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Original Research Article

Efficacy of Aquatic Therapy and VMO Strengthening in Patellofemoral Arthritis

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ABSTRACT

Background: Arthritis is inflammation of joints which leads to pain and stiffness that worsens with age. Patellofemoral arthritis affects the underside of the patella and the channel-like groove in the femur that the patella rests in. PFPS is an overuse injury in which anterior knee pain is present. The patient with patellofemoral arthritis has kneecap pain, stiffness and often swelling in the front part of the knee that typically worsens when walking on inclined terrain, climbing stairs, squatting. The patients with patellofemoral arthritis have reduced functional ability due to pain. It is important to increase the strength of Vastus Medialis Oblique Muscle which helps in stabilizing the patella during knee joint movements in order to reduce the pain. Aquatic physical therapy is considered as a safe and effective treatment program for managing knee OA as it contribute to the increase in the pain threshold and it also decreases the joint overload and pain symptoms and improves functionality and quality of life.

Objective: To compare the effect of aquatic therapy and Vastus Medialis Oblique strengthening on pain and functional ability in patellofemoral arthritis (PFA).

Materials and methods: An experimental study was conducted on total of 30 subjects on the basis of inclusion and exclusion criteria with 15 subjects in group A for VMO strengthening and 15 subjects in group B for aquatic therapy exercise. Outcome measures used were Visual Analogue Scale (VAS) and Anterior Knee Pain Scale (AKPS). The protocol was conducted for 5 weeks, 3 days a week.

Results: A total of 30 patients between the age of 40-65 years were included. Statistically it shows that there was extremely significant difference (p<0.0001) between pre intervention assessment and post intervention assessment. But the subjects treated with aquatic therapy shows more significant difference than the subjects treated with VMO strengthening program.

Conclusion: The present study concludes that the aquatic therapy program is more effective than the VMO strengthening program which showed more reduction in pain and increase in functional ability in PFA.

KEY WORDS: Patellofemoral arthritis, Patellofemoral pain syndrome, knee pain, VMO strengthening, Aquatic therapy, Visual Analogue Scale, Anterior Knee Pain Scale.

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INTRODUCTION

The knee joint is a complex joint. It plays important role in providing weight support and activity control as it has the capacity to bear

weight and wide range of motion (ROM). Knee joint is susceptible to injury because it is constantly influenced by body weight loading at various angles [1].

Osteoarthritis (OA) is a most chronic condition of the joints. It can affect any joint but it occurs most often in knee joint. Hyaline cartilage is present between the joints as it covers the end of each bone which provides a smooth and gliding surface for joint motion and. In arthritis the cartilage breaks down and results into pain and swelling. Arthritis is inflammation of one or more joints. It often leads to pain and stiffness that worsens with age. OA progresses over time and leads to destruction of articular cartilage and joints [9-10].

As the condition worsens over time, bones may break down and develop spurs. There are two types of OA, primary and secondary. Wear and tear of cartilage occurs in primary OA with growing age. In secondary OAthe cartilage breaks down due to specific trigger factors such as injury, genetics and obesity. Furthermore, characteristic changes can be seen in advanced stage of OA which include fibrosis and thickening of the joint capsule, articular cartilage fibrillation and erosion and osteophytes formation which ultimately leads to substantial structural impairments to joint function [11-13].

Patellofemoral arthritis affects the underside of the patella (kneecap) and the channel-like groove in the femur (thighbone) that the patella rests in. Patellofemoral pain syndrome (PFPS) is an overuse injury in which anterior knee pain is present [1]. It causes pain in the front of your knee and can make it difficult to kneel, squat, and climb and descend stairs. The patient with patellofemoral arthritis has kneecap pain, stiffness and often swelling in the front part of the knee that typically worsens when walking on inclined terrain, going up and down stairs, squatting or rising from seated position, limitation in the movement (loss of ROM), cracking sound (crepitus). This pain is aggravated due to increased patellofemoral compressive force by sports activities, kneeling or squatting, stair climbing and prolong sitting with knees flexed [2].

Various factors are responsible for patellofemoral pain such as increased Q- angle, quadriceps weakness, VMO weakness, faulty lower limb mechanics, gender, obesity, occupation, overuse and lateral retinaculum tightness [2]. The patient complains of diffuse knee pain, stiffness, crepitus and locking, decreased activity level. A joint pain and inflammation often leads to adaptive muscle guarding and altered weightbearing to protect the affected limb from further complaints and injuries [11].

Compensatory muscular adaptations are observed in such patients due to inefficient muscle activities which leads to muscle weakness, joint instability and altered limb loading where gait alterations are produced by maladaptive musculoskeletal responses [11,18].

Vastus Medialis Obliquus (VMO) muscle plays an important role in controlling the contact area and pressure distribution in patello-femoral joint [3]. It originates from medial side of the femur and inserts in quadriceps tendon. During knee extension, it aids in enhancing the mechanical advantage of the knee joint.

Exercise is one of the therapeutic options for reducing the negative effects of ageing on the musculoskeletal system while maintaining independence, increasing weight control, and improving or maintaining quality of life, functional capacity, and emotional well-being [10,14,15].

Physical rehabilitation is not only an effective treatment option for managing primary musculoskeletal injuries but also helps in reducing or preventing compensatory gait abnormalities [11,19]. However, land based exercise program can exacerbate joint pain and increase the risk of fall in this population [10,16,17].

Aquatic therapy is beneficial and widely used in rehabilitation program[11.] Aquatic physical therapy is considered as a safe and effective treatment program for managing knee OA as it contribute to the increase in the pain threshold and it also decreases the joint overload and pain symptoms and improves functionality and quality of life [10-21].

Exercise in the water is effective means to

increase joint mobility and promote normal motor skills pattern, increase muscle activity and decrease incidence of secondary musculoskeletal injuries [11].

The variables involved in aquatic therapy are i) Buoyancy which is a lifting force that acts to reduce the axial load on the joints and minimizes the vertical ground reaction force, ii) Viscosity increases muscle activity, joint stability and enhances neuromuscular control, iii) Hydrostatic pressure reduces oedema, increases joint range of motion and decreases pain, iv) Thermodynamic property of the water provides different therapeutic effects depending on temperature, v) Osmolarity reduces oedema and improved mechanical nociceptive threshold [11].

MATERIAL AND METHODOLOGY

An experimental study was conducted on total of 30 subjects on the basis of inclusion and exclusion criteria. A written informed consent was taken from the participants who fulfilled the inclusion and exclusion criteria. The purpose and method of the study was explained to the subjects. The subjects were divided into two groups. Group A was given aquatic therapy exercise and group B was given Vastus Medialis Oblique strengthening exercises. For the pre and post test assessment Visual Analogue Scale (VAS) and Anterior Knee Pain Scale (AKPS) was used. The protocol was conducted for 5 weeks, 3 days a week. After 5 weeks the subjects were assessed and the data was collected.

The following aspects defined the inclusion criteria for the present study:

1. Subjects radiologically diagnosed with patellofemoral arthritis by a certified Orthopedic and a certified a Physiotherapist.

2. Anterior knee pain after performing any two of the following activities: prolong long sitting with knees flexed, squatting, stairs climbing, kneeling, hopping and jumping.

3. Presence of pain more than 1 month.

4. he patient should have 1 or more of the following signs along with anterior knee pain: patellar crepitus and locking, knee stiffness.

5. Anterior knee pain in age group between age 40 to 65 years

The exclusion criteria were based on:

1. Traumatic accident

2. Knee surgery

3. Received non-steroidal anti-inflammatory drugs, injections

4. Meniscal or ligament injury

5. Neurological disease

To be considered in the study, the patient should be diagnosed with Patellofemoral Arthritis (PFA). All the 30 subjects who met the inclusion criteria were randomly assigned to two groups with 15 subjects in group A followed by VMO strengthening and 15 subjects in group B followed by aquatic therapy exercise. Subjects were selected and assigned by convenient sampling and randomized distribution method. The subjects were informed regarding the method, purpose and risks associated with the study. Signed consent forms were taken and pre intervention data were collected from the subjects. Outcome measures were checked. The institutional research ethics committee authorised the study. The materials required for the intervention was medicine ball, hydrotherapy unit and theraband.

Protocol:

	Techniques	Application
Group A - Aquatic therapy exercises:	**Warm up**	10 minutes
	45˚ squats	3 sets of 10 repetitions
	Step from side	3 sets of 10 repetitions
	Standing with the ball held between the knee	10 sec hold with 10 repetitions
	Knee extension with theraband	3 sets of 10 repetitions
	Knee flexion by holding the ball between knees	3 sets of 10 repetitions
	Side step squat	3 sets of 10 repetitions
	External hip rotation with theraband	3 sets of 10 repetitions

Group B - Exercises for Vastus Medialis Oblique strengthening:

Techniques	Application
HMP to knee for 15 minutes	15 minutes
Static exercises for Vastus Medialis Oblique muscle	3 sets of 10 repetitions
Straight Leg Raise (SLR) in all directions	3 sets of 10 repetitions
Double leg semi squat with hip adduction	3 sets of 10 repetitions
Squat exercise	3 sets of 10 repetitions
Squat exercise with wedge	3 sets of 10 repetitions
Single leg inner range quadriceps with band	3 sets of 10 repetitions
Double leg inner range quadriceps with band	3 sets of 10 repetitions
Simple leg press	3 sets of 10 repetitions
Stretching of quadriceps, hamstrings, calf muscles and iliotibial band.	3 sets of 10 repetitions
Cryotherapy	10 minutes

Outcome Measures: Outcome measures used in present study are Visual Analogue Scale (VAS) and Anterior Knee Pain Scale (AKPS). The outcome measures were obtained from 2 occasions: pre intervention measurement and post intervention measurement. The subjects received the intervention according to group allotted after taking the baseline parameters. After 5 weeks again the data was collected.

Data analysis: The data was analyzed by using SPSS version -20. Paired t test was applied to compare the data within the groups. Independent sample test was used to compare the data between the groups.

RESULTS

Paired t test was done to compare the data of VAS and AKPS. Data analysis was performed using SPSS version 20. Independent Sample Test was done to compare the data of pre test and post test values of Visual Analogue Scale and Anterior Knee Pain Scale. Subjects were selected and assigned by convenient sampling and randomized distribution method. After 5 weeks the subjects were assessed and the data was collected. A total of 30 patients between the age of 40-65 years were included**.**

The mean age of patients with VMO strengthening program is 57±6.9 years and that of aquatic therapy program is 53.53±6.06 years. In VMO strengthening program 5 patients were present between the age of 40-54 years out of which 1 was male and 4 were female where 10 patients were present between the age of 55-65 years out of which 1 was maleand 9 were female. Also in aquatic therapy program 9 patients were present between the age of 40-54 years out of which 3 were male and 6 were females where 6 patients were present between the age of 55-65 years out of which 5 were males and 1 was female.

The gender distribution according to particular age group for both the groups is given in table no 1.

Interpretation: Patients treated with the given exercise program has shown decrease in pain VAS on rest. Statistically it shows that there was extremely significant difference (p<0.0001) between pre intervention assessment and post intervention assessment. The subjects treated with aquatic therapy shows more significant difference than the subjects treated with VMO strengthening program.

Interpretation: The table no 3 shows that the subjects treated with both the exercise programs shows decrease in pain on activity. Statistically it proves that there is extremely significant difference (p<0.0001) between pre intervention and post intervention assessment. When compared both the groups, the aquatic therapy program shows more significant difference in VAS on activity than the VMO strengthening program.

Interpretation: The participants treated with both exercise regimens showed a decrease in knee pain, as shown in table 3. Statistically, the difference between the pre-intervention and post-intervention assessments was highly significant (p<0.0001). The result shows that the aquatic therapy program is more beneficial to the patients compared to VMO

strengthening program as it shows more significant difference in Anterior Knee Pain Scale than the VMO strengthening program.

Table 1: Demographic data.

AGE (in years)	VMO STRENGTHENING			AQUATIC THERAPY		
	GENDER			GENDER		
	TOTAL	MALE	FEMALE	TOTAL	MALE	FEMALE
40 to 54	5	1	4	9	3	6
55 to 60	10	1	9	6	5	1

Table 2: Mean, Standard Deviation and *P* Value for VAS On Rest Pre and Post Intervention for both the groups.

	VMO STRENGTHENING		AQUATIC THERAPY	
VAT AT REST	**PRE TEST**	**POST TEST**	**PRE TEST**	**POST TEST**
MEAN	4.833	3.033	5.826	3.1
STANDARD DEVIATION	1.19	0.915	1.282	1.121
PAIRED t VALUE	4.643		6.201	
P VALUE	< 0.0001		< 0.0001	
MEAN DIFFERENCE	1.88		2.727	

Table 3: Mean, Standard Deviation and *P* Value for VAS On Activity Pre and Post Intervention for both the groups

	VMO STRENGTHENING		AQUATIC THERAPY	
VAT ON ACTIVITY	**PRE TEST**	**POST TEST**	**PRE TEST**	**POST TEST**
MEAN	7.066	4.733	7.64	4.733
SD	1.211	1.208	1.029	1.237
PAIRED t VALUE	5.147		6.994	
P VALUE	< 0.001		< 0.001	
MEAN DIFFERENCE	2.273		2.727	

Table 4: Mean, Standard Deviation and *P* Value for AKPS Pre and Post Intervention for both the groups.

	VMO STRENGTHENING		AQUATIC THERAPY	
	PRE TEST	**POST TEST**	**PRE TEST**	**POST TEST**
MEAN	64.866	77.8	61.866	78.2
SD	9.078	5.685	10.281	9.593
PAIRED T VALUE	4.677		4.499	
P VALUE	< 0.0001		0.0001	
MEAN DIFFERENCE	12.933		16.333	

DISCUSSION

Osteoarthritis (OA) is a most chronic condition of the joints. It can affect any joint but it occurs most often in knee joint. Knee joint is susceptible to injury because it is constantly influenced by body weight loading at various angles [1]. In arthritis the cartilage breaks down and results into pain and swelling. Inflammation of one or more joints is referred to as arthritis. It often leads to pain and stiffness that worsens with age. OA progresses over time and leads to destruction of articular cartilage and joints[10]. Patellofemoral arthritis affects the underside of the patella (kneecap) and the channel-like groove in the femur that the patella rests in. Patellofemoral pain syndrome is an overuse injury in which anterior knee pain is present[1]. It makes kneeling, squatting, climbing stairs, and other

activities painful in the front of your knee. This pain is aggravated due to increased patellofemoral compressive force by sports activities, kneeling or squatting, stair climbing and prolong sitting with knees flexed [2].

Most of the studies reports a high prevalence of PFA and proved that the subjects with knee pain or radiographic OA have patellofemoral involvement [4,7]. The patient complains of diffuse knee pain, stiffness, crepitus and locking, decreased activity level.

A joint pain and inflammation often leads to adaptive muscle guarding and altered weight bearing to protect the affected limb from further complaints and injuries [11].

Compensatory muscular adaptations are observed in such patients due to inefficient muscle activities which lead to muscle weakness, joint instability and altered limb loading where gait alterations are produced by maladaptive musculoskeletal responses [11, 18.] Vastus Medialis Obliquus (VMO) muscle plays an important role in controlling the contact area and pressure distribution in patellofemoral joint [3].

The aim of present study is to compare the efficacy of aquatic therapy and Vastus Medialis Oblique strengthening on pain and functional ability in PFA. The goals of this therapy are improving joint motion and reducing pain.

The result of this study demonstrated that the exercise program structured for patients with patellofemoral arthritis have been effective in knee pain. An evident reduction was present in the VAS score and AKPS score. Exercise in the water is an effective mean to enhance normal motor function, increase muscular activity, and reduce the risk of subsequent musculoskeletal injuries [11]. It has been shown by several studies that patellofemoral arthritis is caused by VMO muscle weakening [1].

The result of present study showed that there is significant difference on decreasing pain, increase in functional ability and increase in strength of VMO muscle in both the groups. According to past study material, characteristics of water provide an environment that facilitates exercise for a person with injured musculoskeletal system.

The VMO muscle has been suggested to function as a dynamic medial stabilizer, which helps to realign the patella during the last 20 to 30 degrees of knee extension, so K. Mrityunjaya et al. (2014) state that strengthening the VMO may have a greater impact because it directly relates to the patellar alignment [22]. However, the current research has found that the water treatment programme is more successful than the VMO strengthening programme. The aquatic therapy program showed more reduction in pain and increase in functional ability in PFA.

Exercise is one of the therapeutic options for reducing the negative effects of ageing on the musculoskeletal system while maintaining independence, increasing weight control, and improving or maintaining quality of life, functional capacity, and emotional well-being [10,14,15]. Aquatic physical therapy is considered as a safe and effective treatment program for managing knee OA as it contribute to the increase in the pain threshold and it also decreases the joint overload and pain symptoms and improves functionality and quality of life [10,20,21].

The study conducted by Wyatt FB, Milam S, Manske RC, Deere R did not proved that the aquatic therapy program was more conductive to increasing knee ROM than VMO strengthening program but it did showed that there is significant reduction in perceived pain levels where the study conducted by Green et al (1993) also found that aquatic therapy offered no additional benefit over performance of exercises executed on land however they concluded that simple exercise increased the function levels of subjects with PFA [12,23]. The present study showed that there is significant decrease in perception of pain and increase in functional ability in aquatic therapy group as compared to VMO strengthening group.

CONCLUSION

In this present study, there is significant difference in knee pain in patients with patellofemoral arthritis between pre and post intervention. The structured exercise program designed, have been effective for knee pain in

such patients. Both the exercise programs were effective.

Here, we can conclude that the aquatic therapy program is more effective than the VMO strengthening program. The aquatic therapy program showed more reduction in pain and increase in functional ability in PFA.

ABBREVIATIONS

VAS - Visual Analogue Scale
AKPS - Anterior Knee Pain Scale
PFA - Patellofemoral Arthritis
OA - Osteoarthritis
VMO - Vastus Medialis Oblique

AUTHORS CONTRIBUTION

Supriya Nikam – Data collection, research design, research process, discussion, editing, manuscript drafting.
Trupti Yadav – Research process, review of literature, discussion, research analysis.

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Conflicts of interest: None

ETHICS APPROVAL AND PATIENT CONSENT: The study was approved by the "Institutional Ethics Committee" of Krishna Institute of Medical Sciences, "Deemed to be" University, Karad, Maharashtra. The author had explained the study and the intervention to be given to the participants and had taken participants consent prior to the study from every participant.

REFERENCES

[1]. Lee TK, Park SM, Yun SB, Lee AR, Lee YS, Yong MS. Analysis of vastus lateralis and vastus medialis oblique muscle activation during squat exercise with and without a variety of tools in normal adults. Journal of physical therapy science. 2016;28(3):1071-3.
[2]. Coqueiro KR, Bevilaqua-Grossi D, Bérzin F, Soares AB, Candolo C, Monteiro-Pedro V. Analysis on the activation of the VMO and VLL muscles during semisquat exercises with and without hip adduction in individuals with patellofemoral pain syndrome. Journal of Electromyography and Kinesiology. 2005 Dec 1;15(6):596-603.
[3]. Villafañe JH, Bissolotti L, La Touche R, Pedersini P, Negrini S. Effect of muscle strengthening on perceived pain and static knee angles in young subjects with patellofemoral pain syndrome. Journal of exercise rehabilitation. 2019 Jun;15(3):454.
[4]. Li Z, Liu Q, Zhao C, Gao X, Han W, Stefanik JJ, Jin Q, Lin J, Zhang Y. High prevalence of patellofemoral osteoarthritis in China: a multi-center population-based osteoarthritis study. Clinical Rheumatology. 2020 Dec;39(12):3615-23.
[5]. Coburn SL, Barton CJ, Filbay SR, Hart HF, Rathleff MS, Crossley KM. Quality of life in individuals with patellofemoral pain: a systematic review including meta-analysis. Physical Therapy in Sport. 2018 Sep 1;33:96-108.
[6]. Song CY, Lin YF, Wei TC, Lin DH, Yen TY, Jan MH. Surplus value of hip adduction in leg-press exercise in patients with patellofemoral pain syndrome: a randomized controlled trial. Physical therapy. 2009 May 1;89(5):409-18.
[7]. Yalfani A. The effect of eight weeks of Aquatic therapy with patella taping on pain, motor function and unstable balance in women with the patellofemoral pain syndrome. KAUMS Journal (FEYZ). 2018 Jun 10;22(3):309-17.
[8]. Hart HF, Stefanik JJ, Wyndow N, Machotka Z, Crossley KM. The prevalence of radiographic and MRI-defined patellofemoral osteoarthritis and structural pathology: a systematic review and meta-analysis. British journal of sports medicine. 2017 Aug 1;51(16):1195-208.
[9]. Lankhorst NE, Bierma-Zeinstra SM, van Middelkoop M. Risk factors for patellofemoral pain syndrome: a systematic review. journal of orthopaedic & sports physical therapy. 2012 Feb;42(2):81-94.
[10]. Hame SL, Alexander RA. Knee osteoarthritis in women. Current reviews in musculoskeletal medicine. 2013 Jun;6(2):182-7.
[11]. Alcalde GE, Fonseca AC, Bôscoa TF, Gonçalves MR, Bernardo GC, Pianna B, Carnavale BF, Gimenes C, Barrile SR, Arca EA. Effect of aquatic physical therapy on pain perception, functional capacity and quality of life in older people with knee osteoarthritis: study protocol for a randomized controlled trial. Trials. 2017 Dec;18(1):1-6.
[12]. King MR, Haussler KK, Kawcak CE, McIlwraith CW, Reiser RF. Mechanisms of aquatic therapy and its potential use in managing equine osteoarthritis. Equine veterinary education. 2013 Apr;25(4):204-9.
[13]. Wyatt FB, Milam S, Manske RC, Deere R. The effects of aquatic and traditional exercise programs on persons with knee osteoarthritis. Journal of Strength and Conditioning Research. 2001 Aug 1;15(3):337-40.
[14]. McIlwraith CW, VACHON A. Review of pathogenesis and treatment of degenerative joint disease. Equine Veterinary Journal. 1988 Sep;20:3-11.
[15]. Fibra T, Sá TS, Fontes SV, Driusso P, Prado GF. Quality of life evaluation in elderly people submitted to Aquatic Physical Therapy. Rev Neurocienc. 2006;14(4):182-4.
[16]. Guerrero Y, Soomro N, Wilson G, Dam Y, Meiklejohn J, Simpson K, Smith R, Brand-Miller J, Simic M, O'Connor H, Mavros Y. Train High Eat Low for Osteoarthritis study (THE LO study): protocol for a randomized controlled trial. Journal of physiotherapy. 2015 Oct 1;61(4):217.

[17]. Kim IS, Chung SH, Park YJ, Kang HY. The effectiveness of an aquarobic exercise program for patients with osteoarthritis. Applied Nursing Research. 2012 Aug 1;25(3):181-9.
[18]. Hale LA, Waters D, Herbison P. A randomized controlled trial to investigate the effects of water-based exercise to improve falls risk and physical function in older adults with lower-extremity osteoarthritis. Archives of physical medicine and rehabilitation. 2012 Jan 1;93(1):27-34.
[19]. Astephen JL, Deluzio KJ, Caldwell GE, Dunbar MJ, Hubley-Kozey CL. Gait and neuromuscular pattern changes are associated with differences in knee osteoarthritis severity levels. Journal of biomechanics. 2008 Jan 1;41(4):868-76.
[20]. Hurley MV. The effects of joint damage on muscle function, proprioception and rehabilitation. Manual therapy. 1997 Feb 1;2(1):11-7.
[21]. Barker AL, Talevski J, Morello RT, Brand CA, Rahmann AE, Urquhart DM. Effectiveness of aquatic exercise for musculoskeletal conditions: a meta-analysis. Archives of physical medicine and rehabilitation. 2014 Sep 1;95(9):1776-86.
[22]. Bartels EM, Juhl CB, Christensen R, Hagen KB, Danneskiold Samsøe B, Dagfinrud H, Lund H. Aquatic exercise for the treatment of knee and hip osteoarthritis. Cochrane Database of Systematic Reviews. 2016;3.
[23]. K.Mrityunjay et.al.Comparision between effect of isometric quadriceps exercise and vastus medialis oblique strengthening on quadriceps angle and patellar shift in normal individuals. European Academic Research. July. 2004;II.(4).
[24]. GREEN, J.R, G. MCKENNA, E.J. REDFERN, AND M.A. CHAMBERLAIN. Home exercises are as effective as outpatient hydrotherapy for osteoarthritis of the hip. Br. Soc. Rheumatol. 1993;32:213-216.

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