Deviation; *t-dependent

Based on Table 3 the results show differences in mean improvement analyzed using the paired-samples t-test before and after intervention in group 1 with ultrasound and active assisted exercise with a value of p-value < 0.001 (p-value < 0.05) which means that there is a significant difference of improvement before and after giving the intervention. Testing the group 2 hypothesis with ultrasound and isometric exercise using the paired-samples t-test obtained a value of p-value < 0.001 (p-value < 0.05) which means that there is a significant difference in the increase before and after treatment.

To test the comparison of the average increase before and after in the two groups given ultrasound and active assisted exercise treatment in group 1 and ultrasound and isometric exercise in group 2, the Independent T-test was used. The results can be seen in the following table:

Tabel 4. Between-Group Comparison of Post-Intervention Pain Scores (n = 26)

	Group	Mean ± SD	95% Confidence Interval		p-value*
			Upper	Lower	
Pre-Test	Group 1	5.31 ± 0.86	0.88	0.73	0.846
	Group 2	5.38 ± 1.12			
Post-Test	Group 1	4.08 ± 0.95	0.65	2.27	0.001
	Group 2	2.62 ± 1.04			

Note: SD = Standard Deviation; *t-independent

Based on Table 4 which shows the results of calculating the mean difference in pain reduction, the value obtained is p-value = 0.001 (p < 0.05) for the difference between before and after the intervention in the two groups. This means there is a significant difference between the two interventions. The mean reduction in pain in group 2 (ultrasound and isometric exercise) was greater than in group 1 (ultrasound and active assisted exercise).

The percentage of pain reduction after intervention in group 1 (ultrasound and active assisted exercise) and group 2 (ultrasound and isometric exercise) can be seen in the following table:

Table 5. Comparative Percentage Reduction in Pain Between Groups (n = 26)

Analysis Result	Group 1	Group 2
Pain Reduction Before Intervention	5.31	5.38
Pain Reduction After Intervention	4.08	2.62
Difference Pain Reduction	1.23	2.76
Percentage (%)	23.2%	51.3%

Based on Table 5 which shows the percentage results of pain reduction in group (23.2%) and in group 2 (51.3%). Thus, it can be said that group 2 intervention (ultrasound and isometric exercise) resulted in a greater reduction in pain that group 1 (ultrasound and active assisted exercise).

DISCUSSION

Women have twice the risk of injury and knee osteoarthritis compared to men because decreased levels of the hormone estrogen cause a decrease in chondrocyte

synthesis so that the synthesis of proteoglycans and collagen also decreases. Apart from that, there is an increase in lysosomal activity when a person reaches old age, this is what causes knee osteoarthritis to occur more often in women (Guo et al., 2022). Women's hips are wide, which can cause the legs to be brought closer to the knees so that the pressure on the knees is uneven.

In addition, women have less muscle mass around their knees than men. The role of hormones also influences the occurrence of knee osteoarthritis because during menstruation, estrogen levels in the body increase so that women are very susceptible to knee osteoarthritis (Guo et al., 2022). Subject characteristics based on occupation show that most patients with knee osteoarthritis are housewives. In both groups, other occupations included entrepreneurs, traders, lecturers, retirees, with relatively small numbers and different distributions between group 1 and group 2. These findings indicate that daily activities and domestic workload may be contributing factors to knee pain complaints in the elderly.

Domestic workers' work conditions require heavier physical movements such as lifting heavy loads, going up and down stairs a lot and often standing for long periods while cooking are some of the risk factors for knee osteoarthritis. Another risk factor for knee osteoarthritis can be caused by work that often uses one joint as the main support. Person who does excessive physical activity during work can increase the risk of developing osteoarthritis (Lo et al., 2022).

Heavy activities such as kneeling, squatting, going up and down stairs, standing for long periods and lifting heavy weights in housewife have a greater risk of developing knee osteoarthritis (Schram et al., 2020). In research Deni Prasetyo Utomo et al., 2022 conducted on elderly people with osteoarthritis genu, a total of 46 samples aged 66-88 years, stated that the higher the level of work history carried out by the patient, the worse the degree of knee osteoarthritis suffered by the patient.

In group 1 with ultrasound intervention and active assisted exercise, a reduction in pain was obtained as shown in table 3. The mean score before intervention was 5.31 and the mean score after intervention was 4.08 with a difference of 1.23. The reduction in pain scores was tested using a paired sample t-test, so it was found that $p=0.000$ ($p<0.05$) which means there was a significant change between the reduction in pain before and after the intervention. This shows that ultrasound intervention and active assisted exercise provide a significant reduction in pain in elderly people with osteoarthritis.

Ultrasound has been used as a non-invasive modality for the management of knee osteoarthritis because it can reduce pain, reduce edema, increase joint range of motion and accelerate tissue repair through thermal and mechanical effects (Yousef et al., 2024), Ultrasound causes soft tissue molecules to vibrate from exposure to sound waves. This increased molecular movement generates frictional heat and consequently increases tissue temperature. This increase in temperature is named the thermal effect, which causes changes in nerve conduction velocity, increased enzymatic activity, changes in skeletal muscle contractile activity, increased extensibility of collagen tissue, increased local blood flow, increased pain threshold, reduced muscle spasm (Sakamoto, 2021)

Active assisted exercise focuses on movements that occur due to the work of the muscles concerned against gravity and are assisted by forces from outside the body (assisted). The force of gravity can be used to increase normal lymph flow and will also prevent static fluid in the tissue. So that the inflammatory reaction can be accelerated

progressively, as well as maintaining the elasticity of the participating muscles during active movements with assistance and will provide stimulation for the integrity of bones and joints and will improve coordination to prepare before returning to functional activities (Kisner & Kolby, 2018).

Ultrasound combined with active assisted exercise can reduce pain in elderly people with osteoarthritis genu because ultrasound can speed up the tissue repair process so that pain and muscle spasms can be reduced plus active assisted exercise can maintain muscle elasticity. This is in accordance with research Syah et al., 2020 which states that active assisted exercise can eliminate unnecessary movements and improve the ability to regulate posture (Pourahmadi et al., 2020). In group 2 with ultrasound intervention and isometric exercise, a reduction in pain was obtained as shown in table 3.

The average value before the intervention was 5.38 and the average value after the intervention was 2.62 with a difference of 2.76. The reduction in pain scores was tested using a paired sample t-test, so it was found that $p=0.000$ ($p<0.05$) which means there was a significant change between pain before and after the intervention. This shows that ultrasound intervention and isometric exercise provide a significant reduction in the pain experienced by elderly people with knee osteoarthritis.

Ultrasound with micromassage and heating effects can reduce pain, where the heat produced can help vasodilate blood vessels and produce increased blood circulation to the area so that irritating substances that cause pain can be removed properly and enter the bloodstream so that pain is reduced (Pizzey et al., 2021). Ultrasound in knee osteoarthritis patients uses a large transducer for 5 minutes in the knee area (trigger point) with a frequency of 1 MHz and a dose of 1.5-2 W/cm² using a contact media in the form of a gel to transfer ultrasonic energy to body tissue thereby increasing physical function and improving cartilage in patients with knee osteoarthritis (Luo et al., 2024).

Research results show that ultrasound is a safe and effective modality in relieving pain and improving function in genu osteoarthritis patients. Providing isometric exercise with light and moderate intensity can significantly increase muscle strength in the elderly. The combination of ultrasound intervention plus isometric exercise is effective in reducing pain. Quadriceps muscle strengthening exercises will stimulate large diameter type IA and II afferent fibers (proprioceptors) so that the activity of these afferent fibers can reduce muscle spasms as well as improving peripheral blood circulation, thereby reducing pain at the sensory level (Lyle et al., 2022).

Ultrasound and isometric exercise reduce pain more than ultrasound and active assisted exercise in elderly people with knee osteoarthritis. The mean difference in scores before and after intervention in treatment group 1 with ultrasound intervention and active assisted exercise was 1.231 and the mean difference in scores before and after exercise in treatment group 2 with ultrasound intervention and isometric exercise was 2.769. Independent T-test to test the comparison of the mean reduction in pain before and after in the two groups. Based on the results of calculating the mean difference in pain reduction. This means that there is a significant difference between group 1 and group 2 in reducing pain in patients with knee osteoarthritis at Poly Physiotherapy Merdeka Medical Center.

Ultrasound and isometric exercise reduce pain more than ultrasound and active assisted exercise. This is because when ultrasound is combined with isometric exercise, there is a change in the biological effect of ultrasound as repairing damaged joints through good metabolism and protein transport. It will lead to better joint repair, and the

effect of isometric exercise can improve weak muscle strength because it is done (Syahputra & Nurwijayanti, 2021).

By working muscles against resistance or a weight that does not move or holding an object in a static position. The principle of increasing strength must pay attention to muscle type and if the joint experiences acute inflammation or the joint is unstable, especially in conditions of knee osteoarthritis, isometric exercises can provide light pressure on the joint and can be done by people with knee osteoarthritis who complain of swelling and pain (Zeng et al., 2021b). This exercise can improve muscle strength and static endurance to prepare joints for more dynamic movements.

This is in accordance with research Wirayuni & Arista, 2021 which states that isometric exercise on the quadriceps muscle can cause vasodilation of muscle tissue so that the tissue can be supplied with blood containing oxygen and nutrients, isometric exercise also can maintain muscle and prevent atrophy. By vasodilating the blood vessels, the metabolic system will accelerate so that pain substances such as bradykinin, prostaglandin and histamine will be excreted with the blood flow so that pain will decrease Increasing the strength of the quadriceps muscles is very important to maintain the stability of the knee joint, so that it can reduce the load on the knee joint when resisting body weight or during daily activities (Cao et al., 2024).

Ultrasound is highly effective when combined with an exercise intervention, in addition to reducing pain, this approach is also expected to result in a decrease in disability among patients (Ayu et al., 2022). The effects of ultrasound combined with assisted active exercise are decreased pain, maintenance of muscle elasticity, and movement coordination (Sarto et al., 2021). This study indicates that isometric exercise combined with ultrasound can be used as a more effective physiotherapy protocol to reduce knee pain in elderly patients with knee osteoarthritis.

However, the findings are limited by the relatively small sample size, single-center setting, and short intervention and follow-up period, which may restrict their generalizability. Future research should therefore employ larger and more diverse samples, use random allocation procedures, extend the follow-up duration, and include additional functional and quality-of-life outcomes to strengthen the methodological rigor and applicability of the results.

CONCLUSION

The conclusion of this research is isometric exercise and ultrasound more reduce pain by 51.3% compared to active assisted exercise and ultrasound in elderly people with osteoarthritis genu at Merdeka Medical Center. It is recommended that future researchers pay attention to other factors that can influence pain reduction in genu osteoarthritis patients, such as body weight and history of injury, and it is hoped that the results of this study can become a reference for further research.

ACKNOWLEDGEMENT

The researcher would like to thank the Physiotherapy Department, Faculty of Health Sciences and Patient at Merdeka Medical Center for allowing the research to be conducted.

REFERENCES

Ayu, P., Saraswati, S., Aryantari, S., Thanaya, P., Hendra, M., & Nugraha, S. (2022). The effectiveness of dry needling versus muscle energy technique combined with

ultrasound therapy in reducing disability due to tennis elbow. *Jurnal Keterapian Fisik*, *7*(2). https://doi.org/10.37341/jkf.v0i0.326

Badan Pusat Statistik Indonesia. (2023). *Statistik penduduk lanjut usia 2023*. Badan Pusat Statistik Indonesia.

Basuki, R., Dewi, N. S., Rizqulloh, D. A., & Pranata, S. (2024). Effect of quadriceps isometric exercise on reducing pain in elderly communities with knee osteoarthritis. *Journal of Vocational Health Studies*, *7*(3), 188–193. https://doi.org/10.20473/jvhs.V7.I3.2024.188-193

Cao, B., Xu, Q., Shi, Y., Zhao, R., Li, H., Zheng, J., Liu, F., Wan, Y., & Wei, B. (2024). Pathology of pain and its implications for therapeutic interventions. In *Signal Transduction and Targeted Therapy*, 9 (1). https://doi.org/10.1038/s41392-024-01845-w

Dantas, L. O., Osani, M. C., & Bannuru, R. R. (2021). Therapeutic ultrasound for knee osteoarthritis: A systematic review and meta-analysis with grade quality assessment. *Brazilian Journal of Physical Therapy*, *25*(6), 688–697. https://doi.org/10.1016/j.bjpt.2021.07.003

Deni Prasetyo Utomo, Akbar Ghozali, D., Darma Saputra, R., & Heru Nefihancoro, U. (2022). Hubungan antara riwayat pekerjaan dengan derajat osteoarthritis pada wanita usia di atas 65 Tahun. *Plexus Medical Journal*, *1*(2), 42–48. https://doi.org/10.20961/plexus.v1i2.23

Flint, B., & Tadi, P. (2023). *Physiology aging*. StatPearls Publishing.

Gan, A. K., Rahman, S., Indra Nur Alam, A., & Paterasari, B. (2023). Profile of patients' osteoarthritis at tertiary and teaching in Aceh, Indonesia. *Surabaya Physical Medicine and Rehabilitation Journal*, *5*(1), 25–31. https://doi.org/10.20473/spmrj.v5i1.36881

Guo, J., Huang, X., Dou, L., Yan, M., Shen, T., Tang, W., & Li, J. (2022). Aging and aging-related diseases: from molecular mechanisms to interventions and treatments. In *Signal Transduction and Targeted Therapy*, 7 (1). https://doi.org/10.1038/s41392-022-01251-0

Kangeswari, P., Murali, K., & Arulappan, J. (2021). Effectiveness of isometric exercise and counseling on level of pain among patients with knee osteoarthritis. *SAGE Open Nursing*, *7*. https://doi.org/10.1177/2377960821993515

Kisner, & Kolby. (2018). *therapeutic exercise foundation and techniques* (7th ed.). f.a davis company.

Krupa, M., & Dinesh, S. (2021). A comparative study to determine the effectiveness of three modes of kinetic-chain exercises on pain, range of motion and functional

performance in patients with osteoarthritis of knee. In *International Journal of Health Sciences and Research*, 11 (2).

Lo, G. H., Richard, M. J., McAlindon, T. E., Park, C., Strayhorn, M. T., Harkey, M. S., Price, L. L., Eaton, C. B., & Driban, J. B. (2022). Increased risk of incident knee osteoarthritis in those with greater work-related physical activity. *Occupational and Environmental Medicine*, *79*(8), 543–549. https://doi.org/10.1136/oemed-2022-108212

Luo, Y., Rahmati, M., Kazemi, A., Liu, W., Lee, S. W., Gyasi, R. M., López Sánchez, G. F., Koyanagi, A., Smith, L., & Yon, D. K. (2024). Effects of therapeutic ultrasound in patients with knee osteoarthritis: A systematic review and meta-analysis. *Heliyon*, *10*(10), e30874. https://doi.org/10.1016/j.heliyon.2024.e30874

Lyle, M. A., Cuadra, C., & Wolf, S. L. (2022). Quadriceps muscle stimulation evokes heteronymous inhibition onto soleus with limited Ia activation compared to femoral nerve stimulation. *Experimental Brain Research*, *240*(9), 2375–2388. https://doi.org/10.1007/s00221-022-06422-7

Pizzey, F. K., Smith, E. C., Ruediger, S. L., Keating, S. E., Askew, C. D., Coombes, J. S., & Bailey, T. G. (2021). The effect of heat therapy on blood pressure and peripheral vascular function: A systematic review and meta-analysis. *Experimental Physiology*, *106*(6), 1317–1334. https://doi.org/10.1113/EP089424

Pourahmadi, M., Sahebalam, M., & Bagheri, R. (2020). Effectiveness of proprioceptive neuromuscular facilitation on pain intensity and functional disability in patients with low back pain: A systematic review and meta-analysis. In *Archives of Bone and Joint Surgery*, 8 (4), 479–501. Mashhad University of Medical Sciences. https://doi.org/10.22038/abjs.2020.45455.2245

Sakamoto, M. (2021). Effects of Physical Agents on Muscle Healing with a Focus on Animal Model Research. *Physical Therapy Research*, *24*(1), 1–8. https://doi.org/10.1298/ptr.R0011

Sarto, F., Spörri, J., Fitze, D. P., Quinlan, J. I., Narici, M. V., & Franchi, M. V. (2021). Implementing ultrasound imaging for the assessment of muscle and tendon properties in elite sports: Practical aspects, methodological considerations and future directions. *Sports Medicine*, *51*(6), 1151–1170. https://doi.org/10.1007/s40279-021-01436-7

Schram, B., Orr, R., Pope, R., Canetti, E., & Knapik, J. (2020). Risk factors for development of lower limb osteoarthritis in physically demanding occupations: A narrative umbrella review. *Journal of Occupational Health*, *62*(1). https://doi.org/10.1002/1348-9585.12103

Somaiya, K. J., Samal, S., & Boob, M. A. (2024). Physiotherapeutic Intervention Techniques for Knee Osteoarthritis: A Systematic Review. *Cureus*. https://doi.org/10.7759/cureus.56817

Syah, L. O. M. G., Pangkahila, J. A., Irfan, M., Sundari, L. P. R., Adiputra, I. N., & Jawi, I. M. (2020). Biofeedback exercise lebih baik daripada active assisted exercise untuk meningkatkan kinerja otot bahu pada fungsional meraih posisi 900 fleksi bahu pasien pasca stroke. *Sport and Fitness Journal*, *8*(1), 29. https://doi.org/10.24843/spj.2020.v08.i01.p05

Syahputra, I., & Nurwijayanti, N. (2021). Effect of isometric and isotonic exercise program on increased strength of quardriceps muscles in osteoarthritis patients in Singgasana Rama Physiotherapy Clinic Blitar. *Journal for Quality in Public Health*, *5*(1), 42–48. https://doi.org/10.30994/jqph.v5i1.246

Syamsia, F. N., Aras, D., & Yusfina. (2020). Influence of stretching and strengthening exercise on functional activity in genu osteoarthritis patients. *Journal of Physics: Conference Series*, *1529*(3), 032030. https://doi.org/10.1088/1742-6596/1529/3/032030

Wirayuni, S., & Arista, L. (2021). Isometric exercise of quadriceps and gluteal muscle in patient with close femur fracture. *JIKO (Jurnal Ilmiah Keperawatan Orthopedi)*, *5*(1), 9–16. https://doi.org/10.46749/jiko.v5i1.56

Yousef, E. K. S., Amir, M. S., Saleh, R. A. E. H., Kadah, M. A.-E., & Makhlouf, A. I. A. M. (2024). The Iontophoresis versus ultrasound in treatment of knee Osteoarthritis. *International Journal of Multidisciplinary Research and Development*. www.allsubjectjournal.com

Zeng, C.-Y., Zhang, Z.-R., Tang, Z.-M., & Hua, F.-Z. (2021a). benefits and mechanisms of exercise training for knee osteoarthritis. *Frontiers in Physiology*, *12*. https://doi.org/10.3389/fphys.2021.794062

Zeng, C.-Y., Zhang, Z.-R., Tang, Z.-M., & Hua, F.-Z. (2021b). Benefits and mechanisms of exercise training for knee osteoarthritis. *Frontiers in Physiology*, *12*. https://doi.org/10.3389/fphys.2021.794062