EFFECTS OF TWO TRAINING PROTOCOLS ON THE STRENGTH OF THE MEDIUS AND MAXIMUS GLUTEUS IN ADULT WOMEN

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Abstract
Gluteal muscles are involved into a lot of daily life and sport movements. A review on the best exercises for gluteal muscles[1] suggests how to maximize the EMG activation of these muscles but does not offer any kind of information about the best way to train and about the effects of a training period of gluteal muscles on movement control. Aim of this study is to compare two different training protocols. Fifteen volunteer women (36.6±5.5 yrs; 162.4±5.1 cm; 58.4±6.6 kg) were divided in two homogeneous training groups. Each group was trained by the same instructor for 6 weeks, 2 time/w, 30'/session, the training volume and rest were the same for both groups. Three analytical exercises with emphasis on gluteus medius (Gm) and three integrated exercise with emphasis on gluteus maximus (GM) were performed in A-group and I-group respectively. Manual muscle test with hand held dynamometer (Lafayette Instrument, Sagamore Pkwy, USA) and single leg squat video analysis (Freestep, Sensor Medica, Guidonia-RM, Italy) were performed pre and post the training period. Both Gm and GM strength significantly improved after both protocols (Gm ↑ 26% and 40%; GM ↑ 78% and 90% in A-group and I-group respectively). I-group showed highest values of improvement in comparison with A-group but there were only two significant differences (left Gm max strength and right GM mean strength). No significant differences were found in single leg squat control and deepness for any group. Gluteal muscles training seems to be effective both with analytical and integrated exercises. The study does not show a strong significant difference between the groups in terms of strength improvement. Moreover single leg squat control and deepness seems to be not connected with analytical or integrated gluteal muscles training.

Key words: *gluteus medius, gluteus maximus, gluteal strength, gluteal functions, gluteal exercises.*

Introduction

The acquisition of upright posture, distinguishing man from all primates, has led in time to a series of morphological, structural and functional changes characteristic of the evolution process. The hip is the most involved structure that has to adapt to the new conformation of the pelvis and equip itself with strong muscles.

The muscles have thus developed in the gluteal region to insure the stability of the upright posture, intervene in the correction of eventual anomalous oscillation of the barycenter, all for the better of walking and running (Raimondi & Vincenzini, 2006).

The development of the gluteal muscle is actually a human characteristic; in proportion, the quadrupeds' gluteal muscles are less developed (Delavier, 2010). The gluteal musculature has a fundamental importance in kinesiology and consequently requires particular attention.

The hypothesis is to improve the efficiency of the medius gluteus (Gm) and maximus gluteus (GM) by means of specific exercises to increase the gluteal strength. The aim of the study is to verify the efficacy of the exercises selected to increase the strength of the Gm and GM and verify if the trained musculature can contribute to modify the bending angles of the knee and thus help to control movements.

Materials and methods

The research has been carried out on a sample of 15 voluntary adult women (age 36.6 ± 5.5; height 162.4 ± 5.1 cm; weight 58.4 ± 6.6 Kg). To be able to participate in the study, the subjects have to be of female gender, in good health and not having had serious injuries three months prior to the test. The tests were carried out with a hand held dynamometer, (Lafayette Instrument, Sagamore Pkwy, USA) (Thorborg, Petersen, Magnusson, & Holmich, 2010), a Logitech C615 Full HD 1080p videocamera (Logitech, Aquino-FR, Italy) and FreeStep v.1 analysis software video (Sensor Medica, Guidonia-RM, Italy). The training was performed with the aid of small equipments (5 Kg dumbbell, strong elastic band, strong elastic loop).

For the 2 homogeneous groups we have foreseen 2 training sessions per week of about 30' each, for a period of 6 weeks. The first group, of 8 subjects, called Analytical Group, carried out exercises aimed principally at the Gm. The second group, of 7 subjects, called Integrated Group, carried out exercises for the Gm and GM. Each exercise was carried out in 2 series of 10 repetitions with 1' recovery time between the series and 2' between the exercises (Weineck, (2009). During the execution of the exercises the work rhythm was scanned and the technique checked.

The unilateral exercises were carried out on both limbs alternatively. The A-Group performed 3 exercises in random order: the Pelvic Drop (fig.1), the Side Lying Hip Abduction (fig.2) and the Side-bridge (fig.3) (Bolgla & Uhl, 2005; Ayotte, Stetts, Keenan, & Greenway, 2007; Boren et al., 2011).

Figure 1 Pelvic drop; Figure 2 side lying hip abduction; Figure 3 side bridge.

The I-Group performed 3 different exercises, among which where the Front Lunge (fig.4), the Single Leg Squat Hip Abduction (fig.5) and the Squat Hip Abduction (fig.6) (Bolgla & Uhl, 2005; Ayotte et al., 2007; Boren et al., 2011).

The study foresees randomly controlled repeated measures on the same sample. Each subject of the sample group was tested, by the same operator, before the training and after 6 weeks, at the end of the training protocol.

Figure 4 Front lunge; Figure 5 single limb squat hip abduction; Figure 6 squat hip abduction.

Each subject underwent: 1) A measurement (using a hand held dynamometer) to determine the maximum static strength (max, medium, peak time) of the maximus gluteus, in a prone decubitus position and the medius gluteus in a lateral decubitus position. Both measurements lasted 3″ and were repeated 3 times, first with one limb, then with the other. The instrument was placed behind the knee to measure the strength of the GM and at the top of the ankle for the strength of the Gm; 2) A videography (using the Freestep v.1 software) to obtain the bending angles of the knee both on the frontal plane (valgus angle of the knee) and on the sagittal while executing a bending of the lower limb, repeated for 12″ first on one limb, then on the other. The video camera was placed 160 cm from the work surface and 88.5 cm high (considering the distance from the support and the video camera's lens). The statistical analysis was carried out to study the significant differences between the 2 study groups. With this in view, before proceeding with the analysis, the Kolmogorov-Smirnov test was carried out to test the normality of the sample.

Once the samples of both groups were found to be normally distributed, the following parametric procedures of analysis were used: 1) *t*-test for independent samples to examine the pre-study differences between the 2 groups and test the average differences in the pre-post variations in the 2 groups; 2) Matched-pair-*t*-test in order to test the pre-post differences in each of the 2 groups. The significant level was set at $p<0.05$.

In addition to the parametric statistical tests, Choen's effect size (valued through Hopkins' scale) was calculated so as to obtain a better evaluation of the changes brought by the 2 training protocols on the 2 groups respectively.

Results

The data analysis didn't show any significant difference between the mean values of the analytical strength of the Gm and GM in the 2 groups at the time of the entrance test. This data reassures on the homogeneity of the sample choice.

After a training period, both groups have shown a significant improvement in all the parameters relative to the analytical strength of the Gm and GM (fig.7-8-9-10). In order to test the differences in groups, we used a matched-pair-*t*-test since the sample of both groups proved to be normally distributed. The significant level was set at $p<0.05$.

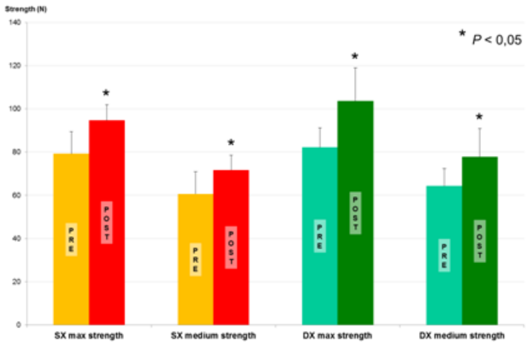


Figure 7 Pre-post training variations; analytical group medius gluteus.

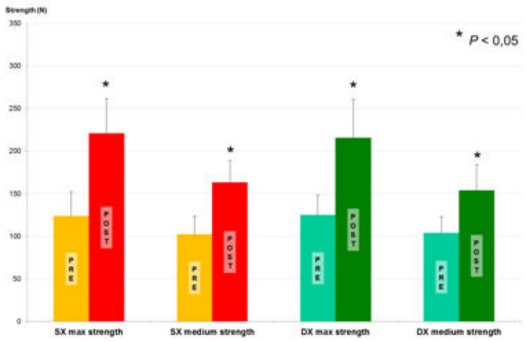
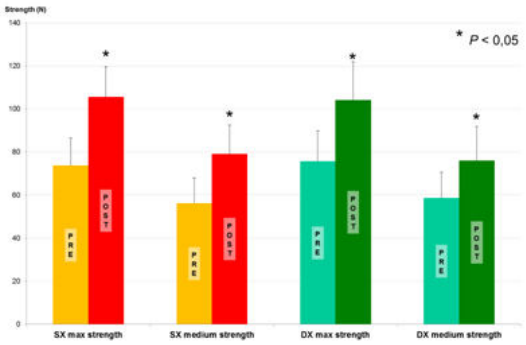


Figure 8 Pre-post training variations; analytical group maximus gluteus.



Figue 9 Pre-post training variations; integrated group medius gluteus.

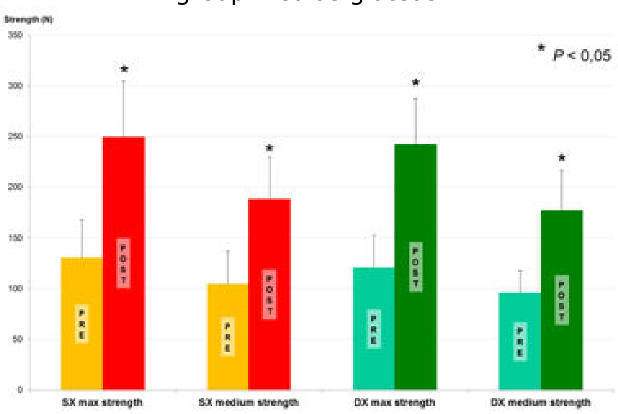


Figure 10 Pre-post training variations; integrated group maximus gluteus.

A t-test for independent samples was used to compare the percentage in the pre-post variations in the 2 groups. Here, the significance level was also set at p<0.05. For an additional qualitative value of the changes resulting from the 2 training protocols in the 2 groups, we calculated Choen's effect size, valued through Hopkins' scale, which suggests that starting from a coefficient equal to 0.2, the effect results become significant (Tab.1).

EFFECT SIZE	DESCRIPTION
< 0.2	Trivial
0.2 – 0.6	Small
0.6 – 1.2	Moderate
1.2 - 2.0	Large
> 2.0	Very large

Table 1 Choen's effect size.

The effect size reflects the width of the effect produced within the 2 groups and it was calculated by comparing the mean of the first group with that of the second group. Once this analysis is carried out, it can be observed that the more significant effects in the increase in strength (both in the Gm and GM) were found in the I-Group protocol (fig.11-12).

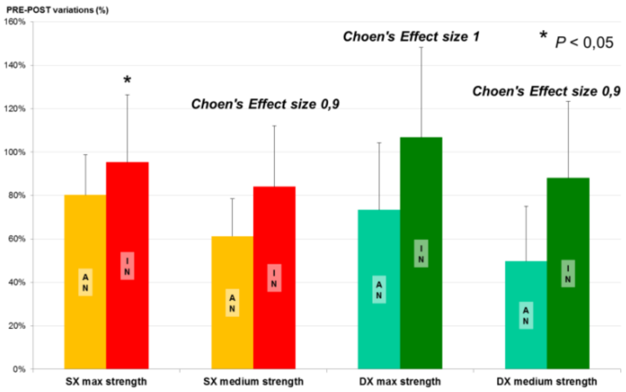


Figure 11 Pre-post variations % on the strength of the Medius Gluteus
Analytical - Integrated groups.

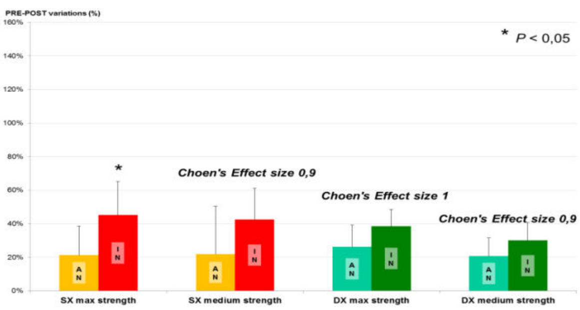


Figure 12 Pre-post variations % on the strength of the Maximus Gluteus
Analytical – Integrated groups.

A 2D video analysis of the bending of the lower limb was performed to study the movement control and the capacity to use the trained musculature during a closed kinetic chain movement. We obtained the bending angles of the knee both from the frontal plane (valgus angle of the knee) and of the sagittal one. Angular values recorded in before the training showed no significant differences, giving the groups a equal starting point.
At the end of the training protocol both groups showed no significant variation relative to the modification of the bending angles of the knee and therefore in the movement control (fig.13).

Figure 13 Pre-post training knee bending angles Analytical – Integrated groups.

Discussion and conclusion

Researchers (Bolgla & Uhl, 2005; Ayotte et al., 2007; Boudreau et al., 2009; Distefano, Blackburn, Marshall, & Padua, 2009; Krause et al., 2009) have used the surface electromyography (EMG) to quantify gluteal muscles activity during various exercises.

They have theorized that exercises requiring greater EMG activity will result in strength gains (Reiman, Bolgla, & Loudon, 2012; Macadam, Cronin, & Contreras, 2015). A systematic review identified 4 levels of muscular activation and the exercises included in each category.
The categories were: Low-level activation (0–20% Maximum Voluntary Isometric Contraction MVIC), Moderate-level activation (21–40% MVIC), High-level activation (41–60% MVIC) and Very high-level activation (>60% MVIC) (Reiman et al., 2012; Macadam et al., 2015). We are expected strength gains of muscles when EMG activity is equal to or greater than 40% MVIC (Ayotte et al., 2007; Escamilla et al., 2010; Reiman et al., 2012; Macadam et al., 2015). The Analytical Group performed 2 exercises included in the category of High-level activation and 1 exercise included in the category of Very high-level activation. The exercises were: the Pelvic Drop, the Side Lying Hip Abduction and the Side-bridge. The Integrated Group performed 1 exercise included in the category of Moderate-level activation and 2 exercises included in the category High-level activation. The exercises were: the Lunge, the Single-limb Squat and the Squat. The resulting analysis of data confirms what has already been described in the literature.

The research wanted to verify the effects that the training of the Gm and GM has on strength improvement. After the training period, both groups have shown a significant improvement in all the parameters relative to the analytical strength of the Gm and GM, though the most marked difference was noticed in the protocol of the Integrated work. It is important to underline that the A-Group participants showed, after the training period, a higher strength of both muscles (Gm and GM) although the training program was specific only for the Gm. The absence of significant variations in the bending angles of the knee shows no change in the movement control after the training. In these terms, both the Analytical and the Integrated training, taken singularly and not together with any other type of intervention, do not seem to be efficacious in terms of changes in the movement pattern. This aspect gives rise to a wide consideration on the training typology that should be followed and suggested on how to reduce the valgus angle during a monopodalic bending and increase the functionality of the lower limbs through a deeper bending angle. In conclusion, the training protocol has defined the positive effects regarding the analytical strength, while it has not produced significant variations to the bending angles of the knee and therefore to the movement control.

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UČINCI DVAJU PROTOKOLA TRENINGA NA SNAGU GLUTEUSA MEDIUSA I MAXIMUSA KOD ODRASLIH ŽENA

Sažetak
Glutealni mišići su uključeni u svakodnevne životne i sportske pokrete. Pregled najboljih vježbi glutealnih mišića sugerira kako maksimizirati EMG aktivaciju ovih mišića, ali ne nudi nikakve informacije o najboljem načinu treniranja i o učincima razdoblja treninga glutealnih mišića na kontrolu kretanja. Cilj ove studije je usporediti dva različita protokola obuke. Petnaest volontera (36,6 ± 5,5 godina, 162,4 ± 5,1 cm, 58,4 ± 6,6 kg) podijeljene su u dvije homogene skupine treninga. Svaku grupu je trenirao isti instruktor 6 tjedana, 2 x tjedno, 30 minuta, obujam vježbanja i odmor bili su isti za obje skupine. Tri analitičke vježbe s naglaskom na gluteus medius (Gm) i tri integrirane vježbe s naglaskom na gluteus maximus (GM) provedene su za skupinu A i skupinu I. Testiranje mišića s ručnim dinamometrom (Lafayette Instrument, Sagamore Pkwy, SAD) te video analiza (Freestep, Sensor Medica, Guidonia-RM, Italija) izvedeni su prije i poslije treninga. Gm i GM snage su znatno poboljšane nakon oba protokola (Gm ↑ 26% i 40%, GM ↑ 78% i 90% u skupini A i I skupina). I-skupina je pokazala najveće vrijednosti poboljšanja u usporedbi s A-grupom, ali postoje samo dvije značajne razlike (lijeva snaga Gm max i desna GM-ova srednja snaga). Nisu zabilježene značajne razlike u kontroli i dubini jednonožnog čučnja za bilo koju skupinu. Oblikovanje glutealnih mišića čini se djelotvornom i s analitičkim i integriranim vježbama. Studija ne pokazuje veću značajnu razliku između skupina u smislu poboljšanja čvrstoće. Nadalje, čini se da kontrola i dubina jednonožnog čučnja nemaju povezanosti s analitičkim ili integriranim trenjem glutealnog mišića.

Ključne riječi: *gluteus medius, gluteus maximus, glutealna snaga, glutealne funkcije, glutealne vježbe.*

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