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Addition of The Barbell Hip Thrust Elicits Greater Increases in Gluteus Maximus Muscle Thickness in Untrained Young Women

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ABSTRACT

Background: Although the barbell hip thrust exercise is widely performed in resistance training programs, evidence on its effectiveness to inducing glutes muscle hypertrophy is limited. Therefore, this study aimed to compare the effects of performing 45° leg press and stiff-leg deadlift (L-S) vs. performing 45° leg press, stiff-leg deadlift plus barbell hip thrust (L-S-BHT) on gluteus maximus muscle size.
Methods: The participants were 33 untrained young women randomly separated into 2 resistance training groups: L-S (n = 15) and L-S-BHT (n = 18). The muscle thickness of the gluteus maximus was assessed through B-mode ultrasound before and after 30 resistance training sessions. The resistance training program was carried out over 10 weeks, 3 days week-1.
Results: Both training regimens elicited significant increases in gluteus maximus muscle thickness from pre to post-training ($P < 0.001$). Notably, L-S-BHT had superior augments (L-S-BHT = +9.3% vs. L-S = +6.0%, $P = 0.016$).
Conclusion: The current results suggest that performing barbell hip thrust, in addition to 45° leg press and stiff-leg deadlift, enhances muscle hypertrophy of the gluteus maximus compared to performing exclusively 45° leg press and stiff-leg deadlift.

Keywords: resistance training, muscle thickness, ultrasound, exercise selection.

INTRODUCTION

Superior muscle hypertrophy is frequently observed when performing higher resistance training volumes (24); training volume herein operationally defined as the number of sets per muscle group performed to or near task failure (1). Based on this, it is reasonable that increasing resistance training volume by adding sets of different resistance exercises to target a specific musculature would enhance muscle growth—e.g., performing barbell hip thrust in addition to leg press to increase gluteus maximus hypertrophy. However, controversy exists as to whether this strategy in fact elicits superior increases in muscle hypertrophy (23). For instance, in a recent meta-analysis, Rosa et al. (23) reported trivial differences when comparing multi-joint versus multi-joint plus single joint resistance exercises, even with greater number of sets for multi-joint and single-joint condition. Importantly, only seven studies met the inclusion criteria, leading to a relatively imprecise estimate of the magnitude of the effect (23). Thus, additional studies on the topic are needed to draw stronger general inferences; especially regarding the hypertrophic effects of exercise addition on other muscles, such as the gluteus maximus.

The gluteus maximus is a large muscle primarily responsible for hip extension (27), which plays an important role in improving performance, health, and aesthetics (19). In this regard, practitioners and athletes have been interested in how to optimize adaptations in this muscle. Exercises often included in hypertrophy-oriented training programs are squat, lunge, 45° leg press, stiff-leg deadlift, and barbell hip thrust (4, 5, 8, 13). There are indications that squat, and leg press effectively induce gluteus maximus hypertrophy (14, 22). In contrast, findings are limited for the other exercises, as is the case for the barbell hip thrust. Notably, the gluteus maximus excitation is superior during the barbell hip thrust compared to the squat (5, 7). However, muscle excitation, per se, may not correspond to an exercise's hypertrophic potential (26). Thus, the efficacy of the barbell hip thrust in inducing gluteus maximus hypertrophy remains to be determined. Since resistance exercises may stimulate the same muscle differently, it is possible to speculate that their combination would optimize the hypertrophy of specific targeted musculature. Thus, we compared the effects of performing exclusively leg press and stiff-leg deadlift vs. leg press, stiff-leg deadlift plus barbell hip thrust on gluteus maximus muscle thickness. We hypothesized that leg press and stiff-leg dead-lift would induce gluteus maximus hypertrophy but adding barbell hip thrust would further enhance the gains.

MATERIALS AND METHODS

Participants

This study's sample comprised a total of 33 healthy untrained young women (L-S, n = 15 [22.6 ± 3.7 years, 59.4 ± 7.6 kg, 163.2 ± 5.7 cm]; L-S-BHT, n = 18 [22.3 ± 4.4 years, 60.0 ± 13.9 kg, 161.9 ± 5.3 cm]). Volunteers were contacted through dissemination on social media and folders on the campus of the local University. All volunteers underwent a clinical anamnesis and answered the physical activity readiness questionnaire (PAR-Q). The inclusion criteria were not responding "yes" to one or more PAR-Q questions; not having osteoarticular problems that could compromise the performance of the resistance training program; not being a user of anabolic steroids and/or dietary supplements (self-reported information); and not being engaged in resistance training for at least 6 months before starting the participation. All subjects were instructed to maintain their routines and habitual eating habits. This investigation was conducted according to the Declaration of Helsinki and the project was approved by the Institution's Ethics Committee of State University of Londrina (protocol number: 3.930.966). All subjects were informed of the inherent risks and benefits and signed an informed consent form.

Study Design

This was a between-group repeated measures design in which subjects were randomly allocated to one of two possible resistance training regimens: 45° leg press and stiff-leg deadlift (L-S) or 45° leg press, stiff-leg deadlift plus barbell hip thrust (L-S-BHT). This study is part of a larger research project designed to analyze the effects of a whole-body resistance training protocol on untrained young women. In this sense, subjects performed lat pull-down and bench press in addition to the lower-limbs exercises (same training protocol for both groups). Before the training intervention, subjects performed 2 weeks of familiarization (6 training sessions interspersed by 48 hours) with the specific resistance exercises. Seventy-two hours after the final familiarization session, the muscle thickness of the gluteus maximus was measured. The resistance training period was initiated, with groups performing their respective training regimen (i.e., L-S or L-S-BHT). The resistance training program was performed three times a week, for 10 weeks, totalling 30 training sessions. Each training session was composed of 2 sets of 10–15 repetitions maximum in each specific resistance exercise. Reassessments of muscle thickness were performed at an interval of 72–120 hours after the final training session (session 30).

Gluteus Maximus Muscle Thickness Measurement

The muscle thickness measurements of the gluteus maximus were taken via B-mode ultrasound (Logiq P5, GE Healthcare, Chicago, IL, USA) with a 7.5-MHz linear probe (8L-RS; GE Healthcare). Before starting the assessment, subjects were placed in a prone position on a stretcher and rested for 10 minutes before the start of the assessment. Gluteus maximus muscle thickness measurement was performed at 50% of the distance between the sacral vertebra and the greater trochanter of the femur. A generous quantity of water-soluble transmission gel was applied over the assessed muscle, without compressing the skin. Two assessors, blinded to group allocation, participated in measurement procedures, so the first handled the probe, and the second was responsible for freezing the images. When the image quality was deemed to be satisfactory, it was stored and analyzed using the Image J software, version 1.46 (National Institute of Health, Bethesda, MD, USA). The same evaluators performed baseline and post-training measurements. The depth of the images was adjusted according to the thickness of the muscle of each subject and ranged between 10.0 and 14.0 cm. All configuration parameters were kept constant (frequency = 7.5-MHz, dynamic range = 75 dB, gain = 49 dB). Images were saved for posterior analysis in a blinded fashion, with the researcher unaware of the subjects' names and their training group. Representative muscle thickness of gluteus maximus from one subject is presented in Figure 1. Twelve subjects were randomly chosen to be evaluated on two days separated by 72 hours to determine the reliability of the muscle thickness measurements. The intraclass correlation coefficient for the gluteus maximus was 0.975; the coefficient of variation was 1.9%; the standard error of measurement was 0.073 cm.

Resistance Training Program

The resistance training program was performed thrice weekly (Mondays, Wednesdays, and Fridays) in the afternoon for 10 weeks. The 45° leg press was performed in a specific device (Ipiranga®, Presidente Prudente, SP, Brazil) with weight plates. The stiff-leg deadlift was performed with barbell and weight plates. During the 45° leg press and stiff-leg deadlift, the feet were positioned between hip- and shoulder-width apart, with the toes pointed slightly outward (9). The hip thrust was performed with barbell and weight plates, having the subjects' upper backs on a bench. The barbell was padded with a thick bar pad and placed over the subjects' hips. During the barbell hip thrust, subjects' feet were slightly wider than shoulder-width apart, with toes pointed slightly outward (5). Representative photos of the initial and final phase of each lower limb exercise are presented in Figure 2. These exercises were interspersed by lat pull-down and bench press in the following order: 45° leg press, lat pull-down, stiff-leg deadlift, bench press, and barbell hip thrust (only the L-S-BHT group performed it). The resistance exercises were performed in 2 sets of 10–15 repetitions, executed until momentary concentric failure (i.e., the point where, despite trying to do so, subjects cannot complete a concentric muscle action) (25). Whenever the subjects reached 15 repetitions in a given set and reported that they could perform ≥ 1 repetition, the weight was increased by 5–10% for the next set to ensure that the participants kept performing the sets to (or very near to) failure

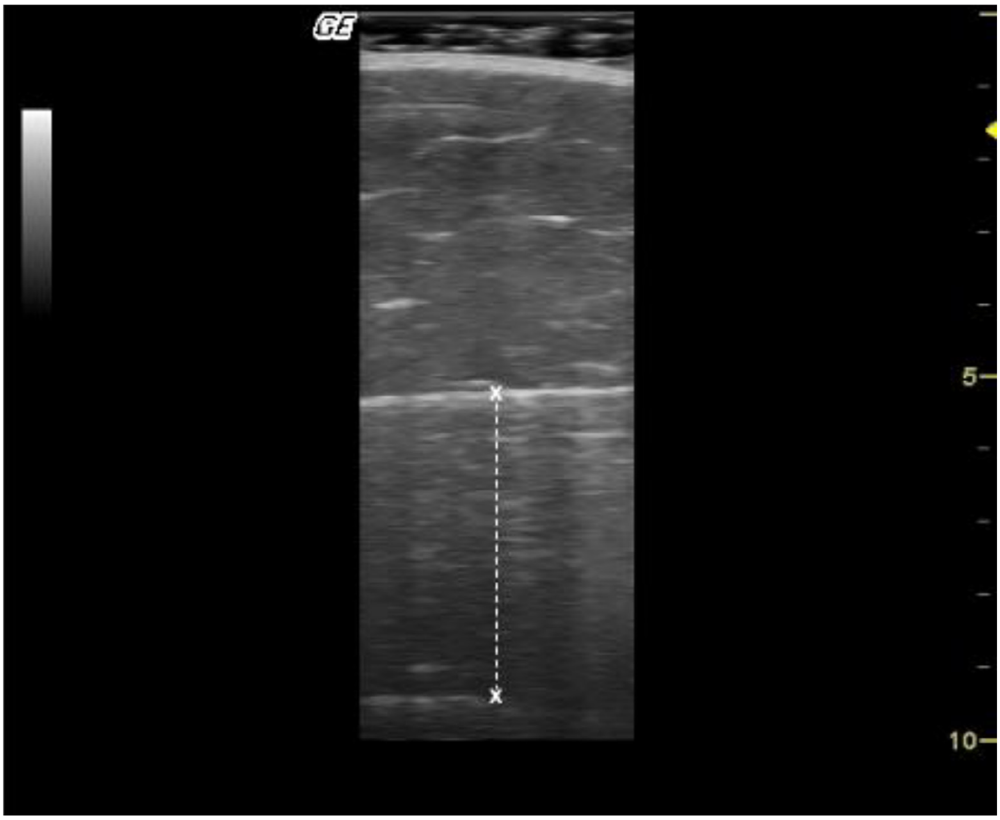

Figure 1. Typical ultrasound image of gluteus maximus.
Note. Image of a participant with the following characteristics: body mass = 58.6 kg, height = 166.0 cm, body mass index = 21.2 kg/m^2.

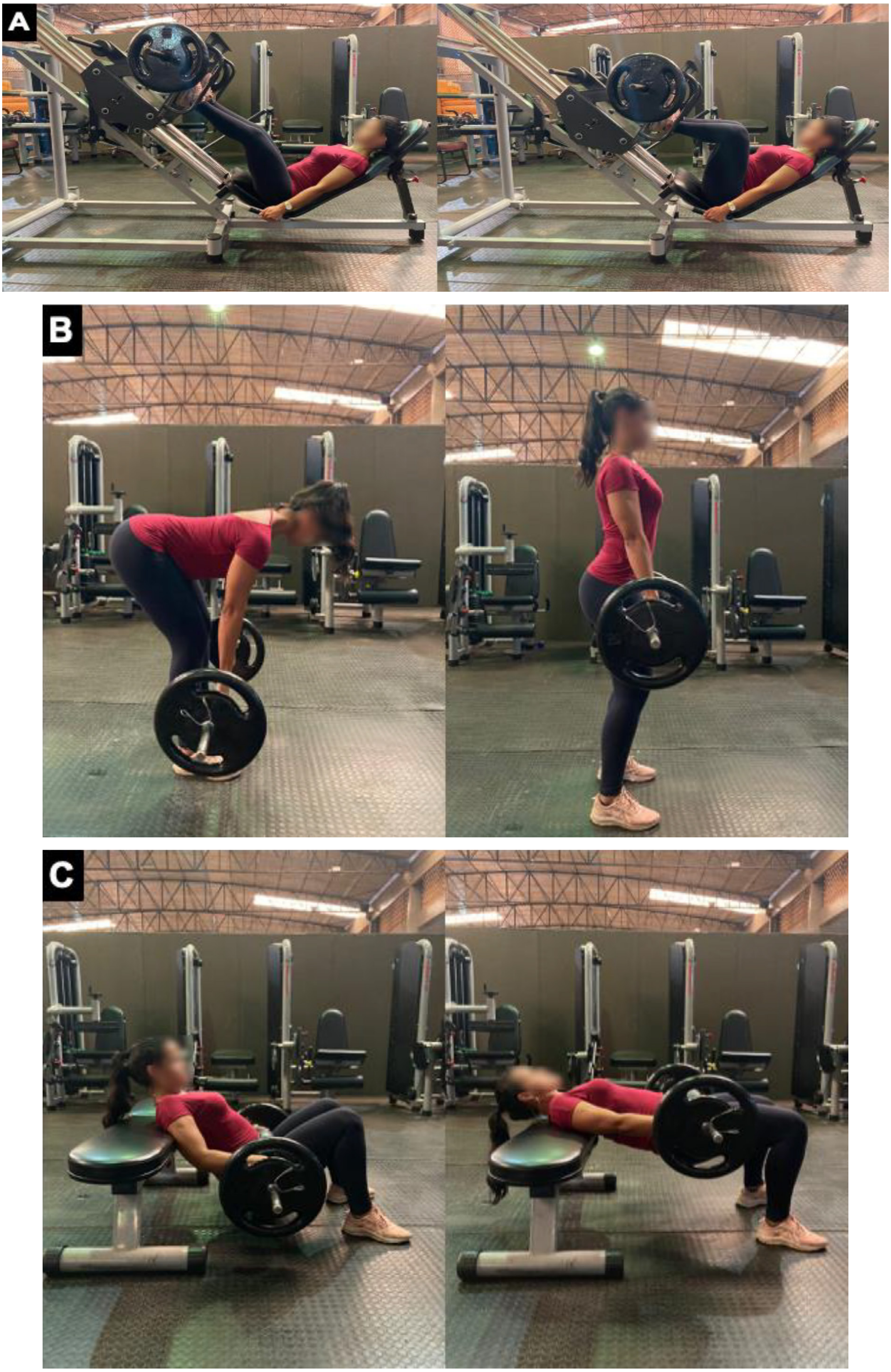

Figure 2. Illustrative photos of 45° leg press (A), stiff-leg deadlift (B), and barbell hip thrust (C) exercises.

in the established repetition range. A 2-min rest interval was given between sets and 3-min between exercises. Exercises were performed in a tempo of 1/1/2/0 (concentric, concentric-eccentric transition, eccentric, and eccentric-concentric transition phases, respectively). Subjects performed all training sessions under specialized supervision (1:2 participant: supervisor ratio) to ensure proper technique and safety.

Statistical Analysis

Data distribution and variance homogeneity were verified through Shapiro-Wilk's and Levene's tests, respectively. The independent t-test was used to compare the baseline characteristics and training attendance between groups. The effects of different resistance training programs (L-S vs. L-S-BHT) on gluteus maximus muscle thickness were compared using an analysis of covariance (ANCOVA) of the raw difference between baseline and post-training values with the baseline score as a covariate. Bonferroni's post hoc test was used to identify the differences between pre and post-training raw data when the F-ratio was significant. The P values for group comparisons were also presented. The effect of time was interpreted from the 95% confidence interval (95% CI) of the mean difference pre to post-training (i.e., there was a significant difference when the inferior and superior confidence limits did not cross zero). The effect size (ES) was calculated as post-training group mean minus the pre-training mean, divided by the groups-pooled pre-training standard deviation (3). For all statistical analyses, significance was accepted at $P < 0.05$. The data were stored and analyzed using Jeffreys's Amazing Statistics Program (JASP) software (version 0.14.1, Amsterdam, NL). The data are presented as mean and standard deviations.

RESULTS

Baseline and training attendance comparisons

No significant differences were found between groups at baseline for any of the compared variables ($P \geq 0.41$). Training session attendance was 88.2 ± 5.0% for the L-S, and 89.0 ± 5.4% for the L-S-BHT, with no difference between the groups ($P = 0.64$).

Muscle thickness of gluteus maximus

There was significant increase in muscle thickness of the gluteus maximus from pre to post-training for L-S (meandiff = 0.25 cm [95% CI: 0.14; 0.35], $P < 0.01$) and L-S-BHT (meandiff = 0.40 cm [95% CI: 0.31; 0.49], $P < 0.01$). A significant group effect was observed for the changes in gluteus maximus muscle thickness ($F = 6.45$; $P = 0.01$), indicating greater increases for L-S-BHT (between-groups meandiff = 0.15 cm [95% CI: 0.03; 0.27]). Pre and post-training muscle thickness were as follows: L-S = 4.26 ± 0.46 and 4.51 ± 0.49; L-S-BHT = 4.40 ± 0.50 and 4.80 ± 0.51. Figure 3 shows the individual relative changes in the gluteus maximus muscle thickness (L-S = +6.0%, ES = 0.52; L-S-BHT = +9.3%, ES = 0.83).

Repetitions and load

Table 1 shows the number of repetitions and weight in the first and last training session.

DISCUSSION

The purpose of this study was to examine the

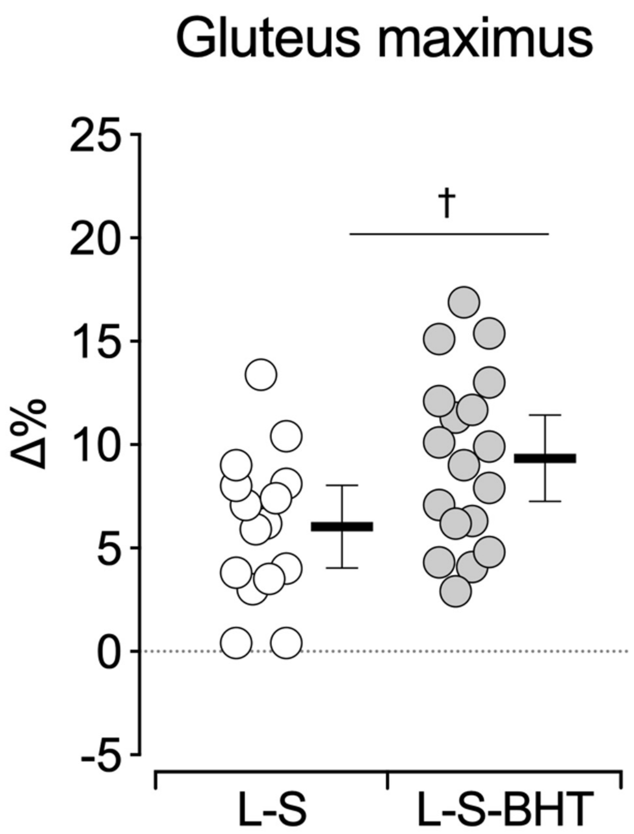

Figure 3. Changes from pre to posttraining period for gluteus maximus muscle thickness.
Note. †P < 0.05 vs. L-S. The horizontal lines represent mean and 95% confidence intervals, whereas each circle represents individual responses. L-S = 45° leg press and stiff-leg deadlift (n = 15); L-S-BHT = 45° leg press, stiff-leg deadlift plus barbell hip thrust (n = 18).

Table 1. Means and standard deviation of pre (first-session) and post-intervention (last session) repetitions and load.

		45° leg press		Stiff-leg deadlift		Barbell hip thrust	
		Pre	Post	Pre	Post	Pre	Post
L-S	Load (kg)	65.3 ± 32.8	105.8 ± 39.5	17.3 ± 4.4	29.2 ± 6.2	***	***
	Reps (n)	12.1 ± 2.1	14.0 ± 1.4	14.1 ± 1.7	14.3 ± 1.2	***	***
L-S-BHT	Load (kg)	66.7 ± 30.8	105.9 ± 36.9	15.3 ± 3.3	29.4 ± 5.1	27.0 ± 5.6	64.9 ± 15.4
	Reps (n)	12.8 ± 2.4	14.2 ± 1.0	14.3 ± 1.3	14.0 ± 1.2	13.8 ± 1.3	14.8 ± 1.6

Note. We averaged across sets; the values represent the average per set within session. L-S = 45° leg press and stiff-leg deadlift; L-S-BHT = 45° leg press, stiff-leg deadlift plus barbell hip thrust.

effects of two different resistance training regimens (L-S and L-S-BHT) on changes in muscle thickness of the gluteus maximus in untrained young women. The main finding of this study was that adding a hip-focused resistance exercise to a lower-limb resistance training regime influenced the magnitude of increases in muscle thickness of the gluteus maximus. Specifically, both training groups increased muscle thickness of the gluteus maximus in response to 10 weeks of regimented resistance training. Importantly, the L-S-BHT (i.e., performing 45° leg press, stiff-leg deadlift plus barbell hip thrust) elicited greater gains on the gluteus maximus size compared to the L-S (i.e., performing exclusively 45° leg press and stiff-leg deadlift). Therefore, our hypotheses that a) performing exclusively 45° leg press and stiff-leg deadlift effectively induces gluteus maximus hypertrophy and b) adding barbell hip thrust would elicit greater gains were confirmed. Potential mechanisms and explanations for our results are presented following.

The first finding of the present study was that exclusively performing the 45° leg press and stiff-leg deadlift was effective in inducing muscle hypertrophy of the gluteus maximus. Regarding the 45° leg press, our results are in line with a previous study that observed hypertrophy of the gluteus maximus after 8 weeks of leg press training in non-resistance trained young men (22). Given that the glutes are primarily hip extensors, it is probably one of the main muscles to contribute during the stiff-leg deadlift (17). This corroborates with the findings suggesting similar muscle excitation (measured by surface electromyography [sEMG]) of the gluteus maximus during the stiff-leg deadlift and squat (17). Thus, it is plausible to suggest that 45° leg press and stiff-leg deadlift acted synergistically to elicit gluteus maximus hypertrophy. Interestingly, based on the greater perpendicular distance between the axis of rotation and the line of force, both exercises likely impose peak forces in the position where the gluteus maximus is at longer lengths (i.e., at the start of the concentric phase). Thus, it is reasonable to suggest that the results observed in the present investigation—as well as in previous studies with leg press (22) and squat (14)—may be attributable to the combination of high peak forces imposed while the gluteus maximus is more elongated.

Indeed, growing evidence suggests that training specific muscles at longer muscle lengths optimizes hypertrophy (10, 16). For example, a previous study observed that full squat training which trains gluteus maximus at longer lengths was more effective in inducing gluteus maximus hypertrophy than half squat training in non-resistance trained individuals (14). Among the potential explanations for these findings, one that stands out is based on the length-tension relationship (11, 27). Specifically, muscles that have fibers that work on the descending limb of the length-tension curve may experience greater overall mechanical tension (due to the sum of forces from the active and passive elements) when trained at longer muscle lengths (15) and, as a consequence, experience stretch-mediated hypertrophy (11, 20). This conceivably helps to explain, at least in part, the muscle hypertrophy of the gluteus maximus observed in the group that performed exclusively 45° leg press and stiff-leg deadlift. However, it is important to note that, to the best of our knowledge, the working sarcomere length ranges of the gluteus maximus have not yet been measured (21). Therefore, this explanation needs investigations to verify its support with empirical data.

The second finding of the present study was that adding the barbell hip thrust enhanced muscle growth of the gluteus maximus. Notably, sEMG studies have reported heightened muscle excitation of the gluteus maximus during the barbell hip thrust, comparable to or greater than other exercises such as squats (5, 7). Importantly, concerns have arisen regarding the effectiveness of sEMG amplitude as a valid indicator of the hypertrophic potential of an exercise (26); denoting the importance of long-term investigations. For example, a muscle may exhibit greater sEMG amplitude at shortened than at lengthened muscle length (26), however greater hypertrophy is often observed when muscles are trained at longer muscle lengths (11). In this sense, our study adds an important finding to the literature when presenting the hypertrophic effects of performing the barbell hip thrust. Regarding the potential explanations for the increased hypertrophy with the addition of the barbell hip thrust, we highlight exercise biomechanics. The barbell hip thrust imposes high forces throughout the entire lifting phase (2, 6) with substantial peak forces at the full hip extension. Interestingly, the gluteus maximus has a greater internal moment arm length with increasing proximity to full hip extension (27). Therefore, the resistance profile of the barbell hip thrust fits with the ability of the gluteus maximus to produce force and contribute to hip extension torque. This may have enhanced the stimulus for the glutes and led to the noted greater hypertrophy for the gluteus maximus.

This fit between the resistance profile of the barbell hip thrust and the contribution capacity of the gluteus maximus is important because other muscles (such as hamstrings, and adductor magnus) play an important role during the task of hip extension (18, 27). Notably, the contribution of the hamstrings and adductor magnus is greater with increased hip flexion and lower with increased hip extension (18, 27). Therefore, it is likely that during the performance of the barbell hip thrust, the gluteus maximus plays a greater role than during other exercises involving peak forces with increased hip flexion (e.g., leg press, stiff-leg deadlift, squat, etc.). Moreover, it is interesting to note that in the top portion of the barbell hip thrust, the gluteus maximus is at shorter muscle lengths. Of note, this factor conflicts with the previously raised hypothesis that the gluteus maximus fibers work on the descending limb of the length-tension curve. In this sense, it is plausible to suggest that the gluteus maximus has fibers that work on the descending limb as well as in the plateau portion (21). This conceivably helps to reconcile the fact that the gluteus maximus hypertrophies in longer and shorter lengths.

Our study has limitations that need to be addressed. First, in both groups, the subjects performed a combination of exercises; for the L-S group, 45° leg press and stiff-leg deadlift, for the L-S-BHT group, 45° leg press, and stiff-leg deadlift, plus barbell hip thrust. This characteristic of the training program prevents us from inferring how much each exercise, in particular, contributed to the hypertrophy observed in the present study. Especially when trying to determine how much hypertrophy was induced by the 45° leg press and the stiff leg deadlift individually. Therefore, future studies should compare the hypertrophic effects of these exercises separately. It is important to note that hypertrophy-oriented resistance training programs are commonly comprised of a variety of exercises (8, 12). This highlights the external validity of our study. Second, we measured the changes in muscle thickness at one site of the gluteus maximus to express muscle hypertrophy; a more valid substitute would be the change in total muscle volume. Furthermore, given that the gluteus has different subdivisions, measurements in different regions could indicate whether the hypertrophy could be regional. Finally, we measured exclusively untrained young women. Thus, future studies should consider testing subjects of different ages, sexes, and training statuses.

CONCLUSION

Our findings highlight that adding a hip-focused exercise influences the magnitude of gluteus maximus muscle hypertrophy in response to regimented resistance training. More specifically, in the present study, both regimens—i.e., performing exclusively 45° leg press and stiff-leg deadlift and performing 45° leg press, stiff-leg deadlift, plus barbell hip thrust—were effective in eliciting gluteus maximus muscle hypertrophy after 10 weeks of resistance training in untrained young women. Notably, muscle size growth was greater with the addition of the barbell hip thrust. From a practical perspective, strength and conditioning professionals and practitioners should consider the inclusion of barbell hip thrust in gluteus maximus hypertrophy-orientated training program.

CONFLICTS OF INTEREST

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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AUTHORS' CONTRIBUTIONS

Author WK and author JPN have given substantial contributions to the conception or the design of the manuscript, all authors contributed to acquisition, analysis, and interpretation of the data. All authors have participated to drafting the manuscript and revised it critically. All authors read and approved the final version of the manuscript.

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