Original Article

Journal of Iranian Medical Council, Volume 7, Issue no. 3
http://dx.doi.org/10.18502/jimc.v7i3.15734

Effects of Gluteal Muscles Isometrics on Abdominals, Back Extensors and Quadriceps Strength

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Received: 22 Aug 2023
Accepted: 28 Oct 2023

Citation to this article
Kumar M, Sharma B, Mohanty P, Arya P, Nakhostin Ansari N, Ali K. Effects of Gluteal Muscles Isometrics on Abdominals, Back Extensors and Quadriceps Strength. *J Iran Med Counc*. 2024;7(3):566-71.

Abstract

Background: Weakness of the gluteus muscle is associated with multiple types of injuries such as low back, hip and knee pathology. However, there is no research regarding the effect of gluteal isometric exercises on abdominals, back extensors and quadriceps muscles strength. Hence, this study aimed to demonstrate the effect of gluteal isometric exercises on abdominals, back extensors and quadriceps strength.

Methods: A total of 100 healthy students aged between 18 and 25 years were recruited to participate in an 8-week program of gluteal muscle isometric exercises. The strength of the abdominal, back extensor, and quadriceps muscles was assessed both at baseline and after the 8-week intervention period.

Results: A paired sample t-test revealed significant improvements in abdominal muscles, back extensor muscle strength ($p<0.001$), and quadriceps muscle strength ($p=0.037$) after an 8-week intervention. The greatest increases were observed in the abdominals (59.05%), back extensors (46.78%), and quadriceps (7.13%).

Conclusion: This study demonstrates that gluteal isometric exercises had a significant positive effect on the strength of abdominals, back extensors and quadriceps muscles.

Keywords: Abdominal muscles, Exercise, Infant, Muscle strength, Quadriceps muscle, Students

Introduction

The interconnection between various segments of the lower limb in the kinematic chain has been widely recognized. Aside from the kinematics, the kinetics aspect, involving the muscle forces responsible for joint movement, is also intricately intertwined (1). The gluteus maximus plays a crucial role in stabilizing the Sacroiliac Joint (SIJ), providing strength for lifting heavy objects, and controlling gait (2,3). Its proximal attachment to the sacrotuberous ligament tightens the ligament, enhancing joint stability while reducing mobility and contributing significantly to hip extension and pelvic stabilization during task-like lifting (2,3). Research has emphasized the importance of contracting the gluteus maximus early in the lifting phase to promote pelvic stability and ensure safe movement (4).

Studies have shown that individuals with chronic low back pain and sacroiliac dysfunction experience reduced pain after strengthening their gluteal muscles (5,6). Low back pain has been associated with alterations in hip extensor recruitment patterns and disrupted lumbopelvic coordination, both of which involve the gluteus maximus muscle (7,8).

Enhanced hip abduction strength is believed to reduce the load on the knee and the risk of injury by counteracting the inward motion of the hip in adduction and mitigate the forces that can lead to knee valgus (inward angling of the knee) and abduction loads associated with acute knee injuries, including Anterior Cruciate Ligament (ACL) injuries, particularly in female athletes (9). Weakness in the gluteal muscles has been linked to a variety of injuries, and strengthening these muscles is related to successful rehabilitation for various conditions (10). Specifically, gluteal strength involving hip abduction, external rotation, and extension has been independently linked to non-contact ACL injuries and knee overuse injuries (11). Additionally, the strength of the gluteus maximus, acting as a hip extensor and external rotator, has been connected to Patellofemoral Pain (PFP) in numerous studies (12,13). A study conducted by Ferber *et al* in 2015 involved 54 females with PFP to assess whether incorporating hip muscle strengthening into a traditional program focused on knee muscle stretching and strengthening yielded better outcomes than the knee-focused program alone (14). The findings revealed that adding hip muscle strengthening exercises resulted in greater improvements in pain and function compared to a rehabilitation program solely targeting the knee (14). Furthermore, gluteal strength has been associated with reducing the risk of falls in the elderly population and alleviating medial tibial pain in college-aged females (15,16). However, the relationship between gluteus medius strength and patellofemoral pain remains somewhat unclear (17). In summary, it is evident that gluteal strength plays a significant role in preventing injuries and addressing various pathologies, extending from the lower back to the lower leg.

The gluteal squeeze exercise is a suitable isometric setting exercise that has been shown to produce higher Electromyographic (EMG) activity compared to many other conventional therapeutic exercises (18). Specifically, the standing gluteal squeeze generates sufficient EMG activity to serve as a position for achieving maximum voluntary isometric contraction of the gluteus maximus (19).

However, the recruitment of abdominal muscles, back extensors, and quadriceps muscles during the gluteal squeeze exercise has not been thoroughly examined, and the impact of the gluteal squeeze on the strength of these surrounding muscles is an under-researched aspect. This study could benefit the geriatric population, as they are more susceptible to developing degenerative changes in the hip and knee joints associated with weakness in the abdominal, back extensor, and quadriceps muscles. Rather than performing separate exercises for each muscle group, designing a single exercise to strengthen all these muscles could prove to be a more effective approach.

Materials and Methods

This is a one group pretest-posttest quasi-experimental design. After obtaining ethical clearance from the Institutional Ethics Committee (IEC) (IEC/MPT-ORTHO/21-22), subjects who fulfilled the inclusion and exclusion criteria were selected for intervention. We included healthy subjects between 18-25 years of age; the subjects had appropriate muscle power, Range of Motion (ROM) and balance ability for performing the exercises in the experiment, muscle power was measured through MMT (Manual Muscle Testing), ROM was measured by goniometry and

balanced was measured through One Leg Stand Test. In case subjects reported current pregnancy, spine, hip, knee pain and had a history of backache and any kind of respiratory problems, recent musculoskeletal trauma, recent period of hospitalization, surgery or injury were excluded.

A hundred subjects (50 males and 50 females) were evaluated as per the inclusion and exclusion criteria, recruited from the department of physiotherapy in SVNIRTAR, India. The entire procedure was explained to the subjects. Verbal instructions were given to them for the study and informed consent was taken from every subject before their participation in the study. Before initiating the intervention, the strength of the abdominals, back extensors and quadriceps were assessed. Therapy started on the same day after evaluating the muscle strength. Abdominal strength was measured by a modified sphygmomanometer. The subjects were made to lie on the plinth in the prone position, and the cuff of the sphygmomanometer was placed under the abdomen. The cuff was inflated up to 70 *mmHg*. The subjects were asked to perform the drawing-in manoeuvre. A decrease of 6 to 10 *mmHg* during the drawing-in manoeuvre indicates proper activation of the deep abdominals. It was done 3 times for 5 *s* with 15 *s* relaxations (ICC 0.51 to 0.94) (19).

Back extensor strength was measured by subjects positioned in a prone and a sphygmomanometer placed over the upper thoracic region inflated up to 20 *mmHg*. Both hands were placed over the lower back region, and instructions to lift the upper back till the sphygmomanometer touched the rod attached to the suspension table. It was done 3 times for 5 *s* with 15-*s* relaxations (ICC=0.57 to 0.98) (20).

For evaluating quadriceps strength, the participants were made to lie on a flat surface such as an examination couch. A sphygmomanometer cuff was rolled out and placed just below the popliteal fossa, and inflated to 20 *mmHg*. In this position, the participants were prompted to push the knee down with the maximum available power. This pressure needs to be maintained for 5 *s* before being released to the initial position with 15 *s* relaxations for 3 repetitions (ICC range: 0.64–0.92) (21).

A gluteal squeeze was prescribed to perform in the supine position. The subjects were made to lie on the plinth and 20 repetitions of gluteus squeeze were performed for 5 *s* followed by 5 *s* relaxations. The subjects performed the following sets of exercises for 8 weeks (5 days per week). The exercise was performed in a set of 20 repetitions; one set was performed twice a day for the 1st and 2nd week and this progressed to two sets twice a day until the 4th week and then three sets twice a day until the 6th week and finally four sets twice a day until 8th week. After the completion of the 8-week program, post-assessments were conducted to evaluate the strength of the abdominal muscles, back extensors, and quadriceps muscles.

Data analysis

Data were analyzed using SPSS version 28. The normality of the data was ascertained using the Shapiro–Wilk test. The demographic characteristics and pre-post intervention findings were assessed using paired sample t-tests to identify any significant differences in abdominal, back extensor, and quadricep muscles strength. A p-value of <0.05 was considered as significant.

Results

At baseline and after the intervention, variations in abdominal, back extensor, and quadriceps muscular strength were assessed within the group and the data was presented in mean and Standard Deviation (SD). There was a statistically significant difference in abdominal and back extensor muscle strength ($p<0.001$*) between the baseline and the 8-week intervention. Similarly, the gluteal strengthening exercises also enhanced the strength of the quadriceps muscles ($p=0.037$*). Maximum strength difference was noted in the abdominals, which was 59.05%, followed by the back extensors, which was 46.78%, and the quadriceps, which were 7.13% (Table 1, Figure 1).

Discussion

The primary findings of the study demonstrate a significant improvement in the strength of abdominal, back extensor, and quadriceps muscles over the 8-week intervention period. When comparing the strength of the back and leg muscles to that of the abdominal muscles, the percentage changes reveal a

Table 1. Results (mean±SD) of Abdominal, Back Extensor and Quadriceps Muscles strength before and after 8 weeks using paired T-Test. Along with Percentage changes

Variables	T0	T1	Difference (T1-T0)	Percentage changes (T0 to T1)	t-value	p-value
Abdominal muscle strength (*mmHg*)	16.12±7.43	25.64±11.05	9.52±3.62	59.05%	-3.51	*
Back extensor muscles strength (*mmHg*)	75.9±37.78	111.41±45.86	35.51±8.08	46.78%	-11.5	*
Quadriceps muscles strength (*mmHg*)	46.23±16.89	49.53±15.54	3.3±1.35	7.13%	-2.11	0.037

T0: Pre intervention values; T1: Post intervention values; * significant (p<0.001).

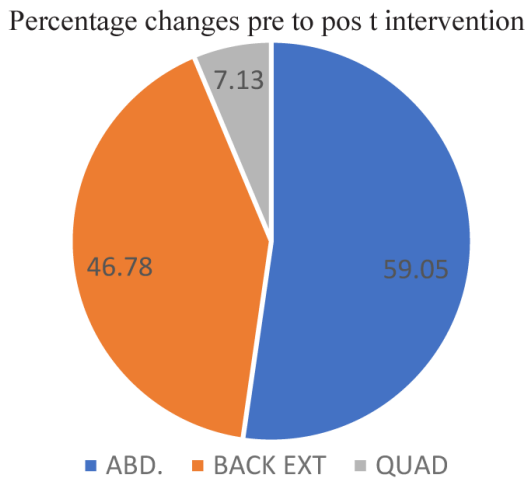

Figure 1. Percentage changes for pre to post intervention in abdominal muscles strength (ABD.), back extension muscles strength (BACK EXT), and quadriceps muscles strength (QUAD).

more pronounced enhancement in abdominal muscle strength.

Following the intervention, our results underscore a noteworthy disparity in strength, particularly in the abdominal muscles (59.05%). This could be attributed to an interplay between the gluteus and abdominal muscles, akin to what is observed in cases of lower cross syndrome. This syndrome is characterized by heightened activity in hip flexors and lumbar extensors, leading to excessive activation and tension. Consequently, this results in reduced activation and subsequent weakness in the deep abdominal muscles at the front, as well as in the gluteus maximus and medius muscles at the rear. Individuals with this syndrome consequently experience concurrent weakening of both their abdominal muscles and gluteus maximus muscles (22). As a result, it is recommended to undergo core muscle stabilization training in conjunction with strengthening exercises for the gluteal muscles as part of the treatment for Chronic Lower Back Pain (CLBP) (23). However, there is limited research exploring the impact of gluteal muscle isometric exercises on the abdominals, back extensors, and quadriceps, which restricts our ability to compare this study's findings with those of others. Nevertheless, targeting the gluteus maximus muscle for strengthening proves beneficial in rehabilitating various conditions, including hip, knee, and lower back pain (24,25).

Moreover, the present study represents significant improvements in the strength of both back extensors and quadriceps muscles. Strengthening the gluteus maximus in conjunction with the abdominal muscles, especially the rectus and transverse abdominis, and the quadriceps muscles is crucial for performing a wide range of functional movements (26). Activities like squatting, jumping, and running require the coordinated operation of these muscles, leading to balance, force production, and precision (27). As the gluteus maximus extends the hips, it also contributes to generating force that traverses through the core and into the quadriceps, which is relevant for exercises involving leg extensions (27,28). Diminished gluteal strength can result in compensatory movements and muscle imbalances, potentially increasing the risk of lower back, hip, and knee injuries (28). This underscores the interconnectedness of gluteal muscles with other core and leg muscles (28,29).

Incorporating exercises designed to strengthen the gluteus maximus into a physiotherapy regimen can significantly enhance abdominal and quadriceps muscle strength.

Conclusion

The study's findings underscore the critical role of strengthening the gluteal muscles in maintaining the overall strength of core muscles such as the abdominals, back extensors, and lower limb muscles like the quadriceps. It is worth highlighting that any instability in the hip can lead to excessive strain on the back and knee, and vice versa. These findings carry both clinical and aesthetic implications, emphasizing the significance of integrating gluteal squeezes into exercise routines for individuals dealing with hip, knee, or low back conditions. Future studies should concentrate on evaluating the effects of these interventions specifically in individuals dealing with hip, knee, or low back problems, rather than solely focusing on individuals in good health.

Conflict of Interest

The authors declare that they have no conflict of interest.

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