

Effectiveness of Quadriceps Exercises on Knee Pain and Muscle Strength among Elderly People in Egypt

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Abstract:

Background: Knee pain is a common complaint in older adults. Exercise is now consistently recommended in improving Quadriceps muscle. **Aim:** To investigate the effect of quadriceps exercises on knee pain and muscle strength among elderly people. **Method:** Experimental research design was used. This study was implemented at the elderly Clubs in Assiut Governorate. The studied sample involved 150 elderly (75 study, 75 control) who selected by simple random sample technique. An interview questionnaire was used which included their socio-demographic characteristics, measurement of quadriceps muscle strength and Knee injury and osteoarthritis outcome score scale which contained 5 separately scored subscales (pain, symptoms and stiffness, function in daily living, function in sport and recreation, and knee-related quality of life). **Results:** There were significant relationship between KOOS Sub-domains in pre and post-test among elderly people (study group) (P. value= 0.046, 0.014, 0.004, 0.010) except in sport/Rec domain (P. value= 0.354) and in quadric muscle strength measurement (P value= 0.001). **Conclusion:** Quadriceps exercises are effective in the decreasing pain, improvement of function and quality of life for elderly patients with knee joint pain. Therapeutic exercise should be used to relieve pain, stiffness and improvement of physical function for elderly patient.

Key words: Elderly, Knee Pain, Muscle Strength, Quadriceps Exercises

Introduction:

As age increases the capabilities of the organ system also changes at every stage of life span. Aging is a natural process and should be regarded as a normal, inevitable biological phenomenon. Keeping oneself healthy and active with aging is one of the most important aspects of life (Kaur and Kohli, 2016). With the pros of increased life expectancy come the burdens of a greater likelihood of joint problems. Half of all older adults self-reported knee pain and which mainly caused by Knee osteoarthritis (Peterson et al, 2019).

The prevalence of osteoarthritis in people aged 65 and above is reported to be between 60 and 90%; about 10% of men and 18% of women over 60 have knee osteoarthritis (Jamali et al, 2020). The incidence increases steadily with age. Furthermore, the severity of the pain increases with age and a greater percentage has pain associated with disability. Women are more vulnerable than men to have conditions that cause joint pain owing to

hormonal fluctuations (Kaur and Kohli, 2016). Obesity and a sedentary lifestyle contribute to the incidence and prevalence of painful knee and hip conditions (Peterson et al, 2019).

Elderly people with chronic knee pain have reduced physical activity, quadriceps strength, and difficulty voluntarily activating the quadriceps compared to pain-free individuals. Correct biomechanics must be achieved through a rehabilitation program that focuses on restoring flexibility to tight muscles (commonly calves, hamstrings, and quadriceps). Strengthening exercise is the cornerstone of conservative treatment for knee pain (Brenneman et al., 2016).

Exercise is now consistently recommended in national and international clinical guidelines as a core treatment. Exercise adherence improves long-term patient outcomes for patients with knee pain, because it strengthens leg muscles, supports the knee, and absorbs shock before it gets to the knee. Exercising the quadriceps muscles increase

circulation in the knee joint and has been shown to stimulate beneficial biochemical changes in the joint fluid of the knee, improving its lubricating properties. Exercise also improves the range of motion of the knee. Gerontological and community health nurses are responsible to empower the patient and family with teaching knowledge and skills necessary to reach optimal safe performance to manage pain and disability. (Mohsen et al., 2021 and Wood et al., 2016).

Significance of the study:

Knee joint pain is a very common condition and frequent problem presenting to the general population. Knee pain affects an estimated 25 % of adults aged over 55 years (Wood et al., 2016). And in Egypt, knee joint pain common and their mean age was 57.30 ± 6.37 (50–75) years (Abdelaleem & Rizk, (2018).

Information stressed that there is no cure for osteoarthritis; therapeutic exercise can help to reduce joint pain and improve flexibility and mobility of joints.

Aim of the study

To assess the effectiveness of quadriceps exercises program on knee joints pain and muscle strength among elderly people attending elderly clubs in Assiut Governorate.

Null hypothesis H0:

The quadriceps exercises program was not effective in improving knee joints pain and enhance muscle strength among elderly people attending elderly clubs.

Hypothesis H1:

The quadriceps exercises program was effective in improving knee joints pain and enhance muscle strength among elderly people attending elderly clubs.

Subjects and Method

Research Design:

Quasi experimental research design was used in the current study.

Setting:

The study was conducted in two geriatric clubs in Assiut city (Geriatric club in Legitimacy Assembly and Geriatric club of Islamic Cultural Center) which had a higher flow rate of elderly.

Sample:

Simple random sample technique was used to assess the knee joint pain experienced

by all elderly in the clubs (150). Older adults are divided into two groups (study and control) equally. Pre-test was done to all the studied elderly which included the assessment of knee joint pain and the measurement of quadriceps muscle strength. A study group received a quadriceps exercises program. Reassessment of knee joint pain and the measurement of quadriceps muscle strength was done to all elderly who participated in the study after one month.

Tools of the study:

Part I: A structured interview questionnaire was used which included personal data as age, sex, marital status, education, occupation, residence, and Body Mass Index (BMI).

Part II included two tools:

Tool I: Knee injury and osteoarthritis outcome score (KOOS): The KOOS evaluates both short-term and long-term magnitudes of the knee injury which was developed by **Roos & Lohmander, 2003**. The KOOS is a knee-specific instrument, developed to assess the patients' knee and associated problems.

It holds 42 items in 5 separately scored subscales which included:

1.**Pain:** It contained 9 items (P1: P9) and used to assess the knee pain during the following activities (twisting/ pivoting on the knee, straightening knee fully, bending knee fully, walking on a flat surface, going up or downstairs, at night while in bed, sitting or lying and standing upright).

2.**Symptoms:** it contained 7 items (S1: S7) and used to assess the joint stiffness after first awakening in the morning and after static position and knee symptoms including; grinding, hanging up, swelling, straightening, and bending knee fully.

3.**Function, daily living:** It included 17 items (A1: A17) and used to assess the degree of difficulty during the following activities (descending and ascending stairs, rising from sitting, standing, bending to floor/ pick up an object, walking on a flat surface, getting in/ out of care, going shopping, putting on socks, rising from bed, taking off socks, lying in bed (turning over, maintaining knee position) getting in/out of the bath, sitting, getting on / off

the toilet, heavy domestic duties, and light domestic duties.

4. Sports and recreational activities: It contained 5 items (SP1: SP5) and used to assess the degree of difficulty during the following activities (squatting, running, jumping, twisting, on the knee and kneeling)

5. Knee-related Quality of life: It involved 4 items (Q1: Q4) and used to assess the knee-related quality of life.

Scoring system for Knee injury and osteoarthritis outcome score (KOOS)

Each question got from 0 to 4. A normalized score (100 indicated no symptoms and 0 indicated extreme symptoms) which was calculated for each subscale. The normalized score is transformed to meet this standard by using formulas provided for each subscale:

1- KOOS Pain = $100 - \text{mean score (p1- P9)} \times 100/4$

2- KOOS Symptoms = $100 - \text{mean score (S1-S7)} \times 100/4$

3- KOOS ADL= $100 - \text{mean score (A1-A17)} \times 100/4$

4- KOOS SPORT/REC= $100 - \text{mean score (SP1- SP5)} \times 100/4$

5- KOOS QOL = $100 - \text{mean score (Q1- Q4)} \times 100/4$

Reliability of the tool:

It was calculated by test-retest method and calculated by Karl Pearson's co-efficient of correlation. The reliability of the tool was found to be 0.98 and hence the tool was reliable (Collins, et al. 2011).

Tool II Measurement of quadriceps muscle strength: This part was developed for the measurement of the patient's quadriceps muscle strength which was done by using the digital strength measuring device. While, the patient is in sitting position, a belt is attached for measurement of isometric knee extension strength, a sensor pad is attached to the front of the distal lower extremity by rope 35 cm on the other side of the machine with a hard object, the patient is asked to push frontally as he can, and finally the power of pushing was translated by number.

Fig. (1): The digital strength measuring device. Beurer GmbH. Adopted from (<https://www.virtualmarket.ifa-berlin>, 2018).



Pilot Study:

The pilot study was done on 15 elderlies from the total studied sample (10%) to assess the feasibility and the clearness of the questionnaire. Also, the pilot study verified the required time to fill it. The sample included in the pilot study was expelled from the present study based on the changes carried out.

Ethical considerations:

An official letter of approval was obtained from the dean of the faculty of nursing to the directors of geriatric clubs at Assiut city to carry out the study. The letter included permission to carry out the study and explained the purpose and nature of the study.

Procedure:

The present study proceeded using the following phases:

Assessment phase:

- Before meeting the elderly, the researcher met the directors of the geriatric clubs, introduced herself, explain the aim of the study, also introduced the agreement letters of the dean of nursing faculty, asking for the permission to collect the data in the clubs. As well as, selecting the appropriate time to meet with the elderly according to the club time table.

- The assessment was done for the entire studied elderly people (150) (study and control group) who attending elderly clubs at Assiut Governorate, by using tool I (Knee injury and osteoarthritis outcome score (KOOS)) and tool II (Measurement of quadriceps muscle strength). The outcome results of the assessment phase were the base line for studied sample

Application phase:

▪ The researcher met the elderly, introduced herself, and explained the purpose of the study then asked the elderly to participate in the study after assuring the confidentiality of their data.

▪ The data collection phase of this study took 6 months, from May 2020 to the end of October 2020

▪ Quadriceps exercises program was demonstrated manually and by using video material to study group (75 elderly) for 1 session weekly/month.

▪ Quadriceps exercises program was applied through four sessions; each session took about 15-20 min. The Control group was not exposed to the exercise program.

▪ The elderly people instructed to apply quadriceps exercises program in their home for five to ten minutes from 3 to 4 times/ day. Quadriceps exercises program contained stretching and strengthening exercises to quadriceps muscles.

▪ Quadriceps exercises program consisted of type of exercises, duration, and instruction for the application of exercise program. Handout provided to the study group after the application of the program

Phase III: Evaluation phase:

▪ Reassessment done to all the study group after one month of program application, by using tool I (Knee injury and osteoarthritis outcome score (KOOS)) and tool II (Measurement of quadriceps muscle strength)

Statistical analysis:

○ Date entry and data analysis were done using SPSS version 19 (Statistical Package for Social Science).

○ Data were presented as mean and standard deviation. Chi-square and Fisher Exact tests were designed to differentiate between qualitative elements.

○ Mann-Whitney test was used to contrast quantitative elements between two

groups and Kruskal Wallis Test for more than two groups in study of non-parametric data.

○ Wilcoxon Signed Rank Test was done to compare quantitative variables between pre-test and post-test. P-value considered statistically significant when $P < 0.05$.

Results

Table (1) showed that the mean age of studied elderly (study group) was 71.89 ± 5.4 with nearly the same mean age of the control group 70.63 ± 4.44 , 96.0% of the study group are females, and 93.3% from the control group. According to the residence, the majority of the studied elderly (study, control) were living in the urban area (90.7%, 92.0) respectively. Also, table (1) revealed that (73.3%, 80.0%) of studied elderly (study, control) were married, 33.3% were secondary education and (70.7%, 61.3%) of them were housewives respectively.

Figure (1) revealed that the mean scores of the study group in the KOOS sub-domain (symptoms, pain, ADL, sport/Rec, and QoL) were 64.4, 63.4, 60.4, 98.1, and 75.4 compared to 61.6, 62.8, 58.7, 96.7, and 68.1 respectively for the control group.

Table (2) showed that symptoms and pain domain of KOOS in pre-test among study group of elderly were 64.57 ± 18.48 , 63.41 ± 14.93 respectively while in post-test it improved to be 58.52 ± 18.25 , 56.89 ± 17.06 respectively. There was significant relationship between KOOS Sub-domains in pre and post-test among elderly people (study group) (P. value= 0.046*, 0.014*, 0.004*, 0.010*) except in sport/Rec domain (P. value= 0.354)

Table (3) indicated that there was no statistically significant difference in quadric muscle strength measurement in the elderly (study group & control group)

Table (4) showed that there was a statistically significant difference in quadric muscle strength measurement among the elderly (study group) in pre and post quadriceps strengthening exercises (P value= 0.001).

Table (1): Socio-demographic data comparison in studied elderly' studys versus control group at elderly clubs in Assiut University

Socio-demographic data	Study (n=75)		Control (n=75)	
	No.	(%)	No.	(%)
Age group				
60-64	11	14.7	11	14.7
65-69	26	34.7	23	30.7
>70 years	38	50.7	41	54.7
Mean±SD	71.89±5.4		70.63±4.44	
Gender				
Male	3	4.0	5	6.7
Female	72	96.0	70	93.3
BMI Level				
Normal weight	22	29.3	13	17.3
Underweight	2	2.7	1	1.3
Overweight	24	32.0	38	50.7
Obese	27	36.0	23	30.7
Mean±SD	28.22±6.14		28.31±3.99	
Residence				
Urban	68	90.7	69	92.0
Rural	7	9.3	6	8.0
Marital Status				
Single	1	1.3	0	0.0
Married	55	73.3	60	80.0
Widowed/ Divorced	19	25.4	15	20.0
Education Level				
Illiterate	9	12.0	9	12.0
Read and write	17	22.7	14	18.7
Primary education	6	8.0	14	18.7
Preparatory	11	14.7	8	10.7
Secondary	25	33.3	25	33.3
University	7	9.3	5	6.7
Occupation				
Free work	1	1.3	4	5.4
Housewife	53	70.7	46	61.3
Retired	21	28.0	25	33.3

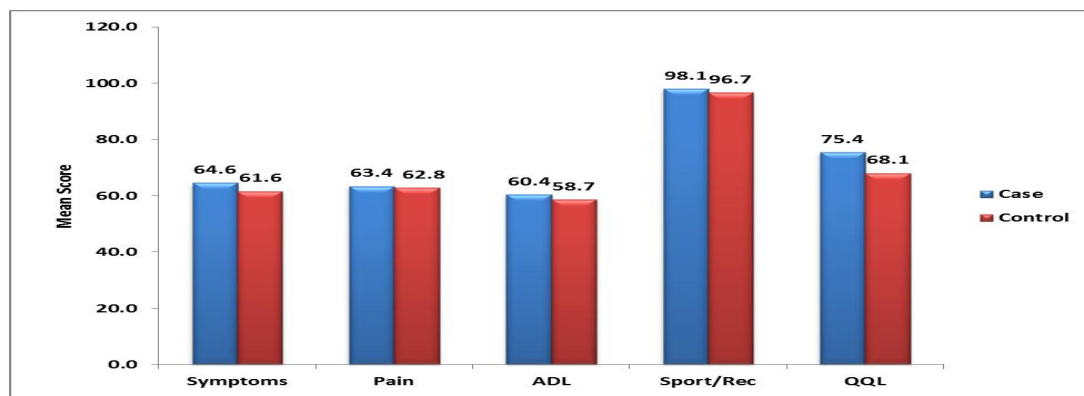
**Figure (1): The mean of Knee injury and osteoarthritis outcome score (KOOS) sub-domain of elderly people' study versus control group in Assiut University**

Table (2): Knee injury and osteoarthritis outcome score (KOOS) Sub-domains in Pre and Post-test among elderly Study group in Assiut University

KOOS Sub-domains	No. items	Max Score	Pre-test Mean \pm SD	Post-test Mean \pm SD	P. value
Symptoms	7	100	64.57 \pm 18.48	58.52 \pm 18.25	0.046*
Pain	9	100	63.41 \pm 14.93	56.89 \pm 17.06	0.014*
ADL	17	100	60.37 \pm 13.41	53.22 \pm 16.15	0.004**
Sport/Rec	5	100	98.07 \pm 4.57	98.67 \pm 3.22	0.354
QQL	4	100	75.42 \pm 25.59	63.75 \pm 29.04	0.010*

Independent T-test *Statistically Significant Difference at P. value <0.05, **Statistically Significant Difference at P. value <0.01

Table (3): Quadric muscle strength measurement in elderly study against the control group in Assiut University

Quadric muscle strength Measurement	Mean \pm SD	P. value
Study (n=75)	5.49 \pm 2.17	0.058
Control(n=75)	6.24 \pm 2.65	

Table (4): Quadric muscle strength measurement in elderly study group in pre and post quadriceps strengthening exercises in Assiut University

Quadric muscle strength Measurement	Study	
	Pre-test	Post-test
Mean \pm SD	5.49 \pm 2.17	7.31 \pm 4.11
P-value	0.001**	

Independent T-test **Statistically Significant Difference at P. value <0.01

Discussion:

Half of all older adults report knee and/or hip pain so; the practitioners should assess joint disorders and recommend exercises for reducing knee and hip pain with patients when appropriate. Exercise adherence strengthens leg muscles, supports the knee, and absorbs shock before it gets to the knee.

The current study showed that the mean age of studied elderly (year) (study group) was 71.89 \pm 5.4 with nearly the same mean age of the control group 70.63 \pm 4.44, the majority of the study & control group are females and married. More than one-third had secondary education, and the mean of BMI 28.22 \pm 6.14 & 28.31 \pm 3.99 respectively.

These findings were consistent with **Chen et al 2019** who studied "the effects of a home-based exercise intervention on elderly patients with knee osteoarthritis" and reported that the majority of the participants were women married and had a junior-high-school education.

Also in the same line **Imoto et al 2012** who conducted a study under the title

"Quadriceps Strengthening Exercises are effective in improving pain, function, and quality of life in patients with osteoarthritis of the Knee" and reported that the majority of the studied participant were female, the mean age of the group (study and group) 58.78 \pm 9.60, 61.50 \pm 6.94 and BMI mean 30.00 \pm 5.05 29.72 \pm 4.11.

The current study agrees with **Shereif & Hassanin, 2011** who compare the uses of therapeutic exercise and heat application on relieve pain, stiffness, and improvement of physical function for a patient with knee osteoarthritis and reported that about two-thirds of the studied group were female and the majority of them were married. While the study disagreed regarding age, occupation and nearly half of the studied group were university education.

According to literature review, it has been shown that women are more severely impacted by knee osteoarthritis. Differences in knee anatomy, kinematics, previous knee injury, and hormonal influences may play a role (**Hame & Alexander, 2013**).

Regarding of KOOS domains, mean score of symptoms, pain and ADL were (64.57±18.48, 63.41±14.93, 60.37±13.41) respectively in pre-application phase. This results disagree with **Abdelaleem & Rizk, (2018)** who studied Health-related quality of life in Egyptian patients with knee osteoarthritis: correlation with performance-related measures and found mean score of symptoms, pain and ADL (39.85±20.75, 35.99±19.24, 36.44±17.27) respectively. From point of view this may be related to the difference of mean age in the sample which was in our study 71.89±5.4 years and in their study was 57.30±6.37 (50–75) years, and knee pain was found to increase according to increasing age **Lee et al (2018)**.

The results of the current study reported that symptoms and pain domain of KOOS in pre-application of quadriceps exercises program among study group of elderly were 64.57±18.48, 63.41±14.93 respectively while after application it improved to be 58.52±18.25, 56.89±17.06 respectively. There was a significant statistical relationship difference between pre and post quadriceps exercises program among the study group of elderly and KOOS Subdomain (P. value= 0.046*, 0.014*, 0.004*, 0.010*) except in sport/Rec domain (P. value= 0.354).

This result agrees with **Shereif & Hassanin, (2011)** who reported that regarding symptoms, pain, stiffness, the activity of the KOOS domain was improved after application of the exercise program. Also, there is a statistically significant difference in the post-program phase regarding experiencing symptoms, pain, stiffness, activity score ($P \leq 0.001$).

Also, it is the same line with **Choudhary & Kishor (2013)** who studied “the effectiveness of Modified Agility and Perturbation Training in Patients with Osteoarthritis Knee- A Case-Control Study” and reported that the studied group who received the conventional knee exercises showed statistically significant results and returning to higher levels of physical activity with less pain and instability following rehabilitation.

Also, the current study agreed with **Imoto et al (2012)** who observed in the exercise group a statistically significant improvement in

pre and post-intervention regarding the functional capacity, pain, and general state of health.

Moreover **Kaur & Kohli, (2016)** who conducted a study under the title "A Quasi-Experimental Study to Assess The Effectiveness of Quadriceps Strengthening Exercises on Knee Joints Pain Among Women in Selected Rural Areas of Ludhiana, Punjab” and reported that there was a highly statistically significant difference between pretest and posttest score of the experimental group ($p \leq 0.001$).

The results of the present study consistent with **Shahnawaz & Ahmad (2014)**, who studied the effect of isometric quadriceps exercise on muscle strength, pain, and function in patients with knee Osteoarthritis: A Randomized Controlled study and reported that there is a positive effect of exercise programs on reduce pain and increase the functional abilities of osteoarthritis patient.

Regarding the measurement of quadriceps muscle strength; the results of the present study illustrated that there was a statistically significant difference between the pre-test and post-test in the study group regarding the measurement of quadriceps muscle strength. The study agrees with **Abd El-Fatah et al (2019)**, who studied the Impact of Nursing Rehabilitation Protocol on Patient's Satisfaction For Tibial Plateau Fracture Surgery, and found that there was a statistically significant difference between the study and control group regarding the measurement of quadriceps muscle strength in the follow-up periods. Our results of the study supported hypothesis H1 which included that the quadriceps exercises program was effective in improving knee joints pain and enhance muscle strength among elderly people attending elderly clubs.

Conclusion

Quadriceps strengthening exercises are effective in decreasing pain degrees and stiffness also; they improved the function and quality of life for elderly patients with knee joint pain. There was a significant relationship between KOOS Sub-domains in pre and post quadriceps strengthening exercises among elderly people and it improved after the application of exercise.

Recommendation:

1. Using of therapeutic exercise as methods of treatment to relieve pain, stiffness, and improvement of physical function for the elderly patient.

2. A simple manual of therapeutic exercises guidelines for elderly patients to decrease the degree of pain and stiffness, improve the quality of life aspects of patients with knee joint pain in all outpatient orthopedic clinics.

3. The effect of the Quadriceps exercises program needs to be explored more fully with a larger sample with knee joint pain.

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Reference

- Abdelaleem E., and Rizk Y., (2018):** Health-related quality of life in Egyptian patients with knee osteoarthritis: correlation with performance-related measures, *Egyptian Rheumatology & Rehabilitation*, 2018, 45:94–99
- Abd El-Fatah M., Abd-El-Lateef Z., Abd EL-Rahim H., & Mohamed H., (2019):** Impact of Nursing Rehabilitation Protocol on Patient's Satisfaction For Tibial Plateau Fracture Surgery, *Assiut Scientific Nursing Journal*, Vol, (7) No, (19) December 2019, pp (100 - 107)
- Beurer G. (2018):** Adopted from <https://www.virtualmarket.ifa-berlin>. Accessed at 12/6/2018 at 6 p.m.
- Brenneman E., Kuntz A., Wiebenga E., and Maly M., (2016):** Does pain relate with activation of quadriceps and hamstrings muscles during strengthening exercise in people with knee osteoarthritis? *Springer Plus* 5:463
- Choudhary N. & Kishor A. (2013):** Effectiveness of Modified Agility and Perturbation Training In Patients with Osteoarthritis Knee- A Case-Control Study *Iranian Rehabilitation Journal*, Vol. 11, No. 17.
- Collins, N., Misra, D., Felson D., Crossley K., and Roos E., (2011):** "Measures of knee function: International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form, Knee Injury and Osteoarthritis Outcome Score (KOOS), *Arthritis care & research* 63 Suppl 11: S208-228.
- Imoto A., Peccin M., and Trevisani V., (2012):** Quadriceps Strengthening Exercises are effective in improving pain, function, and quality of life in patients with osteoarthritis of the Knee, *Acta Ortop Bras.* 2012; 20(3): 174-9 Article received on 10/09/2011, and approved on 12/19/2011.
- Jamali, N., Adib-Hajbaghery, M. & Soleimani, A. (2020):** The effect of *curcumin* ointment on knee pain in older adults with osteoarthritis: a randomized placebo trial. *BMC Complement Med Ther* 20, 305 (2020). <https://doi.org/10.1186/s12906-020-03105-0>
- Kaur K. and Kohli G., (2016):** A Quasi-Experimental Study to Assess The Effectiveness of Quadriceps Strengthening Exercises on Knee Joints Pain Among Women in Selected Rural Areas of Ludhiana, Punjab., *IOSR Journal of Nursing and Health Science (IOSR-JNHS)* e-ISSN: 2320–1959.p- ISSN: 2320–1940 Volume 5, Issue 4 Ver. IV (Jul. - Aug. 2016), PP 75-78 www.iosrjournals.org.
- Lee K., Kang S., Chung C., Park M., Kang D., and Chang C. (2018):** Factors associated with knee pain in 5148 women aged 50 years and older: A population-based study. *PLoS ONE* 13(3): e0192478. <https://doi.org/10.1371/journal.pone.0192478>
- Mohsen M., Sabola N., El-khayat N., and Abd El-Salam E., (2021)"** The Effect of Nursing Intervention on Knowledge and Practice among Elderly with Knee Osteoarthritis, *International Journal of Novel Research in Healthcare and Nursing*, Vol. 8, Issue 1, pp: (716-726), Month: January - April 2021, Available at: www.noveltyjournals.com
- Peterson N. E., Osterloh K.D., and Nichole M., (2019):** Exercises for Older Adults With

Knee and Hip Pain, The Journal for Nurse Practitioners 15 (2019) 263e267

Roos E.M. and Lohmander S., (2003): The knee injury and osteoarthritis outcome score (KOOS): from joint injury health equal life outcome journal Volume.1 page.64.

Shahnawaz N and Ahmad A (2014): Effect of isometric quadriceps exercise on muscle strength, pain, and function in patients with knee Osteoarthritis: A Randomized Controlled Study.

Shereif W. and Hassanin A., (2011): Comparison between Uses of Therapeutic Exercise and Heat Application on Relieve Pain, Stiffness and Improvement of Physical Function for Patient with Knee

Osteoarthritis, Life Science Journal, 2011;8(3) <http://www.lifesciencesite.com>.

Wood L., Blagojevic-Bucknall M., Stynes S., D’Cruz D., Mullis R., Whittle R., Peat G., and Foster N., (2016): Impairment-targeted exercises for older adults with knee pain: a proof-of-principle study (TargET-Knee-Pain), BMC Musculoskeletal Disorders 17:47.

Xini Zhang, Xiaoyu Pan, Liqin Deng and Weijie Fu, (2020): Relationship between Knee Muscle Strength and Fat/Muscle Mass in Elderly Women with Knee Osteoarthritis Based on Dual-Energy X-Ray Absorptiometry, Int. J. Environ. Res. Public Health 2020, 17(2), 573; <https://doi.org/10.3390/ijerph17020573>.