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ASSESSMENT OF LEVEL OF DISCOMFORT AND PAIN IN QUADRICEPS DURING SQUATS FOR CORE STABILITY AMONG HEALTHY ADULTS.

[1]Zufa Shafiq [2]Zohrain Tabassum [3]Asma Saman [4]Syeda Amna Iqbal [5]Ayesha Bashir [6]Shamsa Kanwal [7]Qasim Raza

[1]Physiotherapist at Shalmar Hospital, Lahore, Pakistan

[2]Physiotherapist at Sir Ganga Ram hospital, Lahore, Pakistan

[3]Physiotherapist at University of Management and Technology

[4]Indus College of Physical Therapy and Rehabilitation, Pakistan

[5]Lecturer, Department of Physical Therapy, Islamia University Bahawalpur

[6]Pharmacist in Pervaiz Elahi Institute of Cardiology, Bahawalpur

[7]Indus Hospital and Health Network, Karachi, Pakistan

Abstract

Background The squat is among the most repeatedly used training in the domain of core strengthening. Squats are a well-known exercise for strengthening the lower extremity muscles. **Objectives:** The purpose of this study is to evaluate the discomfort and pain that appears during squatting among healthy adults. **Material and Methodology:** An Observational study was conducted at allied health sciences school of shalamar institute (SSAHS) with sample size of 75 students. Subjects were recruited on the basis of exclusion and inclusion criteria by convenient sampling. Then the subjects were asked to be positioned in squatting, most specifically wall squat position with back straight and 90º knee flexion as quadriceps muscle activity is maximum in this position. The subjects were asked to report immediately if they feel any discomfort and then the time was noted on a stop watch and the subject was asked to answer the questions from the Performa. The whole procedure will take approximately 3-5 minutes. **Results:** Holding time for squat was recorded in both male and female students. The mean holding time of squat in male students was 17.09±3.109 and for female students was 15.75±3.0441. Among females, 35% female students experienced low pain, 10% experienced high and 40% experienced moderate

pain. Among males 51.5% students experienced low, 11.4% experienced high while 31.4% experienced moderate level of pain. Among all students 47 students out of all males and females felt slight discomfort within %age gender of 62.7% while 28 out of all felt moderate discomfort within %age gender of 37.3%. Among total of all male and female students 57 students experienced no inference at all while 18 students experienced slightly inference of pain and discomfort with activities. **Conclusion:** Limit of pain and discomfort for holding time for squats were recorded as, most of the female subjects experienced moderate level of pain and males experienced low level of pain. While 62.7% subjects felt slight discomfort and 24% subjects experienced slight interference of this discomfort with daily life activity.

Key words: Discomfort, Pain, Core stability, Squatting

Introduction: -

The squat is among the most repeatedly used training in the domain of core strengthening. For core strengthening, squat is most repeatedly used training. One of the top three exercises for sports training, recovery, and prehabilitation is the squat. Quadriceps are the prime movers during squatting. Peak quadriceps activity is between 80 and 90 degrees of squat. The squat is a closed-chain biomechanical exercise that needs coordinated extension patterns at the ankle, knee, and hip joints. The squat can be performed in different ways, including alternating foot width. The squat is an ideal exercise for strengthening the entire lower extremity. (Vecchio, Daewoud et al. 2018)

The experience of discomfort can manifest physically or psychologically and is distinguished by an unpleasant sensation that elicits a natural impulse to avoid movement. Discomfort is caused by many reasons but pain is one of the main source, nevertheless not all discomfort can be attributed to pain. Bilateral squats are commonly incorporated into lower body strength training programs, while unilateral squats are primarily utilized as supplemental or rehabilitative exercises. Unilateral squats can be performed with small loads to achieve related magnitude of muscle activity and generate fewer loads on the spine.(Ashkenazy and Ganz 2019)

Core stability training focused on improving trunk and hip control and is an integral part of sports development for injury prevention. Research has shown that the stability of human movement plays a crucial role in the effective generation, transmission, and control of forces or energy during integrated kinetic chain activities. The fundamental stability of movement is essential for proper trunk and limb actions. (Reed et al 2012)

Squats and lunges are most functional exercises that play a crucial role in a wide range of activities. They contribute to lifting, bending, pushing, throwing, and punching, among other movements. Moreover, these exercises effectively improve your ability to maintain an upright posture by training the control of your core muscles. The key to stability in your ankle, knee, hip, and lower back lies in this exercise. Begin by slowly squatting down while running your fingers along the wall. The depth of your squat should be determined by your ability to maintain balance and keep your lower back straight. Return to the starting position and repeat this movement 8-10 times, performing it slowly. It is recommended to do this exercise twice a day. (Liebenson and therapies 2002)

The correlation between the load on the hip and knee joints the activity of the quadriceps varies when performing squats at different depths. Our findings suggest that load on knee joint can be reduced by performing squats at a parallel depth instead of going deeper, without decreasing the activity of the quadriceps muscles. In order to limit the stress on the hip joint, it is recommended to avoid squats deeper than a 90° angle. The contribution of the gluteus maximus and hamstrings in the hip extensor strategy affects the amount of effort required from the quadriceps during the squat exercise. This is because the hamstrings and quadriceps work together to contract the knee. These results indicating the strength of gluteus maximus and quadriceps muscles for lifting heavy loads during squats. (Bryanton, Carey et al. 2015)

Length of muscle is mainly responsible for generating the force exerted by muscle. The aim of this study was to investigate how the positioning of the feet affects the activation of the superficial quadriceps muscles during functional squatting in healthy adults. Surface electromyography was used to measure this muscle activity. Functional squatting is known to be an effective exercise for sessions of cruciate ligament or patellofemoral rehabilitation. In the case of individuals with healthy knees, it is advisable to perform parallel squats rather than deep squats. This because deep squats can increase the risk of injuries to the meniscus, cruciate

ligaments, and collateral ligaments. Additionally, squatting can effectively contribute to the development of musculature in the hip, knee, and ankle regions due to the moderate to high levels of activity generated in the quadriceps, hamstrings, and gastrocnemius muscles.(Escamilla, sports et al. 2001)

The objective of this study was to find out the time duration after which discomfort and pain starts to appear in a healthy adult during squatting, which was being used for core stability training. The existing literature supports the use of Squats in core stability, strength training and rehabilitation but still there is no evidence and literature on relationship of pain & discomfort with squats and optimal required time frame for squatting in core stability training. This study provides understanding of ultimate time frame of squatting without pain & discomfort for designing effective training protocols for core stability exercises.

MATERIALS AND METHODS:

Study Design: This study was conducted at Shalamar School of Allied Sciences (SSAHS) using an observational/cross-sectional design.

Study duration: -2 months after the approval of IRB form.

Sampling Technique:

Subjects will be selected by non-probability convenient sampling method

Sample size: A pilot study was performed on 5 random participants, they were asked to perform wall squats until pain and discomfort appeared in their quadriceps. They were asked to report as soon as discomfort started to appear. Time frame was noted for each participant and mean was calculated as μ= 15.62 , and $\boldsymbol{\delta^2}$ = 1.68 using the formula given below

$$n = \frac{Z^2_{1-\alpha/2} P(1-P)}{\varepsilon^2}$$

$Z_{1-\alpha/2}$ = Level of Significance = 95%
P= Expected proportion with pain= 5%
ε =expected margin of Error = 5%
The calculated sample size from above given n=75

Study Instrument: Stop Watch, Performa for NPRS (Numeric Pain rating scale, Performa for Student Specific Cornell Musculo-skeletal discomfort questionnaire

Inclusion Criteria

- Young healthy adults,
- Age ranging from 18 -25years
- Both males and females

Exclusion Criteria:

- Rheumatoid arthritis, Metabolic disease, psychological problems, fibromyalgia, spinal fractures, previous history of spinal trauma/tumor
- Subjects with chronic illness i.e. musculoskeletal, systematic, psychological or any other comorbidity i.e. diabetes, hypertension, hematological issues. Subjects with any history of trauma or injury

Data collection procedure:

Subjects will be recruited on the basis of exclusion and inclusion criteria by convenient sampling. Subjects will receive detailed information about the purpose and methodology of the study. Prior to participating, written consent will be obtained from each subject, and the study protocol will be provided.

After signing the consent, basic demo graphs will be noted. Muscle strength and muscle flexibility will be examined and documented. Then the subjects will be asked to be positioned in squatting, most specifically wall squat position with back straight and 90º knee flexion as quadriceps muscle activity is maximum in this position. The subject will be asked to report immediately if they feel any discomfort and then the time will be noted on a stop watch and the subject will be asked to answer the questions from the performa. The whole procedure will take approximately 3-5 minutes.

Scoring category for pain will be assessed as (mild pain, moderate pain, high pain). The frequency of discomfort will be scored based on the following scale: 1 (never), 2 (1-2 times last week), 3 (3-4 times last week), 4 (once every day), and 5 (several times a day). The degree of discomfort will be scored as 1 (slightly uncomfortable), 2 (moderately uncomfortable), or 3 (very uncomfortable). In addition, interference with daily activities will be assessed on a scale of 1 (not at all), 2 (slightly interfere), or 3 (substantially interfere).

Ethical Considerations:

The approval of the institutional ethics committee took place at the level of the project synopsis. A written consent form of the participant was obtained before embarking upon data collection. Confidentiality was assured and ensured. The dignity of participants was respected at all examinations.

Statistical Analysis:

After the collection of data, the data was recorded and analyzed using SPSS version 23. Pearson correlation was used to examine the relationship between different variables i.e. pain discomfort, age and squat holding time

A p-value greater than 0.05 signifies that the data is distributed normally or symmetrically, while a p-value less than 0.05 indicates that the data is asymmetrical. The relationship between the duration of squatting and pain or discomfort was assessed using Pearson's correlation.
In statistical analysis, the Independent t-test is employed to compare differences between groups while the Paired Sample t-test is used for comparing differences within groups. A p-value below 0.05 is considered significant, whereas a p-value above 0.05 is deemed insignificant.

Results: -

The SPSS version 23 was utilized for inputting and analyzing the data. During performance of squat the point of pain, intensity of pain discomfort and their inference with activities were observe and noted according to pain and discomfort scales. Every student among female and male had different level of pain and discomfort

Among males n=35 only 18 were going to gym within 51.4%gender and 17 were not going to gym within 48.6% of gender. Among females n=40 only 13 students were going to gym within 32.5% of gender and 27 were not going to gym within 67.5%of gender as shown in table no 03. Among males 20 participants practiced lower limb exercises within 57.1% of gender and 15 were not. Among females 19 were practiced lower limb exercises while 21 were not there percentage within gender was 47.5%.

Among males 22 participants were performed the squat exercise and 13 were never performed squat exercise in gym and among females 25 were performed squat exercises in gym but 19 were not performed even before. During performance of squat the point of pain, intensity of pain

discomfort and their inference with activities were observe and noted according to pain and discomfort scales.

Among female participants 22 felt slightly uncomfortable while 18 felt moderately discomfort during squat. 47 students out of all males and females felt slightly uncomfortable within %age gender of 62.7% while 28 out of all felt moderately discomfort within %age gender of 37.3%.

Table 1: -Demographics statics: -

Gender	**Frequency(N)**	**percent**	**Mean age± St. Deviation**	**Std. Error Mean**
Male	35	46.7	21.94±2.1685	0.36655
Female	40	53.3	21.27±2.037	0.32223
total	75	100.0		

Table is showing frequency among the students 40(53.3%) were female and 35(46.7%) were male.

Table 2: Chi-square for Degree of pain

	VALUE	DF	ASYMPTOTIC SIGNIFICANCE (2-SIDED)	EXACT SIG. (2-SIDED)	EXACT SIG. (1-SIDED)	POINT PROBABILITY
Pearson Chi-Square	1.689[a]	1	.194	.271	.179	
Continuity Correction[b]	.855	1	.355			
Likelihood Ratio	1.774	1	.183	.271	.179	
Fisher's Exact Test				.271	.179	
Linear-by-Linear Association	1.667[c]	1	.197	.271	.179	.135

Among female 35 experienced pain in lower limb with different level of intensities. 14 female students experienced low pain, 4 experienced high and 16 experienced moderate pain within %age gender of 35.0%,10.0% and 40.0% respectively.

Among male participants 30 students experienced pain in lower limb with different intensities .18 male participant experienced low, 4 experienced high while 11 experienced moderate level of pain within %age gender of 51.5%,11.4% and 31.4% respectively.

Table 3: -

Chi-square for degree of discomfort:

	VALUE	DF	ASYMPTOTIC SIGNIFICANCE (2-SIDED)	EXACT SIG. (2-SIDED)	EXACT SIG. (1-SIDED)	POINT PROBABILITY
Pearson Chi-Square	.047[a]	1	.828	1.000	.523	
Continuity Correction	.000	1	1.000			
Likelihood Ratio	.047	1	.828	1.000	.523	
Fisher's Exact Test				1.000	.523	
Linear-by-Linear Association	.046[c]	1	.830	1.000	.523	.209

Degree of discomfort was observed differently among male students. 25 students felt slightly uncomfortable and 10 felt moderately discomfort during squat. Among female participants 22 felt slightly uncomfortable while 18 felt moderately discomfort during squat. 47 students out of all males and females felt slightly uncomfortable within %age gender of 62.7% while 28 out of all felt moderately discomfort within %age gender of 37.3%.

Table 4: Chi-square for frequency of pain and discomfort

	VALUE	DF	ASYMPTOTIC SIGNIFICANCE (2-SIDED)	EXACT SIG. (2-SIDED)	EXACT SIG. (1-SIDED)	POINT PROBABILITY
Pearson Chi-Square	2.153[a]	1	.142	.159	.109	
Continuity Correction	1.508	1	.219			
Likelihood Ratio	2.176	1	.140	.159	.109	

Fisher's Exact Test				.159	.109	
Linear-by-Linear Association	2.125[c]	1	.145	.159	.109	0.66

Among males 10 experienced discomfort and pain for 1-2 times last from lower limb exercise while 26 male students had no episodes of discomfort and pain. Among female participants only 8 students had experienced discomfort and pain 1-2 times last while 31 had not experienced £any discomfort and pain. Among total of male and female students 57 had no experienced discomfort and pain after lower limb activity while 18 experienced discomfort and pain 1-3 times after activity

Table 5:

T-Test

	Gender	**N**	**Mean**	**Std.deviation**	**Std.error mean**
Age	**Male**	35	21.9429	2.16853	.36655
	Female	40	21.2750	2.03794	.32223
Holding time for squat seconds	**Male**	35	17.0937	3.10978	.52565
	Female	40	15.7590	3.04411	.48132

Independent t-test is used to compare differences between groups. Holding time for squat was noted in both male and female participants. The mean holding time of squat in male students was 17.09±3.109 and for female students was 15.75±3.0441

Discussions: -

This study recruited 75 participants, age 18-25 years (21.49±1.29). After obtaining the consent from the participants who were fulfilling the inclusion criteria, squat holding time and level of discomfort and pain are noted. Each reading was noted once to prevent the fatigue. The present study correlates the time and level of discomfort and pain and also calculates the association of squatting and quadriceps.

In contrast to unilateral squats, which were mostly utilized as additional or rehabilitation exercises, bilateral squats were frequently employed in lower body strength training programs in the earlier research. According to the findings, the squat exercise exhibits peak quadriceps activity at an angle of 80–90 degrees. Wall squats with hip support were found to potentially enhance quadriceps activity. The squat exercise, as a whole, is considered beneficial for strengthening the entire lower limb. (Vecchio, Daewoud et al. 2018)

But this study shows that the association of time duration and level of discomfort and pain in quadriceps during squatting. It explains the time after which discomfort and pain starts to appear in a healthy adult during squatting, which is being used for core stability training. Fatigue sets in, after discomfort and pain and it has been shown to be a precursor to injury as a fatigued muscle is not able to absorb sufficient energy due to a reduced ability to generate forces. After fatigue, exercise is of no beneficence.

The existing literature supported the use of Squats in core stability, strength training and rehabilitation(Eliassen, Saeterbakken et al. 2018)

But still there was no evidence and literature on relationship of pain & discomfort with squats and optimal required time frame for squatting in core stability training. This study will provide understanding of ultimate time frame of squatting without pain & discomfort for designing effective training protocols for core stability exercises.

This study also introduces and raises the awareness of proper physiotherapy exercises that can reduce the level of pain and discomfort among healthy adults.

Quadriceps dysfunction caused by both pain and swelling, but the combination of these stimuli does not result in an increase in the or extent of the activation deficit. Therefore, the stimulation of quadriceps inhibition is equally effective through the presence of pain and effusion. Considering that many knee disorders are accompanied by pain and effusion, it is likely that quadriceps dysfunction occurs frequently. (Palmieri-Smith, Villwock et al. 2013)

A study carried out in Beijing, China has found that squatting for extended periods after experiencing initial pain is a significant risk factor for knee osteoarthritis (OA). The likelihood of developing tibiofemoral OA increased as the amount of time spent squatting at age 25 increased for both men and women. This was observed when comparing individuals who squatted for less than 30 minutes per day at age 25. (Zhang, Hunter et al. 2004). A study conducted in Pakistan found similar results, showing that the prevalence of the phenomenon increased with age and was more common among women.

Participants' involved in gym training and lower limb exercises had longer average time of holding squats up to the limit of pain and discomfort than the ones who had no gym exposure or exercise training before.

CONCLUSIONS:

There is moderate pain intensity and slight discomfort associated with squat holding time. Longer the holding time, greater is the fatigue that sets in, after discomfort and pain and it has been shown to be a precursor to injury as a fatigued muscle is not able to absorb sufficient energy due to a reduced ability to generate forces. After fatigue, exercise is of no beneficence

Limitation

The limitations of this study are as follows:

- Data is taken from Shalamar school of allied health sciences where frequency of females' participants is higher than the male participants
- Single reading was taken for all variables

Suggestions

Suggestions for this study are as follows:

- Co-relation of pain and discomfort with age can be found
- Muscles other than quadriceps can be studied to observe pain and discomfort
- Exercise like lunges, bridging can be used in place of squatting
- Ground squat can be used in place of wall squat
- Comparison between gym going and non-gym going population can be made

Conflict of interest: Authors revealed no competing interest.

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