Pakistan Journal of Rehabilitation

OPEN ACCESS

ORIGINAL ARTICLE **Volume 11(Issue 2), 2022 | Page No.53-61**

EFFECTIVENESS OF HIGH RESISTANCE VERSUS LOW RESISTANCE EXERCISES ALONG WITH STRETCHING EXERCISES IN KNEE OSTEOARTHRITIS

Sajida Dilawar[1], Amna Yaseen[2*], Sumaira Riffat[3], Shazia Abdul Hamid Khalfe[4]

[1]Assistant Professor Physiotherapy Jinnah Sindh Medical University, Karachi, Pakistan

[2*]Lecturer, Baqai Institute of Physical Therapy Rehabilitation Medicine Baqai Medical University, Karachi, Pakistan

[3]Lecturer, Department of Physiology Sindh Medical College Jinnah Sindh Medical University, Karachi, Pakistan

[4]Vice Principal/Assistant Professor, Isra University of Rehabilitation Sciences Isra University, Karachi, Pakistan

ABSTRACT

Background and aim: With the advancing of age knee osteoarthritis has become the common musculoskeletal condition among males and females, various treatment strategies have been applied to improve the patient symptoms therefore the aim of this study is to compare the effectiveness of low resistance versus high resistance exercises along with stretching exercises on pain, physical function, & walking time in knee osteoarthritis.

Methodology: Considering the pre-assessment inclusion criteria, a total no of 170 participants were enrolled in the study and divided into 5 groups by random apportion. Group A received a high resistance exercise, group B received low resistance exercises, group C high resistance exercises and stretching exercises, group D low resistance exercises and stretching exercises and group E received only stretching exercises for 3 weeks. After that pain, function, and walking time were reassessed.

Study design: Experimental study, randomized control trial.

Results: The intergroup results were significant with a p-value of <0.001. We assumed that all 5 groups' interventions in the current study show a clinically meaningful reduction in pain and enhanced the level of functional activities. Effects of various exercise training are the same in all groups. Therefore, no significant difference has been noted.

Conclusion: All 5 groups' high resistance exercise along with stretching, low resistance exercise along with stretching, high resistance exercise, low resistance exercise, and stretching exercise reduced pain and improved functional activity in patients with knee osteoarthritis.

Keywords: *Gait, quads drill, biomechanics, isometric exercise, cryotherapy, rheumatic disorder.*

Introduction

The knee joint is the complex and biggest weight-bearing joint in the human body; it's a synovial joint of a hinge variety, which allows two movements that are flexion and extension with the help of a supportive group of muscles known as hamstring and quadriceps. The joint is formed by the femur and tibia. Anteriorly a patella is present

*Lecturer, Baqai Institute of Physical Therapy Rehabilitation Medicine Baqai Medical University, Karachi, Pakistan

Email: amna_yaseen2011@yahoo.com

Citation: Dilawar S, Yaseen A, Riffat S, Khalfe SAH. EFFECTIVENESS OF HIGH RESISTANCE VERSUS LOW RESISTANCE EXERCISES ALONG WITH STRETCHING EXERCISES IN KNEE OSTEOARTHRITIS. Pakistan Journal of Rehabilitation. 2022 July 7;11(2):53–61. Available from: https://doi.org/10.36283/pjr.zu.11.2/009

Received: Wed, Sept 8, 2021 **Accepted:** Thurs, April 28, 2022 **Published:** Thurs, July 7, 2022

which glides over the patellar surface of femur and forms a gliding joint. The stability of the joint depends upon ligament attachment. The menisci (fibrocartilage structures) present around the knee joint act as shock absorbers, whereas the presence of fluid-filled sacs called bursa helps in movement[1].

With advancing age, the knee joint undergoes irreversible degenerative changes. The most common musculoskeletal condition affecting the knee joint is osteoarthritis (OA), in which many of the structures are involved but hyaline cartilage gets affected the most[2]. The weakness of the Quadriceps femoris muscle considers the consequence of knee pain and functional disability[3].

Globally, osteoarthritis is declared as the 4th leading cause of mobility impairment and non-fatal burden of disease of Year lives with disability (YLDs). The data estimated the prevalence of the KOA (knee osteoarthritis) 1,770 in males and 2,693 in females. It summarized that OA affects females more as compared to males[4].

Worldwide the prevalence of KOA found in the USA is 42.1% in women and 31.2% in men, 28% in Pakistani urban areas and 25% in rural areas, 5.8% in rural regions of India and approximately 28% in urban regions, while 7.5% Bangladeshi rural areas, 9.2% in urban slum and 10.6% in urban affluent communities respectively. Whereas it was found that KOA is 7.5% prevalent in Chinese people, 7% in the Australian population and 41.9% prevalent in the Iranian population[4].

The classification of KOA is either primary (idiopathic) or secondary but diagnosed mainly based on symptoms. It includes joint pain, limitation of movement, difficulty in initiating movement, crepitus, joint effusion pain and mobility disability[5]. These are the most common perturbing factors. However, other risk factors include older age, female gender, obesity, vitamin D deficiency or calcium insufficiency, osteoporosis, profession-related problems, sporting activities, earlier trauma, less muscular strength or dysfunction, proprioceptive insufficiency, smoking, enzymes level and hereditary factors[6].

The management approach of OA is either conservative or surgical. The non-invasive management includes NSAIDs or pain killers whereas the rehabilitative management includes panoptic innovation which consists of conventional therapy, dry needling, intraarticular injections, and exercises [7]. Evidence of the different research shown that knee OA gains beneficial effects from rehabilitation exercises than non-exercises[8]. The frequently prescribed rehabilitative strategy for weak muscles across the world for lower limb osteoarthritis (OA) is strengthening exercises, which improve the muscles activities by reducing pain and disability[9,10]. But the recommendation of exercises is still a great concern as there is limited data on strengthening exercises, thus selection of specific exercises needs more valid data and research with the evidence-based practice and by the expertise opinions.

Therefore, this study has been conducted to find out the effectiveness of high resistance (HR) versus low resistance (LR) exercises along with stretching exercises in KOA among Pakistani KOA patients, to find out the effectiveness of the various exercises' regimens.

Methodology

This study has been conducted from Aug 2018- Aug 2021; a sample size of 170 was calculated by using Open EPI calculator version 3.0. All the participants enrolled in the study were explained about KOA, weight reduction strategies, behavioral adaptation to gain better functional outcomes and taught about discomfort and pain management.

Confidential and informed consent has been taken; by simple randomized sampling technique participants were allocated into 5 groups, each group includes 34 participants. An orthopedic surgeon made the diagnosis of KOA based on clinical and radiological classification (ACR) criteria. Both male and female gender, who were aged between 45-60 years old presented with mild to moderate KOA (according to Kellgren and Lawrence classification), knee pain (according to American College of Rheumatology criteria) and had quadriceps & hamstring muscles strength of grade 3 or more (according to manual muscle testing -MMT) were enrolled in the study. Participants who were osteoporotic or had a history of recent lower limb fractures, surgery, involve in any kind of knee rehabilitation program from the past 3 months and on any pain killers/ steroids/ NSAIDs were excluded from this study.

To obtain the difference between HRX and LRX along with stretching exercises the Group A would be treated with HRX along with stretching exercises. Group B was treated with LRX along with stretching exercises. Group C treated only with HRX. Group D was treated with LRX. Group E was treated only with stretching exercises. To observe accurate effects on participants, we asked them to quit any other workouts, exercise, or therapies.

Pre and post assessment were made on a self-designed questionnaire which consists of 2 parts, part A includes demographics measurement of height and weight, whereas part B composed of assessment of walk time (to find out the problem during walking on different surfaces (I. Level ground, ii. Stairs, iii, Figure eight patterns, IV. Spongy surface) and The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) to assess pain and physical function sub score.

In the initial 3 days range of motion exercises, knee strengthening exercises, cryotherapy or TENS was applied according to the patient's condition. After that treatment protocol was applied which includes flexion, extension, static Quads, leg press, Quads drill, static stretching exercises of hams, quads and calf muscles and theraband exercises according to patients group respectively. The high and low resistances were given according to the muscular strength and severity of pain. The resistance was set as 90 kg and 50 kg 1RM for HRX and LRX respectively[3]. For RX resistance was provided by different colors therabands.

Figure 01: Theraband for stretching

All participants received 30 mints treatment session which comprises 10 minutes warm-up on a stationary bike (Enraf-Nonius), 3 sets of therapeutic exercises and cryotherapy for 10 minutes at the knee. Each set comprised 10 repetitions with a 10 second hold, after the

completion of 1 set pt. rested for 1 min and between right and left leg 5 minutes rest interval was set. After 3 weeks of reassessment, the results were observed and concluded.
Data were analyzed by using a parametric test, paired t-test, Chi-square, and ANOVA on SPSS version 23.0.

Results

There was a significant difference among the demographic's variables of all 5 groups.
The frequencies of females were 104 and males were 66 out of 170 participants. The mean percentage of female participants is highest i: e (61.2%), whereas the overall mean age of participants is 52 ± 5.7, the mean height is 65 ± 4.07, mean weight is 66.3 ± 11.3 and mean onset of KOA duration is 6.55 ± 4.6. On X-Ray, the highest frequency of grade I KOA is found which is about 44.5%, whereas grade II is about 41.8%, and grade III is 14.1%.

Groups	Gender N (%)		Knee N (%)			X-ray Grade N (%)		
	Male	Female	Right	Left	Both Knee	I	II	III
A-High resistance along with stretching exercise	11(32.4)	23(67.6)	18(52.9)	10(29.4)	6(17.6)	11(32.4)	16(47.1)	7(20.6)
B-Low resistance along with stretching exercise	14(41.2)	20(58.8)	16(47.1)	9(26.5)	9(26.5)	14(41.2)	15(44.1)	5(14.7)
C-High resistance exercise	13(38.2)	21(61.8)	19(55.9)	13(38.2)	2(5.9)	12(35.3)	16(47.1)	6(17.6)
D-Low resistance exercise	12(35.3)	22(64.7)	20(58.8)	7(20.6)	7(20.6)	19(55.9)	12(35.3)	3(8.8)
E-Stretching exercise	16(47.1)	18(52.9)	20(58.8)	10(29.4)	4(11.8)	19(55.9)	12(35.3)	3(8.8)
Total	66(38.8)	104(61.2)	93(54.7)	49(28.8)	28(16.5)	75(44.1)	71(41.8)	24(14.1)

**Chi-square test% in rows*

Table 01: Comparison between variables of age, height, weight, KOA onset, knee involvement and X-Ray grades with exercise groups.

In comparison between variables of age, height, weight and KOA onset duration with exercise groups of HRX with stretching, LRX with stretching, HRX, LRX and stretching. The mean age is highest in HRX with stretching which is 53.8 ± 5.64, p-value 0.149, whereas the highest mean height among participants in different groups is more in a stretching group which is 66.5 ± 11.96, p-value 0.081, the highest mean weight 70.3 ± 11.12, p-value 0.021 and the highest mean of onset of KOA duration is 7.29 ± 5.07, p-value 0.591 is again highest in the stretching group.

In the comparison of knee involvement, according to chi-square test, involvement of right (Rt) knee is more than left (Lt) and both knees, which is N=18(52.9%) in HRX along with stretching exercise, N=16(47.1%) in LRX along with stretching exercise, N=19(55.9%) in HRX, N=20(58.8%) in LRX, N=20(58.8%) in stretching exercise. So, the Rt knee N=93(54.7%) involves which is highest than left N=49(28.8%) and both 28(16.5%) therefore p-value 0.460.

In the comparison of X-Ray grades, grade I N=75(44.1%) is more than other grades, grade II has N=71(41.8%), grade III has N=24(14.1%). In HRX along with stretching the percentage and frequency of grade II is more N=16(47.1%) than grade I N=11(32.4%) and grade III N=7(20.6%), whereas, in LRX along.
With stretching, grade II is more, which is N=15(44.1%) than I N=14(41.2%) and grade III N=5(14.7%). In the HRX group grade ll is again more N=16(47.1%) than l N=12(35.3%)

and grade lll N=6(17.6%). But in the LRX group grade l is more N=19(55.9%) than grade ll N=12(35.3%) and grade lll N=3(8.8%) and in a stretching group the percentage of grade l is high N=19(55.9%) than grade ll N=12(35.3%) and grade lll N=3(8.8%), hence p-value 0.462.

The comparison of pre- and post-assessment WOMAC subscale score and walking time in different groups is presented below in the tabular form.

		Pre-Assessment Walk Time			Post Assessment Walk Time		
		Mean	**SD**	**p-value**	**Mean**	**SD**	**p-value**
Level	**A-High resistance along with stretching exercise**	7.21	1.82	0.477	8.06	1.46	0.398
	B-Low resistance along with stretching exercise	6.97	1.47		7.91	1.11	
	C-High resistance exercise	7.53	1.9		7.94	1.46	
	D-Low resistance exercise	7.06	1.3		7.97	1.09	
	E-Stretching exercise	7.50	1.29		8.44	1.11	
Stairs	**A-High resistance along with stretching exercise**	5.03	2.22	0.371	6.26	2.14	0.112
	B-Low resistance along with stretching exercise	5.18	1.85		6.65	1.5	
	C-High resistance exercise	4.85	1.74		6.00	1.84	
	D-Low resistance exercise	4.82	2.05		6.26	1.66	
	E-Stretching exercise	5.68	1.84		7.06	1.5	
Figure eight patterns	**A-High resistance along with stretching exercise**	6.12	1.75	0.118	7.53	1.64	0.068
	B-Low resistance along with stretching exercise	6.56	1.42		7.53	1.13	
	C-High resistance exercise	5.97	1.40		7.21	1.53	
	D-Low resistance exercise	6.79	1.37		7.94	1.07	
	E-Stretching exercise	6.65	1.6		8.06	1.28	
Spongy surface	**A-High resistance along with stretching exercise**	6.41	1.62	0.573	7.47	1.64	0.143
	B-Low resistance along with stretching exercise	6.50	1.48		7.56	1.08	
	C-High resistance exercise	6.35	1.15		7.50	1.24	
	D-Low resistance exercise	6.74	1.33		7.85	1.21	
	E-Stretching exercise	6.82	1.38		8.15	1.16	

**One Way ANOVA test*

Table 02: Comparison of pre and Post Assessment Walking Time in Different Groups

	Comparison of Pre and Post-Assessment WOMAC Score in Between Groups						Comparison of Pre- and Post-Assessment WOMAC Score in Within Groups			
	Pre-Assessment			Post Assessment			Comparison of Pre-Assessment WOMAC Score in Within Groups		Comparison of Post Assessment WOMAC Score in Within Groups	
WOMAC Score	**Mean**	**SD**	**p-value**	**Mean**	**SD**	**p-value**	**groups**	**p-value**	**groups**	**p-value**
A-High resistance along with stretching exercise	49.7	18.5	0.199	39.8	17.7	0.065	**A versus B**	> 0.05	**A versus B**	> 0.05
							A versus C	> 0.05	**A versus C**	> 0.05
B-Low resistance along with stretching exercise	45.9	12.4		39.2	10.2		**A versus D**	> 0.05	**A versus D**	> 0.05
							A versus E	> 0.05	**A versus E**	> 0.05
C-High resistance exercise	48.5	12.4		38.9	13.4		**B versus C**	> 0.05	**B versus C**	> 0.05
							B versus D	> 0.05	**B versus D**	> 0.05
D-Low resistance exercise	44.3	15.5		36.0	13.8		**B versus E**	> 0.05	**B versus E**	> 0.05
							C versus D	> 0.05	**C versus D**	> 0.05
E-Stretching exercise	42.1	13.1		31.3	11.9		**C versus E**	> 0.05	**C versus E**	> 0.05
							D versus E	> 0.05	**D versus E**	> 0.05

**One way ANOVA, Post Hoc Tukey HSD*

Table 03: Comparison of Pre and Post-Assessment WOMAC Score in different groups and in between Groups

Discussion

Evident literature is present on the effectiveness of exercises on KOA[5]. Therapeutic exercises have greater benefits in KOA but regimen and the selection of specific exercise matters[11]. NejatiParisa. et al worked on the different non-pharmacological modalities, self-management techniques, strengthening & water-based exercises, and their effects. His observations concluded that strengthening exercise reduces the risk of rising KOA[12]. Another research data revealed that the effects of exercise therapy on KOA, in the study showed that regular KOA exercises provide a significant effect in relieving pain and advance knee functions[13].

The mean age of the study participant was 52 (St. 5.7) & the p-value=0.149 which was not significant because all participants had a different age between 45-60 years old. On the other hand, a p-value of gender is 0.766 which is also insignificant. The study reveals that the male population is less affected by KOA than females. Iqbal, N.M conducted an observational study to find out the frequency and associated factors of KOA in tertiary care hospital, the average age of affected participants were ≥55 years old, more overly females were also affected the most in their study [6]. Therefore, this can be concluded that the mean age of occurrence KOA ≥45 years old and the disease is more common in the female population. KOA can limit the range of motion by causing severe pain, a researcher applied resisted exercises on KOA and remarked that RX not only plays a vital role in pain despite that it also gives psychological support to the patient[14].

Results of research, clinical effects of HRX and LRX training for patients with KOA had shown a great impact on the patient with the age of more than 50 yrs. Participants were allocated into 3 groups, on which group 1 performed LRX, group 2 performed HRX with max reps and group 3 was a control group. The intensity of pain, functional activities and walking time were observed. The observer noticed decreases in the intensity of pain more in group 1 but no significant difference was observed in overall condition[3].

Therefore, in this study, significant results were found in group C and group D but no comparison could be made due insufficiency of literature. Another systematic review was done by Lange AK. et al to explore the efficacy of strength training for the treatment of KOA. Results demonstrated that RX not only improves muscular strength and the level of physical activities but also reduces the pain[15]. Whereas Afonso, J et.al obscure that in order

to get the optimal increase in ROM stretching and strengthening exercises some mechanical loading exercises also be prescribed to the patient[16].

The research done by Latham N et.al concluded even in old age-progressive RX have tremendous, it improves pain intensity and performance ADLS as compared to elderly aged KOA pts, accounting that Garishma et. Al mentioned in knee OA pts,low RX are more effective than the high RX[17,18].

Furthermore, in another study acute RX was performed in KOA pts. Results revealed that irrespective of age there is decreased in pain but not in the level of tolerance[19]. However, progressive eccentric or concentric RX training for KOA concludes that level of ADLS and strength of the lower limb can enhance by eccentric and concentric modes of RX[20]. Progressive RX with eccentric loading for the management of KOA summarized that the patient shows development in muscle power, enhancement in ADLS level and decrease in pain after 12 weeks of eccentric strengthening exercise training[21].

Similarly, in our research when comparison has been made between the treatments of the participants who performed HRX or LRX substantial results were observed. Clark DI et. al establishes a result that proprioceptive muscle stretching and strengthening traits of exercise is the efficacious schema for KOA, which permit patients to release from physiotherapy[22]. Likewise, in our study participants who only performed stretching exercises for the treatment of KOA also mentioned the effectiveness of treatment. Walking is an essential functional activity of daily life. A RX was given to participants and walking time was noted before and after treatment. It was observed that walking time is improved in all groups[3]. Similarly, when in our study after training walking time was observed on different terrains p-value found to be significant, therefore it concludes that training sessions not only improves pain but also improve neuromuscular control of lower extremity.

After nine months 'Follow up a study showed the beneficial effects of exercise debilitated over a period and finally vanish[23,24]. Consequently, in this research effectiveness of all groups treatments was significant but inter groups comparison doesn't reveal any marked improvement and efficacy of treatment. Perhaps results couldn't be summarized as the treatment was only given for 3 weeks and no follow-ups were taken after that. Therefore, it is important to focus on the targeted muscles, type of exercises and the choice of exercise in the pain management and increase of KOA[25].

Conclusion

All 5 groups' HRX along with stretching, LRX along with stretching, HRX, LRX and stretching exercises WOMAC scores were improved and no significant difference detected among the treatment of various groups. Might be better results could be observed if the treatment protocol followed longer for a month or 2.

AUTHORS' CONTRIBUTION:
The following authors have made substantial contributions to the manuscript as under:
Conception or Design: Sajida Dilawar, Amna Yaseen, Sumaira Riffat, Shazia Abdul Hamid Khalfe
Acquisition, Analysis or Interpretation of Data: Sajida Dilawar, Amna Yaseen, Sumaira Riffat, Shazia Abdul Hamid Khalfe
Manuscript Writing & Approval: Sajida Dilawar, Amna Yaseen, Sumaira Riffat, Shazia Abdul Hamid Khalfe
All authors acknowledge their accountability for all facets of the research, ensuring that any concerns regarding the accuracy or integrity of the work are duly investigated and resolved.

ACKNOWLEDGEMENTS: I acknowledge all participants.

INFORMED CONSENT: Assuring confidentiality and informed consent has been taken for publishing the data regarding their cases

CONFLICT OF INTEREST: Authors declared no conflict of interest.

FUNDING STATEMENTS: None declared

ETHICS STATEMENTS: Ethical approval was obtained by the Institutional Review Board of Isra institute of rehabilitation sciences, Isra University, Karachi campus.

References

1. Józsa LG. Human tendons: anatomy, physiology and pathology. Human kinetics. 1997.
2. Jenkins G, Tortora GJ. Anatomy and physiology. Wiley-Blackwell; 2011
3. Mei-Hwa Jan, PT, MS. Investigation of Clinical Effects of High- and Low-Resistance Training for Patients with Knee Osteoarthritis: A Randomized Controlled Trial. PTJ . 2008;88(4): 427-436.
4. Zakir A, Ahmed SI, Aziz S. Effectiveness of manual therapy versus exercise therapy for the management of knee osteoarthritis in Karachi Pakistan. Int J Physiother. 2016;3(1): 86-93.
5. Anna L, Mark E. Epidemiology and Burden of Osteoarthritis. Br Med Bull. 2013;105(1): 185-199.
6. Muhammad NI, Haidri FR. Frequency of factors associated with knee osteoarthritis. J Pak Med Assoc. 2011;61(8): 786-789.
7. The AAOS clinical practice guideline, “Treatment of Osteoarthritis of the Knee” 2nd edition.
8. Brown GA. AAOS clinical practice guideline: treatment of osteoarthritis of the knee: evidence-based guideline, 2nd edition. J Am Acad Orthop Surg. 2013 Sep;21(9):577-9. doi: 10.5435/JAAOS-21-09-577. PMID: 23996989.
9. Alshami AM. Knee osteoarthritis related pain: a narrative review of diagnosis and treatment. Int J Health Sci. 2014;8(1):85-104.
10. Iwamoto J, Sato Y, Takeda T, Matsumoto H. Effectiveness of exercise for osteoarthritis of the knee: A review of the literature. World J Orthop. 2011;2(5):37-42.
11. Michael JW, Schlüter-Brust KU, Eysel P. The epidemiology, etiology, diagnosis, and treatment of osteoarthritis of the knee. DtschArztebl Int. 2010;107(9):152-162.
12. Goh, SL., Persson, M.S.M., Stocks, J. et al. Relative Efficacy of Different Exercises for Pain, Function, Performance and Quality of Life in Knee and Hip Osteoarthritis: Systematic Review and Network Meta-Analysis. Sports Med 49, 743–761 (2019).
13. Nejati P, Farzinmehr A, Moradi LM. The effects of exercise therapy on knee OA: a randomized clinical trial. Med J Islam Repub Iran. 2015;29:186.
14. Iwamoto J, Sato Y, Takeda T, Matsumoto H. Effectiveness of exercise for osteoarthritis of the knee: A review of the literature. World J Orthop. 2011;2(5):37-42.
15. Vincent KR, Vincent HK. Resistance exercise for knee osteoarthritis. PM&R. 2012;4(5):45-52.
16. C, Lefèvre-Colau. M.M, et.al, Rehabilitation (exercise and strength training) and osteoarthritis: A critical narrative review, Annals of Physical and Rehabilitation Medicine,59(3);2016:190-195
17. Afonso, J.; Ramirez-Campillo, R.; Moscão, J.; Rocha, T.; Zacca, R.; Martins, A.; Milheiro, A.A.; Ferreira, J.; Sarmento, H.; Clemente, F.M. Strength Training versus Stretching for Improving Range of Motion: A Systematic Review and Meta-Analysis. Healthcare 2021, 9, 427.
18. Latham N, Liu CJ. Strength training older adults: the benefits for osteoarthritis. ClinGeriatr Med. 2010;26(3):445-59.

19. Gajwani HG, Borkar P. High resistance verses low resistance training on pain in patients with knee osteoarthritis. Int J Health Sci Res. 2017; 7(12):91-98.
20. Burrows NJ, Booth J, Sturnieks DL, Barry BK. Acute resistance exercise and pressure pain sensitivity in knee osteoarthritis: A randomised crossover trial. Osteoarthritis Cartilage. 2014;22(3):407-14.
21. Vincent KR, Montero C, Vincent HK. Progressive enhanced eccentric or concentric resistance exercise training for knee osteoarthritis. Osteoarthritis Research Society International (OARSI). 2013 World Congress on Osteoarthritis, April 18-21, 2013 Osteoarthritis Cartilage, 21:S275.
22. Hernandez HJ, McIntosh V, Leland A, Harris-Love MO. Progressive resistance exercise with eccentric loading for the management of knee osteoarthritis. Front Med (Lausanne). 2015;2:45.
23. McClinton, S. M., Cobian, D. G., & Heiderscheit, B. C. Physical Therapist Management of Anterior Knee Pain. Curr Rev Musculoskelet Med. 2020;13(6):776-787.
24. Krauss, I., Mueller, G., Haupt, G. et al. Effectiveness and efficiency of an 11-week exercise intervention for patients with hip or knee osteoarthritis: a protocol for a controlled study in the context of health services research. BMC Public Health 16, 367 (2016).
25. Thompson AR, Christopherson Z, Marshall LM, Carlson HL, Carlson NL. A pilot randomized controlled trial for aerobic and strengthening exercises on physical function and pain for hip osteoarthritis. Pm&r. 2020 Mar;12(3):229-37.
26. Lai Z, Zhang Y, Lee S, Wang L. Effects of strength exercise on the knee and ankle proprioception of individuals with knee osteoarthritis. Res Sports Med. 2018 Apr-Jun;26(2):138-146. doi: 10.1080/15438627.2018.1431541. Epub 2018 Jan 24. PMID: 29366340.