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Effect of Inclined Squat Position on Neuromuscular Activity of Gluteus Medius and Gastrocnemius Muscles in Normal Children

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ABSTRACT

Background: The varied position of squatting involves bending the knees and hips while maintaining the body's weight on the feet. Variations of used tools in squat and angles of joints affect the neuromuscular activity of the muscles. The muscles in the lower limbs are crucial for maintaining a good gait as well as for doing various exercises like jumping and sprinting. **Objective:** This study aimed to investigate how the inclination of ankle joint affects the activity of gluteus medius (GMed) and gastrocnemius (GC) muscles.

Methods: Thirty normal children were included in this study. Two wooden wedges covered by rubber with inclination angles 5 and 10 degrees were used. To examine the muscle activity of the GMed and GC, a comparison analysis with electromyography was conducted. **Results:** The muscle activity of GMed and GC muscles increased with increased the angle of inclination. When squatting on 5 degrees inclined board, the muscle activity of both muscles was significantly higher than during squatting on the ground, and when squatting on 10 degrees inclined board, the muscles activity was significantly higher than squatting on 0 and 5 degrees inclination.

Conclusion: Squatting on an incline board is a good position for increasing muscle activation in the GMed and GC.

Keywords: Electromyography, Neuromuscular activity, Normal children, Squatting.

INTRODUCTION

Among the several weight training techniques, squatting is the most popular exercise since it is simple to perform without the need for any equipment [(1)]. Squatting is a common closed-kinematic chain exercise that works several muscles and joints in the lower limbs and is utilized in physical rehabilitation and sports training [(2)]. It is among the most crucial components in developing leg strength. Squatting appears to be an evaluation tool in motor control assessment because of its multi-joint nature [(2)]. The gluteal, quadriceps, and trunk muscles—all crucial for running, leaping, and lifting—are strengthened by squat exercises. Squat exercises are superior to non-weight bearing workouts because they include greater joint movement, muscle mobilization, and more proprioceptive stimulation [(1)].

Surface electromyography (EMG) is a useful tool for quantifying muscle activity by measuring the electrical activity of a muscle using EMG amplitude [(3)]. EMG is frequently used to assess the time and force of muscle contractions [(4)]. The muscular contraction that has been studied the most is the isometric contraction [(5)]. According to **Phillips *et al.*** [(6)], exercise experts can get useful information to enhance the results of their training programs by using EMG to evaluate the isometric squat. According to **Schäfer *et al.*** [(7)], doing squat workouts on different surfaces and situations causes the trunk and lower extremities' muscles to contract more.

Workouts involving weight bearing were reported to have considerably higher gluteus medius activation than workouts without weight bearing [(8)]. Furthermore, compared to non-weight bearing workouts, weight bearing exercises more closely mimic functional activities of daily living [(8)]. This study's objective was to investigate the effect of inclined squat position on activity of Gluteus medius and Gastrocnemius muscles.

SUBJECTS AND METHODS

This was a cross-sectional study. Thirty normal children were recruited from 3 different schools at Nasr City.

Sample size calculation: The G*POWER statistical program (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany) was used to conduct the analysis, which showed that a sample size of 30 subjects was necessary for this investigation. Based on a prior pilot research, calculations were performed using MANOVA repeated measures, within factors with α=0.05, β=0.2, and effect size = 0.35.

Participants: The thirty typical children (19 males and 11 girls) took part in the research. The age range of the children was 10 to 14 years old. The children had typical physical characteristics and were capable of independently completing everyday tasks. Their average weight and height were within normal ranges, and they demonstrated the ability to comprehend and adhere to directions during the testing process, resulting in precise and trustworthy measurements.

Exclusion criteria: Any foot or lower limb deformity, leg length disparity, poor balance, aberrant gait pattern, history of lower extremity surgery, musculoskeletal abnormalities such as flat foot, and visual or hearing impairments.

Procedures: This cross-sectional study was used to assess the effect of inclined squat posture on the gluteus medius (GMed) and gastrocnemius (GC) muscles at varied inclination angles 0°, 5°, and 10° beneath the foot in normal children. Following the electrodes' insertion to the subject's GC and GMed, the

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maximum voluntary isometric contraction (MVIC) was assessed. The volunteers were able to comprehend the experimental technique by practicing each position at least three times before the experiment began, thanks to the researcher's thorough description of the squat action to them.

Using the BioTrace+ software for the Nexus-10 biofeedback system (Mind Media, UK), electromyographic data were captured at a sample frequency of 2048Hz [(9)]. To lessen skin resistance, electrode locations were shaved and then massaged with a cotton swab soaked in alcohol. Surface electrodes were spaced more than two centimeters apart [(10)].

The GMed and GC muscles' EMG data were gathered. On the line connecting the greater trochanter to the iliac crest, the GMed electrodes were positioned at 50%. This role aligns with the GMed's highest level of significance. The GC electrodes were positioned at one-third of the distance from the heel to the head of the fibula. At the tibial tuberosity, the ground electrode was positioned. The root mean square values were calculated from the raw data within a 50 ms interval. In order to reduce variables or disparities across various recoding locations and people, normalization was required [(11)].

Squatting without inclination: While standing on the ground, the arms were extended forward in a motion parallel to the floor while the feet were split shoulder-width apart. The waist and knee were bent such that the head and knees did not overlap the toes; the knees were bent up to 95° and kept in this posture for about three seconds. Then squatting on 5° inclined wedge. After that squatting on 10° inclined wedge.

Ethical consent: The Ethical Research Committee of Cairo University's Faculty of Physical Therapy accepted the study's protocol [P.T.REC/012/004078]. All participants gave their informed consents after being educated about the procedures, risks, and benefits before to participation. Throughout the course of the investigation, the Helsinki Declaration was adhered to.

Statistical Analysis

SPSS version 22.0 for Windows was used to conduct all statistical tests. The measured variables were presented using descriptive statistics in the form of mean ± standard deviation, minimum, maximum, and frequency. The EMG amplitudes of GC and GMed were compared between 0, 5 and 10 degrees of inclination using an ANOVA with repeated measurements. Every statistical test had a significance threshold of $p \leq 0.05$.

RESULTS

All children had the right side as dominant side. Their mean age, weight, height and body mass index (BMI) were 12.77 years, 41.13 kg, 154.82 cm and 17.22 kg/m² respectively (Table 1).

Table (1): Basic characteristics of participants

	mean ± SD	Maximum	Minimum
Age (years)	12.77 ± 1.43	14	10
Weight (kg)	41.13 ± 3.74	48	33
Height (cm)	154.82 ± 8.95	171	138
BMI (kg/m²)	17.22 ± 1.57	20.89	14.36
	N	**%**	
Sex distribution			
Girls	11	36.7	
Boys	19	63.3	

There was a significant effect of inclination on EMG amplitude of GC and GMed ($F = 17.79$, $p = 0.001$, partial eta squared = 0.84). There was a significant increase in EMG amplitude of right and left GC muscles at 10 degrees of inclination compared to that at 5 and 0 degrees ($p < 0.01$, $p < 0.01$) respectively and a significant increase in EMG amplitude at 5 degrees of inclination compared to that at 0 degree ($p < 0.01$) (Table 2).

Table (2): Mean Gastrocnemius muscle EMG amplitude at 0, 5 and 10 degrees of inclination

Gastrocnemius EMG amplitude (mV)	0 degrees mean ± SD	5 degrees mean ± SD	10 degrees mean ± SD	P value
Right	5.81 ± 2.47	7.58 ± 3.06	9.19 ± 3.26	0.001
Left	4.94 ± 1.35	6.26 ± 1.92	8.54 ± 2.49	0.001

	Multiple comparison						
	Right			Left			
	Mean difference	% of change	p- value	Mean difference	% of change	p- value	
0 degrees vs 5 degrees	-1.77	30.46	0.01	-1.32	26.72	0.001	
0 degrees vs 10 degrees	-3.38	58.18	0.001	-3.6	72.87	0.001	
5 degrees vs 10 degrees	-1.61	21.24	0.01	-2.28	36.42	0.001	

There was a significant increase in EMG amplitude of right and left GMed muscles at 10 degrees of inclination compared to that at 5 and 0 degrees ($p < 0.05$, $p < 0.05$) respectively and a significant increase in EMG amplitude at 5 degrees of inclination compared to that at 0 degree ($p < 0.01$) (Table 3).

Table (3): Mean Gluteus medius muscle EMG amplitude at 0, 5 and 10 degrees of inclination

Gluteus medius EMG amplitude (mV)	0 degrees mean ± SD	5 degrees mean ± SD	10 degrees mean ± SD	P value
Right	11.41 ± 2.81	13.28 ± 3.41	15.11 ± 5.65	0.001
Left	11.34 ± 3.74	12.52 ± 4.71	14.78 ± 5.55	0.001

	Multiple comparison						
	Right			Left			
	Mean difference	% of change	p- value	Mean difference	% of change	p- value	
0 degrees vs 5 degrees	-1.87	16.39	0.0٠٥	-1.18	10.41	0.01	
0 degrees vs 10 degrees	-3.7	32.43	0.00٥	-3.44	30.34	0.001	
5 degrees vs 10 degrees	-1.83	13.78	0.0٢	-2.26	18.05	0.001	

DISCUSSION

This study aimed to evaluate the impact of an inclined squat position on GMed and GC muscle activation. According to **Vianna *et al.*** [12], compared to other workouts like the bench press, triceps extension, and latissimus pull down, the half-squat exercise exhibited a considerably higher energy consumption.

In **Allam's** [13] investigation, it was proven that the squat exercise with a 10° inclination substantially enhanced muscular activation in the Gluteus Maximus compared to the squat at neutral or 5° inclination. It was proposed that increasing the base angle limits the mobility of the ankle joint, causing the center of gravity to shift backward, and increasing the muscle activity of the Vastus Medialis Obliques [13].

Alizamani *et al.* [14] found that exercise on unstable support surfaces stimulated more neuromuscular systems than on stable support surfaces.

Since the exercise we presented in our study used both feet and is consequently more stable than a bipodal execution, the elevated activation of the gluteal muscles may have resulted from pelvic and knee stability [15]. In actuality, squats are commonly done for rehabilitation even though they don't require an external load [16].

Regarding lower limb exercise, **Muyor *et al.*** [17] discovered that the Vastus Lateralis and Vastus Medialis had much greater EMG activity than the other muscle groups. A comparable activation of the GMed and Rectus Femoris was also noted [17].

Rodrigues *et al.* [18] reported that in women with patellofemoral discomfort, lower proximal and distal EMG amplitudes during the single-leg squat appear to be influenced by hip abductor strength and ankle dorsiflexion range of motion. Additionally, because the support surface was unstable, raising the ankle angle induced the muscles to contract in order to maintain balance, which in turn stimulated the Gluteus Maximus to contract in order to overcome the instability [19]. Furthermore, the 10° inclination only allowed for 50% of the ankle's dorsiflexion, which caused the ankle to become unstable and the muscles to contract [20]. The Gluteus Maximus muscle exhibited an increase in activity to counteract instability [20].

Cho *et al.* [21] demonstrated that increasing the angle of inclination in healthy normal people changes muscular activation in the femoral head muscles.

CONCLUSION

Modification of ankle dorsiflexion during the squat posture should be included in rehabilitation regimens for various ailments. This study demonstrated that this form of intervention can be an effective way to improve the lower limb strength of healthy youngsters.

LIMITATIONS

Small sample size so we recommend providing larger sample size to validate our results.

- **No funding.**
- **No conflict of interest.**

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