Warsono *et. al.* Babcock Univ. Med. J.2024 7(2):66-72
https://doi.org/10.38029/babcockuniv.med.j..v7i2.363
eISSN: 2756-4657

RESEARCH ARTICLE OPEN ACCESS

Effect of Neuromuscular Control on Pain among Patients with Osteoarthritis in Indonesia: Quasi-Experiment

Warsono W[1ID], Fahmi FY[2ID], Rachmawati A[1ID], Pranata S1[ID]

[1]*Faculty of Nursing and Health Sciences, Universitas Muhammadiyah Semarang, Semarang, Central Java, Indonesia*
[2]*Faculty of Nursing, Universitas Muhammadiyah Kendal Batang, Kendal, Central java, Indonesia*

Submitted: 16th December 2023
Accepted: 10th August 2024
Published: 31st December 2024
ID: Orcid ID

Abstract
Objective: to analyse neuromuscular control's effect on pain among osteoarthritis patients.
Methods: A quasi-experimental study with a pre-posttest control group design of 88 respondents. Respondents with knee osteoarthritis, stages II and III underwent an initial rehab medical program and were included in the study. Respondents were randomised into two groups. The first group consisted of 44 respondents who carried out neuromuscular control exercises and analgesic drug therapy; the second group of 44 respondents only took analgesic medication. The intervention was given for 1 month, where every day it was carried out 3 times in the morning, afternoon and evening and pain was measured before and after the procedure using the Numeric Rating Scale measuring instrument. The analysis was conducted using the Wilcoxon test.
Results: Using the Wilcoxon test in the control group, the p-value = 0.01, while in the intervention group with a value of p < 0.00. All groups experienced a significant decrease in pain scale, particularly in the intervention group compared to the control group, where the control group yielded a value of p<0.01, while in the intervention group, it was p<0.00. From these results, it can be concluded that neuromuscular control exercises are effective in reducing pain intensity in grade 1 to 3 knee osteoarthritis.
Conclusion: It can be concluded that neuromuscular control exercises are effective in reducing pain intensity in osteoarthritis genu grades 1 to 3. Neuromuscular control exercises can be recommended as an independent therapy in reducing the pain intensity of knee osteoarthritis.

Keywords: Neuromuscular Control, Pain, Osteoarthritis

Plain English Summary
Osteoarthritis is a condition characterized by symptoms that often impair the lives of those affected. Pain is a primary symptom in individuals with osteoarthritis, typically arising after engaging in activities that place excessive stress on the joints. This study aims to analyze the influence of neuromuscular control on pain in osteoarthritis patients. The findings of this research conclude that neuromuscular control exercises can decrease the intensity of mild to moderate pain in knee osteoarthritis of grades 1 to 3. Therefore, it can be recommended as a self-therapy to alleviate pain intensity in knee osteoarthritis.

Background

Osteoarthritis affects the joints of the knees, hips, hands, and spine. Epidemiological data shows that the prevalence of osteoarthritis tends to increase with age. Globally, it is estimated that more than 10% of the world's population suffers from osteoarthritis, with higher rates in older age groups (1). Apart from age factors, obesity, joint injuries, and genetics also play a role in increasing the risk. The high prevalence rate of osteoarthritis has had significant economic impacts, including increased healthcare costs, as well as reduced productivity in society. Therefore, understanding the prevalence and influencing

Correspondence:
Warsono, Warsono
Department of Nursing, Faculty of Nursing and Health Sciences, Universitas Muhammadiyah Semarang,
Semarang, Central Java, Indonesia
(024) 76740296, warsono@unimus.ac.id

factors of osteoarthritis is essential to designing more effective prevention, management and treatment strategies and minimising its impact on the quality of life of individuals and society need to discover (2).

Osteoarthritis presents symptoms that often significantly impact the lives of those afflicted. These symptoms include recurring pain or tenderness in the joints, stiffness, restricted range of motion, crepitus (joint cracking or popping), joint swelling, weakness in the muscles around the knee, and muscle atrophy (3). Pain stands out as a primary symptom among individuals with osteoarthritis, typically emerging after engaging in activities that exert excessive stress on the joints (4). Respondents experiencing osteoarthritis-related pain may encounter joint and muscle dysfunction, leading to limitations in mobility as well as declines in muscle strength and balance. Approximately 18% of knee osteoarthritis patients with pain encounter difficulties and limitations in their daily activities, experience decreased work capacity, and suffer a decline in overall quality of life (5).

Analgesics are one of the main therapies in pain management. Unfortunately, one of the biggest reasons for inappropriate pain management is ~~a~~ lack of knowledge about analgesic pharmacology. Although pain management is done with drugs, several non-pharmacological techniques can also be used for pain such as massage, exercise, relaxation and imagination, nerve stimulation with transcutaneous electricity, use of hot and cold compresses, therapeutic touch, meditation, hypnosis, acupressure, and Transcutaneous Electrical Nerve stimulation (TENS). These techniques are generally safe, easily available and can be performed at home or in a treatment facility setting (6).

Exercise is recommended for elderly people with grade 1 to 3 osteoarthritis to strengthen muscle and joint mobility, improve functional capacity, relieve pain and stiffness and prevent further deformity. Therefore, pain system management should be a new target for both pharmacological and non-pharmacological interventions (7). Physical exercise therapy can provide benefits to respondents both directly and indirectly. Neuromuscular control is another form of elastic resistance that allows people to perform different exercises to increase muscle strength, mobility, and function and reduce joint pain (8).

Neuromuscular control is an exercise where muscles are contracted to see changes in increasing muscle strength. This is due to changes in muscle morphology, namely the greater the muscle mass formed, the more mitochondria produced. The effect of strengthening exercises will increase dynamic strength in muscles so that muscle power increases. If muscle power increases, endurance and balance will also increase. Blood circulation will increase due to vasodilation of blood vessels. Apart from that, it will also improve strength, size and prevent inflammation and increase the flexibility of fat tissue which can reduce pain (9).

Kendal Community Health Center is one of the health centres in Kendal, Indonesia with a high number of osteoarthritis patients. Based on the results of observations and interviews with 4 respondents at the Community health centre, respondents underwent a physical examination and then were given pharmacological therapy in the form of analgesic drugs and supplements. From this preliminary study, the author assessed the need to apply neuromuscular control exercise therapy to strengthen the quadriceps femoral and gastrocnemius muscles among patients. Therefore, the purpose of this study was to analyse the effect of neuromuscular control on pain among patients with Osteoarthritis.

Methods

Design

This study used a quasi-experimental research design with a pre-posttest control group design, which is carried out by giving a pre-test before the treatment is given and measuring again (post-test) pain among respondents after the treatment.

Study Population

The population in this study were osteoarthritis patients with grades 1-3 at Kendal Community Health Center. The sample was determined using total sampling, which is a sample selection method that includes the entire population as research subjects. A total of 88 respondents with grade 1-3 osteoarthritis were recruited to become a sample of the study where 44 subjects in the intervention group and 44 subjects in the control group.

Respondents with knee osteoarthritis in the Kendal community health centre, aged 45 years old, moderate pain scale, and diagnosed with osteoarthritis grade I to III (K/L Scale) were included in the study. Patients with knee osteoarthritis who experienced severe pain, and respondents who had undergone hip osteoarthritis surgery, and underwent intraarticular injections during the last 6 months were excluded from the study.

Pre-Intervention

Before the intervention, respondents underwent pain intensity assessment using the Numeric Rating Scale (NRS). This procedure was conducted for both the control and intervention groups on the first and thirtieth days.

Intervention
This intervention lasted for a month, with sessions held three times a day, particularly in the morning, afternoon, and evening. The intervention consisted of a 10-minute warm-up walk, followed by neuromuscular control exercises, with each step lasting for 10 seconds, and ending with a cool-down involving deep breathing to achieve a relaxed state. Pain measurement was then conducted using the NRS. Subsequently, researchers instructed respondents to perform neuromuscular control exercises every day at 06:00, 11:00, and 16:00 Western Indonesian Time (WIB) until the thirtieth day, with researchers monitoring via group video calls. Researchers gathered the respondents back on the thirtieth day at the Community Health Center for pain scale measurements at 16:00 WIB.

Instrument
The assessment of respondents' joint pain severity was conducted using the Numeric Rating Scale (NRS), which is an internationally standardized tool for evaluating pain scales. The Numeric Rating Scale (NRS) was utilized to measure respondents' pain levels before and after treatment, employing a numerical scale ranging from 0 to 10, where 0 represents the absence of pain and 10 indicates the worst imaginable pain. This measurement was carried out in both the intervention and control groups.

Data analysis
Based on the results of the normality test conducted on the intervention group using the Kolmogorov-Smirnov test, it was found that before administering neuromuscular control, the p-value was 0.032, and after administering it, the p-value was 0.02. For the distribution of data in the control group, a p-value of < 0.05 was obtained, indicating that the data is not normally distributed. Consequently, when the data is not normally distributed, the Wilcoxon test is used to examine the differences before and after treatment.

Results
The results of the univariate analysis provide an overview of the distribution of participants according to participant characteristics (Gender, Age, and Body Mass Index) and the evaluation results in providing neuromuscular control exercises.

Participant Characteristics (Gender, Age and Body Mass Index)

Table 1: Distribution of Participant Characteristics Based on Age and Body Mass Index Intervention Group (N=44) and Control (N=44)

Variable	Group		
	Intervention Mean + SD	Control Mean + SD	p-value
Gender (Male: Female)	6:38	3:41	0.47
Age	61.50±1,210	61.70±1,525	0.62
Body Mass Index (BMI)	30.04±1.606	30.25±1.616	0.28

Based on Table 1 above, it can be concluded that the frequency of knee osteoarthritis patients by gender in both the control group (86.36%) and intervention group (93.2%) is predominantly female. The average age of respondents in the intervention group was 61.5 ± 1.21, while in the control group, it was 61.7 ± 1.525. Additionally, concerning BMI, respondents in the intervention group had a mean BMI of 30.04 ± 1.606, whereas the control group had a mean BMI of 30.25 ± 1.616.

Results of Neuromuscular Control Exercises Before and After Intervention in Reducing Pain Intensity in the Intervention and Control Groups

Table 2: Effect of providing Neuromuscular control intervention in reducing pain intensity Intervention group (N=44) and Control (N=44)

Variable	Group	
	Intervention Mean±SD	Control Mean±SD
Before doing neuromuscular control exercises	5.34±0.435	5.42±0.520
After doing neuromuscular control exercises	0.84±0.207	4.25±0.616
p-value	0.000*	0.010*

**significant at α 0.05 (p value= 0.000) with the Wilcoxon Test

Based on the results of Table 2 in the intervention group, it can be concluded that the mean pain scale before the intervention was 5.34±0.435 and after being given intervention for one month the mean was 0.84±0.207 and the value: was 0.00. Meanwhile, the mean pain scale of the control group on the first day was 5.42±0.520, and after thirty days it was 4.25 ± 0.616, with a p-value of 0.010.

Discussion

Respondent characteristics

The majority of respondents in the control and intervention groups were female, whereas in the control group the gender was 86.36% while in the intervention group, it was 93.20%. This is the same as the research by Hussaini and his colleagues (10), where the majority of knee osteoarthritis participants were women (89.06%). This finding is similar to what was reported in a study by Madry et. Al,. (11), where 68.59% of the participants with osteoarthritis were women. Then the incidence of osteoarthritis increases the surgical program of joint replacement, either Total Knee Replacement (TKR) or Total Hip Replacement (THR), more in women over the age of 50 years and men over the age of 60 years. Women suffer from knee osteoarthritis more often than men. Women have twice the risk of knee injuries and osteoarthritis because women's hips are wide, this causes the knees to be wider and in an "O" shape so that the joint position is uneven, as well as the muscle mass around the knees in women is less than in men. Apart from that, there are other factors, namely, the menopause process in women which is faster than in men, and has an impact on decreasing the hormone estrogen, where the function of this hormone is to provide an elastic effect on the joints.

This study discovered a correlation between age and osteoarthritis. Besides being influenced by gender, osteoarthritis is also affected by age. In the age group of 45-49 years, knee osteoarthritis typically begins to manifest. A study has indicated that the ageing process plays a role in the development of osteoarthritis in knee joints. Ageing is associated with an increased risk of chronic diseases, including osteoarthritis and osteoporosis. Research has shown that the onset of osteoarthritis may commence during the menopausal period, specifically between the ages of 45-49 years (12), with 59% of cases occurring within the age range of 55-74 years, and 31% occurring in individuals aged over 75 years (13).

The ageing process results in a gradual decline in physiological function, leading to functional impairments and reduced adaptive capacity to stress. Additionally, ageing increases exposure to environmental factors. Advanced age is also linked to an increased risk of osteoarthritis due to biological changes, such as a decrease in synovial fluid secretion with advancing age (14). Furthermore, ageing is associated with cellular ageing, which plays a role in the inflammation of cells in osteoarthritis (15).

This study found that the Body Mass Index (BMI) among respondents in both control (Mean 30.25±1.616) and intervention (30.04±1.606) groups were classified above normal. This showed that body weight above normal is one of the factors that will have an influence or impact on the occurrence of knee osteoarthritis (16, 17, 18, 19). The results of this research are supported by a study which states that both men and women have the opportunity to have an excessive BMI because men experience visceral (abdominal) obesity while women can contribute to increasing fat which is supported by modern times, namely a bad lifestyle which can influence increasing BMI (2).

The effect of neuromuscular control training on the intensity of knee osteoarthritis pain

The results of neuromuscular control training in the intervention group indicated a significant effect, with a p-value < 0.001, whereas in the control group without such training, neuromuscular control training also demonstrated an impact on the intensity of knee osteoarthritis pain. This suggests that the implementation of neuromuscular control has a greater influence on the intensity of pain in knee osteoarthritis patients. These findings are consistent with previous research showing that the application of neuromuscular control over sixty days effectively reduces the intensity of knee osteoarthritis pain. Additionally, other studies have indicated that the effect of neuromuscular control on the intensity of knee osteoarthritis pain over fourteen days experienced a significant decrease and was more effective in improving daily activities (20, 21, 22).

These muscle strengthening exercises can be done as a routine for respondents and as an alternative therapy to reduce the intensity of grade I, II, and III (K/L) knee osteoarthritis pain from mild to moderate pain. This is in line with a study which showed that neuromuscular control was very significant (p= 0.001) in reducing knee osteoarthritis pain and improving joint elasticity (2). Where exercising the hamstring and quadriceps muscles, will reduce other problems such as impaired muscle flexibility, joint stability, and muscle wasting which further worsens the condition and increases the pain (23, 24, 25, 26). There is a reason that no cure for osteoarthritis has been found except surgery, so management

focuses on how to reduce symptoms such as eliminating pain and improving joint function is the main goal in providing nursing care (27). Osteoarthritis also causes a decrease in the stability of the knee joint due to impaired quadriceps muscle strength, pain, and changes in joint structure. To maintain joint function and reduce knee instability, the hamstring muscles must be activated so that compensation occurs. Thus nursing actions are often recommended to reduce pain and increase mobility (26). So exercise movements must be done regularly to prevent muscle atrophy. A regular and measured exercise program is recommended for osteoarthritis respondents (26). A type of exercise therapy with a focus on muscle strengthening and stretching (flexibility) exercises. Several muscle groups that function to control knee movement and stability are the quadriceps muscles at the front and the hamstring muscles at the back (2).

Conclusion

Characteristics in this study that can influence the occurrence of the osteoarthritis process are gender, age, and BMI. Neuromuscular control exercises have proven effective in reducing pain intensity in patients with grade I, II and III knee osteoarthritis from mild to moderate pain. With this practice, there is an increase in proteoglycan synthesis which will increase bone matrix formation and attract cations resulting in an increase in osmolality in articular cartilage. This makes the joint surface smooth and the joint easy to move so that pain is reduced. Apart from that, this exercise can also increase the daily activities that become part of the participants' routine. During implementation, neuromuscular control did not have any adverse side effects on participants, but it was proven to be effective in reducing pain and drastically increasing participants' daily activities.

List of Abbreviations

TENS: Transcutaneous Electrical Nerve stimulation
NRS: Numeric Rating Scale
TKR: Total Knee Replacement
THR: Total Hip Replacement

Declarations

Ethical approval and consent to participate

This research has received recommendations and ethical permission from the FIKKES Ethics Commission Universitas Muhammadiyah Semarang, Indonesia with Number: 525/KE/10/2023. Permission has been obtained from Kendal Community Health Center.

Consent for publication

All the authors gave consent for the publication of the work under the Creative Commons Attribution- Non-Commercial 4.0 license.

Availability of data and materials

The data and materials associated with this research will be made available by the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

The research was sponsored by LPPM Universitas Muhammadiyah Semarang.

Author contributions

WW and PS conceived the original idea. FYF wrote the preliminary draft. RA and PS revised the original draft. WW performed an extensive literature search. All authors were involved in the entire revision process and final approval.

Acknowledgement

None

References

1. Fahmi FY, Fatikhah F, Warsono W. Reduction of pain in patients with knee osteoarthritis by using hip abductor strengthening exercise. Media Keperawatan Indonesia. 2022 Feb 25;5(1):33-4. https://doi.org/10.26714/mki.5.1.2022.33-42
2. Hatfield GL, Costello KE, Astephen Wilson JL, Stanish WD, Hubley-Kozey CL. Baseline gait muscle activation patterns differ for osteoarthritis patients who undergo total knee arthroplasty five to eight years later from those who do not. Arthritis care & research. 2021 Apr;73(4):549-58. https://doi.org/10.1002/acr.24143
3. Khairurizal K. Perbandingan Pengaruh Kombinasi Latihan Hold Relax Dan Open Kinetic Chain Dengan Latihan Hold Relax Dan Close Kinetic Chain Terhadap Peningkatan Kemampuan Fungsional Pasien Osteoartritis Knee. Nusantara Medical Science Journal. 2019;4(2):55. https://doi.org/10.20956/nmsj.v4i2.6564
4. Madry H, Kon E, Condello V, Peretti GM, Steinwachs M, Seil R, Berruto M, Engebretsen L, Filardo G, Angele P. Early osteoarthritis of the knee. Knee Surgery, Sports Traumatology, Arthroscopy. 2016 Jun;24:1753-62. https://doi.org/10.1007/s00167-016-4068-3

5. Pamungkas YI, Hartati E, Supriyono M. Efektifitas pemberian stretching terhadap di unit pelayanan sosial lanjut usia. Jurnal ilmu keperawatan dan kebidanan (JIKK). 2017:1-9.
6. Vance CG, Rakel BA, Blodgett NP, DeSantana JM, Amendola A, Zimmerman MB, Walsh DM, Sluka KA. Effects of transcutaneous electrical nerve stimulation on pain, pain sensitivity, and function in people with knee osteoarthritis: a randomized controlled trial. Physical therapy. 2012 Jul 1;92(7):898-910. https://doi.org/10.2522/ptj.20110183
7. Hasanah K. Pengaruh Terapi Transcutaneous Electrical Nerve Stimulation Dan Kompres Panas Dalam Menurunkan Nyeri Pada Penderita Osteoartritis Lutut (Doctoral dissertation, Universitas Gadjah Mada).
8. Arif A, Siddique MA, Shahid G, Khan R, Usman M. Effect of resistance training of quadriceps muscle in patients with knee osteoarthritis : a randomized control trial. International Journal of Physical Medicine. 2020 Apr 11;8(1000570):3-6.
9. Marlina TT. Efektivitas latihan lutut terhadap penurunan intensitas nyeri pasien osteoarthritis lutut di yogyakarta. Jurnal Keperawatan Sriwijaya. 2015 Nov 12;2(1):44-56.
10. Hussain SM, Cicuttini FM, Alyousef B, Wang Y. Female hormonal factors and osteoarthritis of the knee, hip and hand: a narrative review. Climacteric. 2018 Mar 4;21(2):132-9. https://doi.org/10.1080/13697137.2017.1421926
11. Madry H, Kon E, Condello V, Peretti GM, Steinwachs M, Seil R, Berruto M, Engebretsen L, Filardo G, Angele P. Early osteoarthritis of the knee. Knee Surgery, Sports Traumatology, Arthroscopy. 2016 Jun;24:1753-62. https://doi.org/10.1007/s00167-016-4068-3
12. Lou C, Xiang G, Weng Q, Chen Z, Chen D, Wang Q, Zhang D, Zhou B, He D, Chen H. Menopause is associated with articular cartilage degeneration: a clinical study of knee joint in 860 women. Menopause. 2016 Nov 1;23(11):1239-46. https://doi.org/10.1097/GME.0000000000000697
13. Jung JH, Bang CH, Song GG, Kim C, Kim JH, Choi SJ. Knee osteoarthritis and menopausal hormone therapy in postmenopausal women: A nationwide cross-sectional study. Menopause. 2019 Jun;26(6):598–602. https://doi.org/10.1097/GME.0000000000001280
14. Hussain SM, Cicuttini FM, Alyousef B, Wang Y. Female hormonal factors and osteoarthritis of the knee, hip and hand: a narrative review. Climacteric. 2018 Mar 4;21(2):132-9. https://doi.org/10.1080/13697137.2017.1421926
15. Wang J, Xie Y, Wang L, Lei L, Liao P, Wang SQ, et al. Hip abductor strength-based exercise therapy in treating women with moderate-to-severe knee osteoarthritis: a randomized controlled trial. Clin Rehabil. 2020 Feb;34(2):160–9. https://doi.org/10.1177/0269215519875328
16. Newberry SJ, FitzGerald J, SooHoo NF, Booth M, Marks J, Motala A, Apaydin E, Chen C, Raaen L, Shanman R, Shekelle PG. Treatment of osteoarthritis of the knee: an update review. Available from: http://www.aaos.org/research/guidelines/TreatmentofOsteoarthritisoftheKneeGuideline.pdf
17. Chang WY, Choi S, Yoo SJ, Lee J, Lim C. Factors Associated with Osteoarthritis and Their Influence on Health-Related Quality of Life in Older Adults with Osteoarthritis: A Study Based on the 2020 Korea National Health and Nutrition Examination Survey. Int J Environ Res Public Health. 2023 Oct 18;20(12):6073. https://doi.org/10.3390/ijerph20126073
18. Aggarwal V, Maslen C, Abel RL, Bhattacharya P, Bromiley PA, Clark EM, Compston JE, Crabtree N, Gregory JS, Kariki EP, Harvey NC. Opportunistic diagnosis of osteoporosis, fragile bone strength and vertebral fractures from routine CT scans; a review of approved technology systems and pathways to implementation. Therapeutic advances in Musculoskeletal Disease. 2021 Jul;13:1759720X211024029. https://doi.org/10.1177/1759720X211024029
19. Khachian A, Seyedoshohadaei M, Haghani H, Amiri F. Effect of self-management program on outcome of adult knee osteoarthritis. Int J Orthop Trauma Nurs. 2020 Jun 6;39:100797. https://doi.org/10.1016/j.ijotn.2020.100797
20. Wang J, Xie Y, Wang L, Lei L, Liao P, Wang S, Gao Y, Chen Y, Xu F, Zhang C. Hip abductor strength–based exercise therapy in treating women with moderate-to-severe knee osteoarthritis: a randomized controlled trial. Clinical Rehabilitation. 2020 Feb;34(2):160-9. https://doi.org/10.1177/0269215519875328
21. Arif A, Siddique MA, Shahid G, Khan R, Usman M. Effect of Resistance Training of Quadriceps Muscle in Patients with Knee Osteoarthritis: A Randomized Control Trial. Int J Phys Med Rehabil. 2020;8:570.

22. Yuenyongviwat V, Duangmanee S, Iamthanaporn K, Tuntarattanapong P, Hongnaparak T. Effect of hip abductor strengthening exercises in knee osteoarthritis: a randomized controlled trial. 2020; https://doi.org/10.1186/s12891-020-03316-z
23. Sorour AS, Ayoub AS, Abd El Aziz EM. Effectiveness of acupressure versus isometric exercise on pain, stiffness, and physical function in knee osteoarthritis female patients. J Adv Res. 2014;5(2):193–200. https://doi.org/10.1016/j.jare.2013.02.003
24. Onwunzo CN, Igwe SE, Umunnah JO, Uchenwoke CI, Ezugwu UA. Effects of Isometric Strengthening Exercises on Pain and Disability Among Patients With Knee Osteoarthritis. Cureus. 2021;13(10):14-9. https://doi.org/10.7759/cureus.18972
25. Liu CT, Wu BY, Chen YH, Tsai MY. Pain Experiences and Coping Strategies in Rural Older Adults With Chronic Musculoskeletal Pain in Mountainous Areas of Taiwan. Pain Management Nursing. 2021 Nov 16;23(4):524–31. https://doi.org/10.1016/j.pmn.2021.08.010
26. Johnson AJ, Palit S, Terry EL, Thompson OJ, Powell-Roach K, Dyal BW, et al. Managing osteoarthritis pain with smart technology: A narrative review. Rheumatol Adv Pract. 2021 May 29;5(1):rkab021. https://doi.org/10.1093/rap/rkab021
27. Khairurizal K. Perbandingan Pengaruh Kombinasi Latihan Hold Relax Dan Open Kinetic Chain Dengan Latihan Hold Relax Dan Close Kinetic Chain Terhadap Peningkatan Kemampuan Fungsional Pasien Osteoartritis Knee. Nusantara Medical Science Journal. 2019;4(2):55. https://doi.org/10.20956/nmsj.v4i2.6564