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Expert Opinion Article

Effect of targeted gluteus medius strengthening exercises on Q angle, lower limb alignment, and functional outcomes in female patients with knee osteoarthritis: An experimental study

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ABSTRACT

Background- Osteoarthritis (OA), the most common form of arthritis, is characterized by chronic joint degeneration .Its etiology is multifactorial, and a complex interaction of local and systemic factors lead to its development. OA is considered the main cause of pain and disability in the elderly and is a major cause of reduced life expectancy due to disability

Method and material- A total of 31 subjects was selected on the basis of inclusion and inclusion criteria.

Design of study: Experimental study

Data analysis: Analysis of the data collected was done by SPSS software version 23.00.The result was considered statistically significant at P<0.001The characteristics of the data were presented through tables and graphs. Wilcoxon signed-rank test used for statistical hypothesis testing .

Results- The good outcomes of the exercise outlined here lend credence to the theory that patient with knee OA has shown significant improvement in pain , Q angle and physical activity.

Conclusion- This study examined significant high quality data showing the benefits of gluteus medius training for obese female patients with osteoarthritis in their knee. The good outcomes of the exercise outlined here lend credence to the theory that patient with knee OA has shown significant improvement in pain , Q angle and physical activity.

INTRODUCTION

Osteoarthritis (OA), the most common form of arthritis, is characterized by chronic joint degeneration .Its etiology is multifactorial, and a complex interaction of local and systemic factors lead to its development . OA is considered the main cause of pain and disability in the elderly and is a major cause of reduced life expectancy due to disability[1].OA will continue to become increasingly prevalent as the global population ages . The formulation of guidelines for managing the disease that aim to improve patient functional performance and quality of life is needed[2] .

The knee joint is more often affected in OA, particularly in women. Changes in muscle function are commonly see in patients with knee OA and is considered as both cause and consequence of the disease. The lower limb muscles absorb load and promote dynamic stability of the knee joint, functions that are impaired in OA because of changes in muscle strength and flexibility . Muscle weakness is considered the best predictor of disability in OA, as altered concentric and eccentric quadriceps strength is seen in patients with OA, and is considered to have an important role in disease onset and progression . The length-tension relationship of the hip, thigh, and abdomen can also influence OA, as modification of the static and dynamic alignment of the knee and hip exposes the articular cartilage of the knee to increased focal loads[3] .

Instability of knee joint can change neuromuscular control system of lower limbs followed by abnormal changes in core muscles that control hip joint such as gluteus maximus (Gmax) and gluteus medius (GMed). Gmed malfunction and decreased muscle activity cause adduction and internal rotation in hip joint during weight bearing while walking. Like in the case of VMO weakness, this

increases Q-angle, causes genu valgum and moves patella to lateral side to increase valgus vector[4].

Studies that examine the electrical activity of muscles during locomotion have played a central part in defining the role of muscles in producing and controlling locomotion. Data from Winter and Yack demonstrate the normalized electromyography [EMG] data for sixteen muscle . These data reveal important principles regarding muscle activity during gait. In order to understand the role muscles play during gait it is important to recall that each lower extremity functions in both an open and closed kinetic chain, open through the swing phase and closed through the stance phase. Consequently, a muscle contraction can affect not only the joint crossed by that muscle, but also joints throughout the chain[5]

The gluteus medius contracts just before ground contact and continues its activity through most of stance, until loading begins on the opposite side. The activity of the hip abductors provides essential frontal plane stability to the pelvis throughout stance and adds to hip and knee extension support in mid to late stance [5].

Q angle is the angle formed by drawing a line from anterior superior iliac supine to the centre of patella and a second line drawn from centre of patella to the tibial tubercle. If Q angle is increased it means there is some patellar sublaxation. Biomechanics of the patella femoral joint is largely affected by Q angle. Value of q angle is different for males and females. Normal value of q angle for males is 14.Normal value of Q angle for female is 17.Q angle for females is greater than for males because of femoral anteversion and larger pelvis. Q angle of value greater than 20 degree is considered to be abnormal.[6]

It creates an increased lateral force on the patella and causes pathological changes. A research Inderbir Singh, Jaspal Singh Sandhu, shyamal and at all (1999) was done to find out the association of obesity with OA. All males and females were obese. study concluded that q angle was greater in obese males and females having knee OA as compare to those having normal weight. A new research conducted in 2013 suggested that Obesity and Osteoarthritis plays important role in incidence and progression of knee OA.A study conducted in (2010). In this study Q-angle was assesses through goniometer measurements in obese females with knee OA by fisioter and Pesqui. They concluded a positive but poor correlation between body mass index (BMI) and quadricep angle(Q-angle). They further enlighten relationship of obesity and joint degeneration.[7]

As no disease-modifying treatments exist, total knee replacement or hip replacement is often considered an effective strategy for treating end-stage OA patients[8], Trial sequential analysis and network meta-analysis from Olalekan et al. (Uthman et al., 2013) analyzed 60 trials covering 12 exercise interventions and 8218 patients, which showed that as of 2002 sufficient evidence supported the significant benefits of exercise over no exercise in OA patients. They suggested that an approach combining exercises to increase strength, flexibility, and aerobic capacity might be more effective in the management of lower limb OA. Many clinical trials from other groups have also demonstrated the effectiveness of various physical therapies[9]

A cross-sectional study from Muollo et al. (2022) also found that the knee flexor torque and knee muscle quality decline with ageing and obesity, which emphasized that physiologists should include exercises designed to train both the knee flexor and knee extensor in elderly OA patients with obesity. However, some kinds of physical therapy should not be recommended for elderly OA patients[10]. Park et al. (2022) reported that aerobic exercise could alleviate OA pain and articular cartilage degradation in testosteronedeficient OA rats by improving body metabolism, including decreased fat mass and lipid peroxide. In addition, physical therapy usually has good effects on protecting cartilage and decreasing systematic inflammation[11]. Allen et al. (2021) also reported that a stepped exercise program resulted in better improvements in knee OA symptoms compared with the education-only group in a randomized controlled trial with 345 OA patients[12]. (Bandak et al., 2021) suggested that none of the numerous randomized controlled trials has used adequately designed placebo comparison controls due to the lack of an underlying mechanism of exercise and education programs works on symptoms. Thus, future studies should take contextual factors into account when estimating treatment responses to physical therapy in OA[13].

As mentioned above, OA is the most common joint disease and one of the leading causes of pain and disability worldwide, yet there are no disease-modifying drugs. Physical therapy represented by regular exercise has many advantages when compared with surgery and pharmacological intervention, such as ease of application, few adverse effects and relatively low costs. Therefore, physical therapy has unanimously been recommended as an important treatment strategy for OA by leading international organizations and authorities[14].

METHODOLOGY

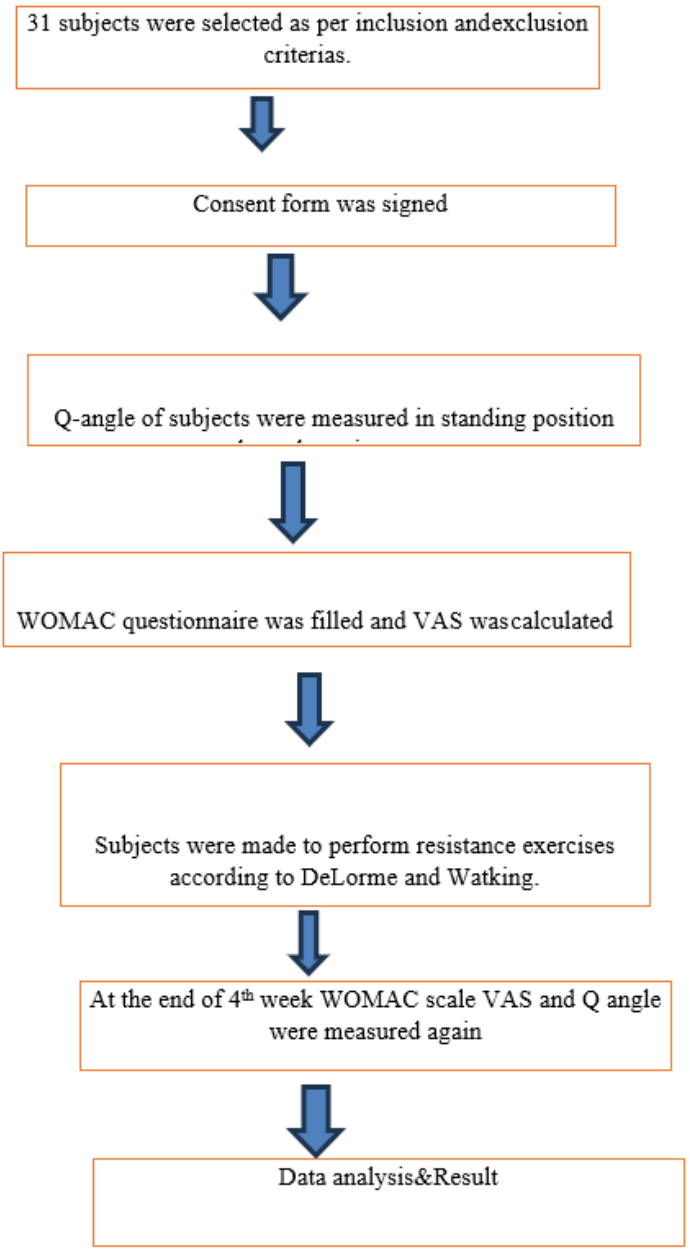
The present study was an experimental study conducted at private physiotherapy centre. A total of 31 subjects were selected based on specific

inclusion and exclusion criteria using a convenient sampling method. The inclusion criteria comprised females aged 50 to 70 years who were obese, diagnosed with knee osteoarthritis, and able to walk without the use of assistive devices. Participants were excluded if they had undergone total knee replacement, experienced recent hospitalization, had a history of soft tissue injury, or engaged in physical activities leading to a fall, dizziness, or fainting within the previous two months. Total knee replacement or recent hospitalisation.

Instrumentation

- Stadiometer
- Step -up
- Weighing Machine
- Weight cuff.
- Goniometer

PROTOCOL



PROCEDURE

All the subjects were recruited depending upon inclusion and exclusion criteria. and Subjects were informed and explained about the aim and procedure of the study and written consent was obtained prior to testing .All the outcome measures were recorded at baseline i.e.at the beginning of the study and after 4th week i.e. after completion of the

study .Q angle were measured in standing position through goniometer .WOMAC questionnaire were taken and VAS scale Taken for physical evaluation and pain respectively .

Wontario and McMaster Universities Osteoarthritis Index (WOMAC): The WOMAC is specific to the assessment of symptoms and physical function in patients with OA of the knee hip . It consists of 24 questions: give regarding pain, two for stiffness, and 17 addressing difficulties performing Western physical functions. It uses a Likert scale with descriptors (none, mild, and moderate, strong, and very strong) corresponding to an ordinal scale of 0 - 4. The higher the score, the worse the pain, stiffness, and functional limitation .

Visual analogue scale (VAS): The VAS assists with measuring pain intensity and is scored 0 - 10, where 0 means no pain and 10 is the worst possible pain . Scores of 1 - 2 represent mild pain, 3 - 7 indicate moderate pain, and 8–10 correspond to severe pain .

Physical evaluation: Body weight in kilograms and height in meters were measured by a scale and a measuring tape and BMI was calculated using the formula -BMI =WEIGHT(kg)/HEIGHT ($m^{2)}$

Ten-repetition maximum (10-RM): According to DeLorme and Watkins a systematic method of applying progressive resistive exercises.

Timed 10-meter test: The timed 10-m test was used to measure walking speed. The patient was instructed to walk at a comfortable speed and avoid the interference of acceleration and deceleration. The time was recorded within the central 10 m, while the initial and ending 2 m were discarded . The test was performed three times and the average was calculated

Physical therapy protocol: The physical therapy protocol consisted of 4 weeks of resistance exercises and muscle stretches to promote muscle strength and reduce pain .

STRENGTHENING DeLorme's was applied on the affected knee .Exercise was performed on each week. The program for each day was repeated as each Set of exercises 1 sets with 2 min rest intervals in between .Exercise were given 5 times a week. Each set was composed of a series of progressive load ; 10 repetitions at 50 percent ; Of the 10 RM,10 repetitions at 75 percent; of the 10 RM, and 10 repetitions at 100 percent ;of the 10 RM. A 5 min warm up exercise were prior to the every training exercise .

EXERCISE	**REGIME**			
	Week 1	Week 2	Week 3	Week 4
Clam shells	10 times with ½ kg	10 times with ¾ kg	10 times with 1kg	Progression 10 RM 10+10RM 1kg+1kg=2kg
Side lying leg lifts	10 times with ½ kg	10 times with ¾ kg	10 times with 1kg	Progression 10 RM 10+10RM 1kg+1kg=2kg
Step ups	10 times with ½ kg	10 times with ¾ kg	10 times with 1kg	Progression 10 RM 10+10RM 1kg+1kg=2kg
Lateral band walk	10 times with ½ kg	10 times with ¾ kg	10 times with 1kg	Progression 10 RM 10+10RM 1kg+1kg=2kg

Fig1.Lateral band walk

Fig2. clamp shells exercise.

Fig3. Step-ups exercises

Fig4. Side lying leg lift exercise.

DATA ANALYSIS:

Analysis of the data collected was done by SPSS software version 23.00.The result was considered statistically significant at P<0.001

The characteristics of the data were presented through tables and graphs. Wilcoxon signed-rank test used for statistical hypothesis testing.

RESULT:

	Mean	SD	Median	Min	Max	Valid N
Age	63.00	5.65	62.00	54.00	74.00	31

Table5.1 Descriptive statistics

Age Interval	N	%
50-60 years	13	41.9%
61-70 years	13	41.9%
>70 years	5	16.1%
Total	31	100.0%

Table 5.2 Descriptive statistics of age interval

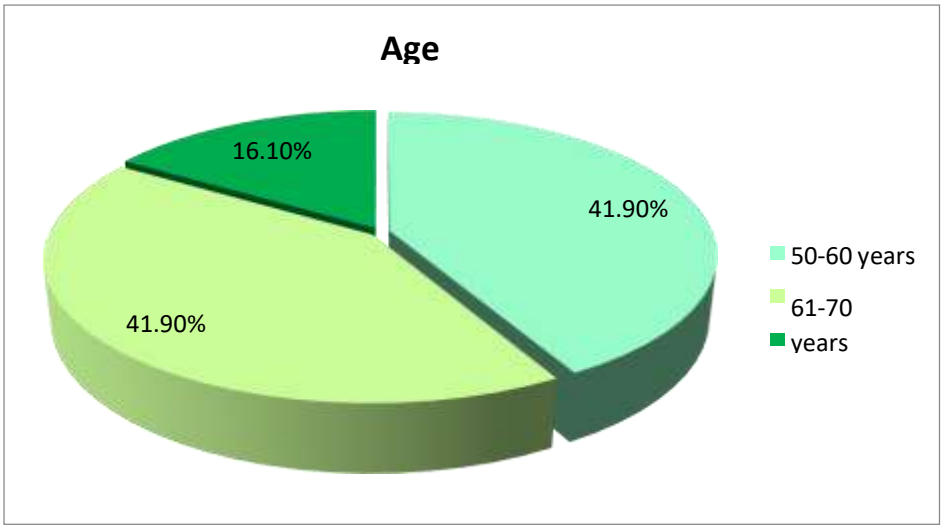


Fig 5.1Pie chart representing age interval

The analysis reveals that among the 31 participants, the average age is 63 years with a standard deviation of 5.65. The age range spans from 54 to 74 years, with a median age of 62. In terms of age intervals, 41.9% fall between 50-60 years and another 41.9% between 61-70 years. The remaining 16.1% are above 70 years old.

	Mean	SD	Median	Min	Max	Valid N
Height	161.03	6.65	160.00	147.00	172.00	31
Weight	72.10	11.33	70.00	55.00	118.00	31
BMI	26.90	2.05	26.40	20.30	31.20	31

Table 5.3 Descriptive of height ,weight ,BMI

The analysis of height, weight, and BMI among the 31 participants shows the following statistics: the mean height is 161.03 cm with a standard deviation of 6.65 cm, ranging from 147.00 cm to 172.00 cm. For weight, the mean is 72.10 kg with a standard deviation of 11.33 kg, ranging from 55.00 kg to 118.00 kg. The mean BMI is 26.90, with a standard deviation of 2.05, and it ranges from 20.30 to 31.20.

BMI	N	%
Underweight	0	.0%
Normal	3	9.7%
Overweight	26	83.9%
Obesity	2	6.5%
Total	31	100.0%

Table 5.4 Representing BMI

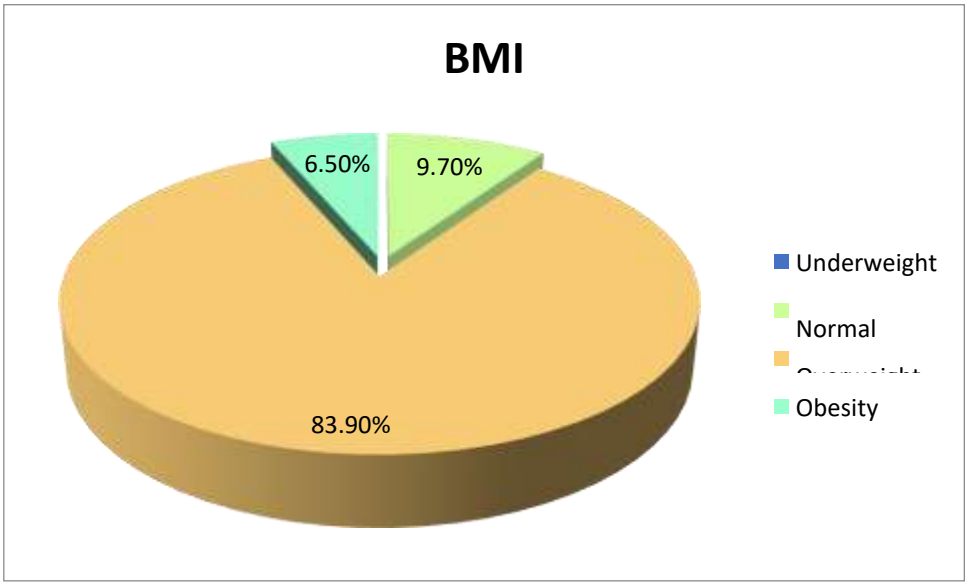


Fig 5.2Pie chart representing Distribution of BMI

The BMI distribution among the 31 participants indicates that 9.7% fall within the normal weight range, while the majority, comprising 83.9%, are classified as overweight. Additionally, 6.5% are categorized as obese, with no participants falling under the underweight category.

	Mean	SD	Median	Min	Max	Valid N
Pre VAS	5.06	1.39	5.00	3.00	8.00	31
Pre q angle	24.10	2.81	24.00	19.00	29.00	31
Pre WOMAC	61.61	6.98	60.00	51.00	75.00	31

Table 5.5 Descriptive analysis

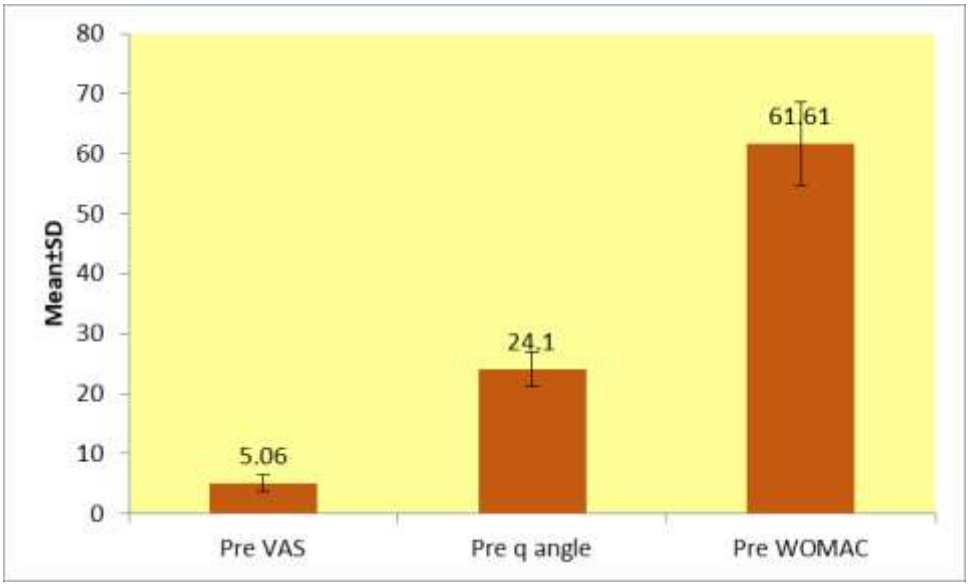


Fig 5.1Bar chart representing pre treatment measurements.

The pre-treatment measurements for Visual Analog Scale (VAS), q angle, and WOMAC scores are summarized as follows: The mean pre-VAS score stands at 5.06, with a standard deviation of 1.39 and a median of 5.00. In terms of q angle, the mean pre-measurement is 24.10 degrees, with a standard deviation of 2.81 and a median of 24.00.

Additionally, for WOMAC scores, the mean pre-treatment value is 61.61, with a standard deviation of 6.98 and a median of 60.00.

	Mean	SD	Median	Min	Max	Valid N
Post VAS	3.87	.88	4.00	2.00	5.00	31
Post q angle	21.90	2.36	22.00	18.00	26.00	31
Post WOMAC	56.52	6.84	55.00	48.00	70.00	31

Table5.6 Post treatment descriptive.

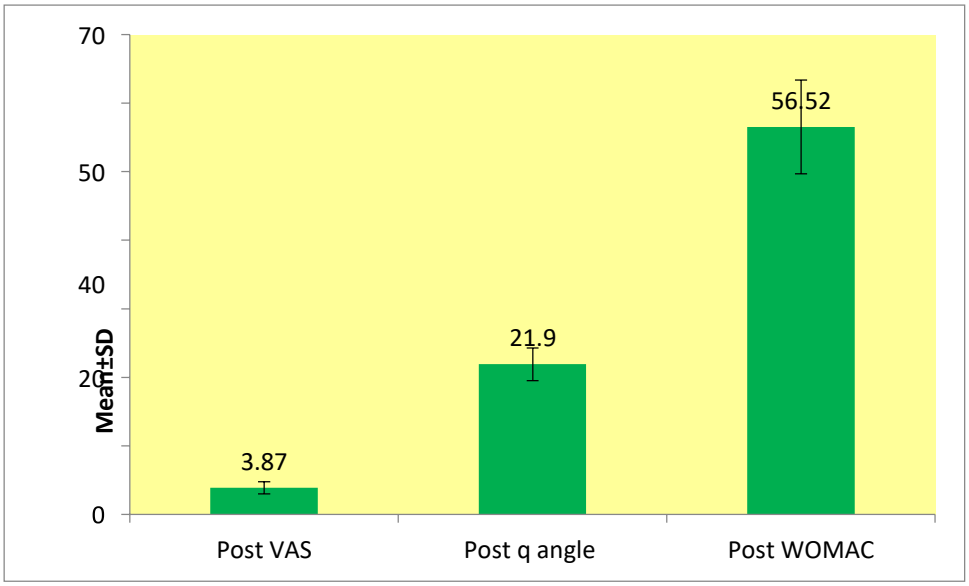


Fig5.2 Bar chart representing descriptive analysis post treatment

The post-treatment measurements reveal the following statistics: The mean post-Visual Analog Scale (VAS) score is 3.87, with a standard deviation of 0.88. Similarly, the mean post-q angle measurement is 21.90 degrees, with a standard deviation of 2.36. Lastly, the post-treatment WOMAC scores exhibit a mean of 56.52, with a standard deviation of 6.84.

Paired Samples Statistics							
	Mean	N	SD	Mean change	% mean change	Z value	p value
Pre VAS	5.06	31	1.39	1.19	23.57	-4.401	**<0.001**
Post VAS	3.87	31	0.88				

Table 5.7 Representing paired sample statistics.

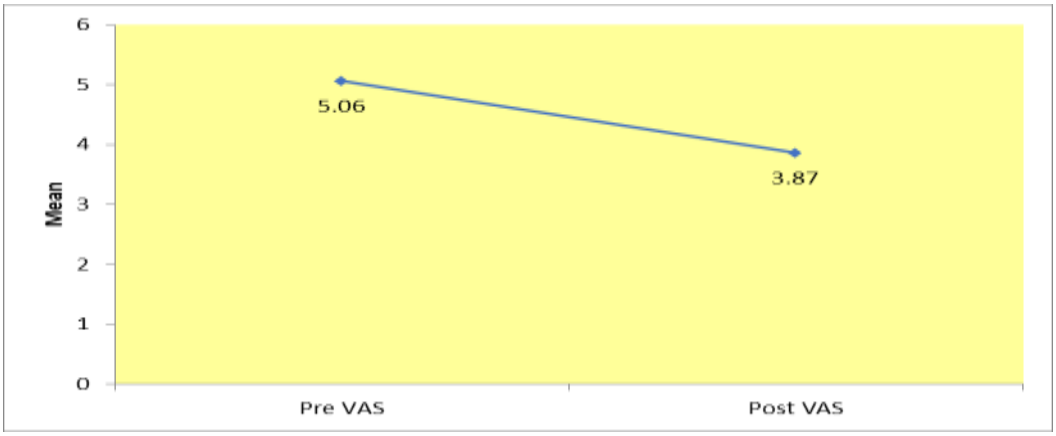


Fig 5.1 Graph representing pre and post VAS

The paired samples statistics for pre- and post-Visual Analog Scale (VAS) measurements show significant differences. The mean pre-VAS score is5.06 with a standard deviation of 1.39, while the mean post-VAS score is3.87. The mean change is 1.19, representing a 23.57% decrease in scores. The Z-value is -4.401, with a corresponding p-value of <0.001, indicating a highly significant difference between pre- and post-VAS measurements.

Paired Samples Statistics							
	Mean	N	SD	Mean change	% mean change	Z value	p value
Pre q angle	24.10	31	2.81	2.19	9.10	-4.895	**<0.001**
Post q angle	21.90	31	2.36				

Table5.8 Representing paired sample statistics.

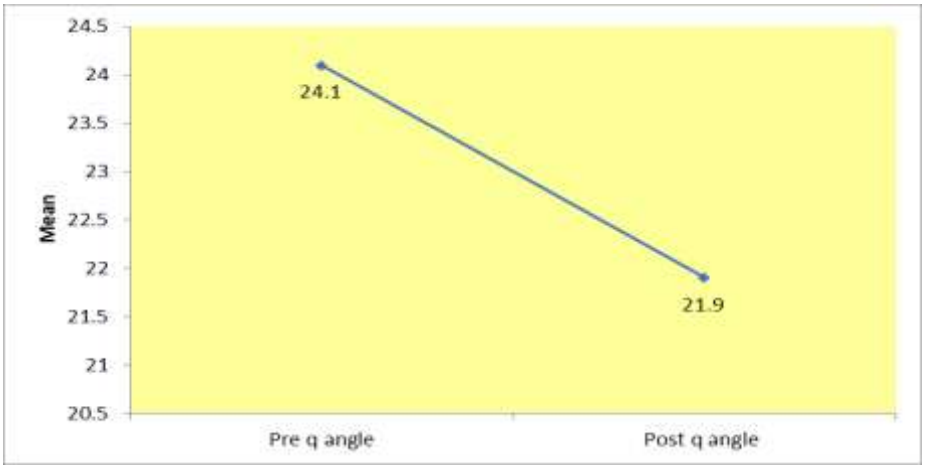


Fig5.2 Graph representing pre and post q angle

The paired samples statistics for pre- and post-q angle measurements reveal a notable difference. The mean pre-q angle is 24.10 degrees with a standard deviation of 2.81, while the mean post-q angle is 21.90 degrees. This results in a mean change of 2.19 degrees, representing a 9.10% decrease in the q angle measurement. The Z-value is -4.895, indicating a significant difference between pre- and post-q angle measurements ($p < 0.001$).

Paired Samples Statistics							
	Mean	N	SD	Mean change	% mean change	Z value	p value
Pre WOMAC	61.61	31	6.98	5.10	8.27	-4.978	**<0.001**
Post WOMAC	56.52	31	6.84				

*Table 5.9 Representing p**aired sample statistics.***

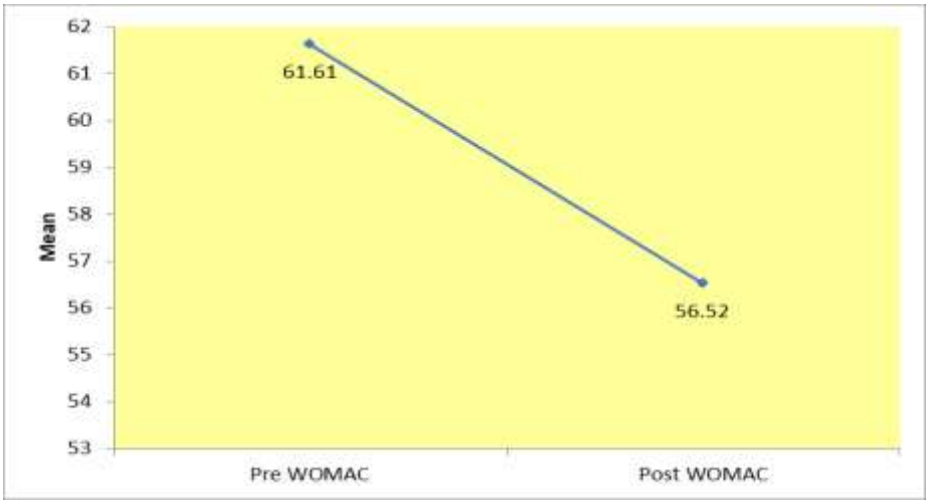


Fig 5.3 Graph representing pre and post WOMAC

The paired samples statistics for pre- and post-WOMAC scores indicate a significant difference. The mean pre-WOMAC score is 61.61 with a standard deviation of 6.98, while the mean post-WOMAC score is 56.52. This results in a mean change of 5.10 points, representing an 8.27% decrement in WOMAC scores. The Z-value is -4.978, indicating a highly significant difference between pre- and post-WOMAC scores ($p < 0.001$).

DISCUSSION:

The sample composed of predominantly elderly women with clinically diagnosed 100% knee OA with mean age of 63 and BMI 26.90. obesity in female has already been associated with knee OA weakness of musculature around knee increases Q angle and also Gait.

Various treatment strategies has been used to treat knee OA like electrotherapy, ultrasound , IFT, laser, manual therapy, mobilisation technique , acupuncture. Strengthening or resistance training is one of the widely used therapeutic plan to accomplish treatment of knee OA.

This study proposes resistance exercises regime for gluteal muscle adopting DeLormes Watkins PRE technique .The exercise regime improve Q angle decrease VAS and WOMAC score in elderly obese OA knee subjects. The training parameter were set using DeLormes and Watkins of PRE. The meta analysis by Rhea et al showed that the ideal training range for untrained subject is a 60% of 1RM to maximise strength gain.

This study targeted progressive change in the resistance in exercise protocol for gluteal strengthening. Changes in the resistance training for gluteal muscles leading to strength gain in this muscle group. This study corroborating the findings similar to Lange, Vanwanseele, and Singh. This strength gain in gluteal muscle reinforce knee joint and surrounding Structure. Therefore improving the Q angle 2.2^0 post 4 week resistance training of the gluteal muscle. however direct measurement of gluteal muscle post study was not done.

Exercise is thought to be the most effective strategy for improving function and managing pain. Resistance training for gluteus medius and maximus muscle led to pain reduction ,according to VAS and WOMAC pain perception results This study supports a study by Baker et al. that used a similar protocol and found that patient with knee OA who underwent strength training experienced improvement in their physical function and strength. This conclusion is supported by the study`s findings. The values observed in every WOMAC domain decreased ,indicating both an improvement in functional performance and increases in average walking speed .Nyland et al. demonstrated that because isometric hip adduction is linked to pelvic stability and controls femur internal rotation, it would raise G Med activity.

G Med weakening results in lateral knee joint instability, which leads to overactivity, shortness of the iliotibial tract tensor fascia latae, and gonarthritis. Open kinetic chain exercises frequently involve hip joint abduction exercises performed while side lying position. According to a Distenfano et al. study on hip muscle strengthening, Gmed exhibited the highest level of muscular activity when lying down. Arthritis has been linked to report decreases in muscular strength . This link between muscle strength and functional status has been observed in studies including healthy subjects. Moreover, there is a correlation between the risk of repeat falls and muscle strength. It goes without saying that physical stamina and strength correspond to high functional ability.

Fisioter Pesqui`s randomized controlled trial examined how the Q Angle changed in the cases of osteoarthritis in the knee .The study revealed that obese patients had a significantly higher Q Angle. OA is degenerative joint condition characterized by joint deformity and inflammation related discomfort. Another significant risk factor is obesity. The study demonstrated a connection between knee OA, Q-Angle, and anthropometric measurement. According to a study, central obesity may play a role in the development of knee OA in obese women. Thus, this study confirms the findings of the current investigation, which show that patients with knee OA had a markedly increase higher Q angle.

It was suggested that by strengthening the hip abductors, the frontal plain`s pelvic control would lessen the strain of the medial knee compartment. But just like with quadriceps strengthening ,hip muscle training did not change the knee`s medial compartment burden. The first factor contributing to this non significant outcome was the absence of any discernible hip muscle weaking in the Bennell et al. sample . Foroughi et al. reasoned that the second exercise intervention in their study was not specifically designed to restore alignment in functional weight-bearing positions.

Kobsar et al. revealed that variables such as low activity of the daily life score and altered hip kinematics in the frontal plane cycle were connected with the favourable outcome after 4 week muscle strengthening program. Strengthening the hip muscle would therefore be advantageous for a patient with knee OA who also have changed hip joint kinematics.

According to Runhaar et al. the processes underlying beneficial effects of the exercise therapy in individual with knee OA include improvements in muscle strength. In addition, exercise has antinociceptive and general health benefits for people with OA knee.

The improvement in the VAS score was supported by decrease in WOMAC score reflected by improved functional activity of the subjects – walking, stair climbing etc.

Considering that OA is a chronic disease, new or enhanced therapeutic measures are essential for promoting better quality of life in affected individuals. Physical function is one of the elements that contribute to an individual remaining independent and engaged in the community; therefore, it is an indicator of quality of life . In this study, functional performance improvement was followed by an improved perceived quality of life as evidenced by the statistically significant changes in the areas of pain perception, functional capacity. Furthermore ,exercise for person with knee OA leads to general health related benefits antinociceptive effects.

LIMITATION OF THE STUDY

- Only gluteus medius muscle were used to check the effect on Q-Angle.
- Hip abductors exercises dominated in the protocol .
- Small sample size.

FUTURE RESEARCH

Other muscle groups and how hip exercises can be utilized to correct varus knee alignment through eccentric control needs to be explored.

More research is required to determine the relative effectiveness of open and closed kinematic chain hip exercises.

CONCLUSION:

This study examined significant high quality data showing the benefits of gluteus medius training for obese female patients with osteoarthritis in their knee. The good outcomes of the exercise outlined here lend credence to the theory that patient with knee OA has shown significant improvement in pain , Q angle and physical activity.

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