Barbell Hip Thrust, Muscular Activation and Performance: A Systematic Review

Walter Krause Neto 1,2, Thais Lima Vieira 2 and Eliane Florencio Gama 1
1 Department of Physical Education, Laboratory of Morphoquantitative Studies and Immunohistochemistry, São Judas Tadeu University, São Paulo-SP, Brazil; 2 Department of Graduate Studies, Estácio de Sá University, São Paulo-SP, Brazil

Abstract
The present systematic review aimed to analyze the activation of the muscles involved in the barbell hip thrust (BHT) and its transfer to sports activities that include horizontal displacement. A search of the current literature was performed using the PubMed, SPORTDiscus, Scopus and Google Scholar databases. The inclusion criteria were: (a) descriptive studies, (b) physically trained participants, (c) analyzed muscle activation using normalized EMG signals or as a percentage of maximal voluntary isometric contraction (MVIC) and (d) acute or chronic transfer of the BHT to horizontal displacement activity. Twelve articles met the inclusion criteria and the following results were found: (1) neuromuscular activation: hip extensor muscles (gluteus maximus and biceps femoris) demonstrated greater activation in the BHT compared to the squat. The straight bar deadlift exercise demonstrated greater biceps femoris activation than BHT; (2) Regardless of the BHT variation and intensity used, the muscle excitation sequence is gluteus maximus, erector spinae, biceps femoris, semitendinosus, vastus lateralis, gluteus medius, vastus medialis and rectus femoris; (3) acute transfer; four studies demonstrated a significant improvement in sprinting activities after BHT exercise; (4) as for the chronic transfer: two studies demonstrated improved sprinting time, while other two studies failed to present such effect. We concluded that: (a) the mechanics of BHT favors greater activation of the hip extensor muscles compared to more conventional exercises; (b) regardless of the variation of BHT used, the muscle excitation sequence is gluteus maximus, erector spinae, hamstrings, and quadriceps femoris; (c) the acute transfer of the post-activation potentiation of the BHT is significant, improving the sprinting time; and (d) despite training with BHT submaximal loads can improve sprint times, further investigations are needed.

Key words: Exercise, skeletal muscle, muscle contraction, athletic performance, sports.

Introduction
In recent decades, strength training has gained worldwide prominence, being recommended for both, health and aesthetic programs, and physical preparation of highly trained athletes (Freitas et al., 2018; Loturco et al., 2018; Vinstrup et al., 2017). This fact is related to the various possibilities of applying strength exercises, and their variations. For this, it is essential to understand the patterns of recruitment, neuromuscular activation and multifunctional transfer level of some types of strengthening exercise.

The use of strength exercises varies according to their level of neuromuscular excitation, whose standards can be measured using the electromyography method [EMG] (Contreras et al., 2015, Andersen et al., 2018; Vigotsky et al., 2018). According to Vigotsky et al. (2018), EMG can be defined as an electrophysiological recording technology used for detection of the electric potential resulting from the transmembrane current of the muscle fibers (muscular excitation). Thus, EMG studies enable us to infer which muscles are excited in certain movements, being able to compare exercises with different mechanical patterns. Contreras et al. (2015) demonstrated different levels of muscular excitation when comparing barbell hip thrust and traditional squat exercises. In this way, muscles such as the gluteus maximus and quadriceps femoris, being activated differently, have different practical applications regarding their structure (Contreras et al., 2017; Williams et al., 2018). Thus, the interpretation of these data leads us to the possibility of new forms of training prescription, and therefore, more practical results. Nevertheless, kinesiology studies help us to understand, and better interpret, the strategies of exercise choices for specific sports modalities (Hales et al., 2009). Of course, the physical preparation of athletes should use the best tools to improve motor performance, thus making the choice of exercises fundamental to the success of the training program, whether health, aesthetic or athletic. Moreover, it is also suggested that the specificity in the direction of the production of force in certain exercises, causes a more direct transference for certain motor activities (Loturco et al., 2018; Williams et al., 2018).

It is possible to affirm that despite the mechanical differences between barbell hip thrust (BHT) and more traditional exercises, such as squatting, the inclusion of these in a strength training program can produce summative effects on the performance of international level speed athletes (Loturco et al., 2018). According to Loturco et al. (2018) and Williams et al. (2018), BHT is an exercise whose predominance of hip extension and excitation of its specific muscles is transferred to explosive and short duration exercises as sprints of high speed and short duration, clearly demonstrating the applied principles of specificity and transference.

Recently, BHT has gained considerable attention from the scientific community, and from physical trainers, due to its mechanical nature and the highly neuromuscular demand of the hip extensor muscles (Contreras et al., 2011; Dello Iacono et al., 2018; Dello Iacono and Seitz, 2018; Eckert and Snarr, 2014; Loturco et al., 2018; Williams et al., 2018). This strengthening exercise has muscle activation different from those associated with more traditional exercises such as squatting (front or back barbell), split squats, deadlifts and others (Andersen et al., 2018; Bishop et al., 2017; Williams et al., 2018). As a result, a growing number of researches show that there is a possibility of cute
transferring gains from this exercise to horizontal displacement motor activities (Dello Iacono et al., 2018; Dello Iacono and Seitz, 2018; Loturco et al., 2018; Williams et al., 2018). However, it is not clear if BHT training can induce positive chronic effects as seen in the acute type investigations.

The aim of this systematic review was to analyze the activation of the muscles recruited in the BHT and its transfer to sports activities that include horizontal displacement at maximum velocities.

**Methods**

The preferred item declaration guide for systematic review and meta-analysis reports (PRISMA) was used to conduct this systematic review (Moher et al., 2009). In addition, the quality of all eligible studies included was assessed by WKN, TLV, and EFG using the PEDro quality scale. The PEDro scale consists of eleven questions and scores proportional to the number of questions. However, due to the inability to "blind" coaches and practitioners, we excluded 3 questions, determining 8 points as the maximum score. Thus, studies with a score equal to or greater than 5 points were considered of good methodological quality.

A search of the current literature was conducted using the PubMed/MeLine, SportDiscuss, Scopus and Google Scholar electronic databases, without restriction of languages and dates until August 6th, 2018. The MeSH descriptors, along with their related terms and keywords included, were used as follows: ((hip thrust OR hip thrusts OR pelvic exercise) AND (resistance training OR resistance exercise OR training, resistance OR strength training OR training, strength OR weight-lifting strengthening program OR strengthening program, weight-lifting OR strengthening programs, weight-lifting OR weight lifting strengthening program OR weight-lifting strengthening programs OR weight-lifting exercise program OR exercise program, weight-lifting OR exercise programs, weight-lifting OR weight lifting exercise program OR weight-lifting exercise programs OR weight-bearing strengthening program OR strengthening program, weight-bearing OR strengthening programs, weight-bearing OR weight-bearing strengthening program OR strengthening programs OR weight-bearing exercise program OR exercise program, weight-bearing OR exercise programs, weight-bearing OR weight bearing exercise program OR weight-bearing exercise programs)) AND ((muscle development OR development, muscle OR muscular development OR development, muscular OR myogenesis OR myofibrillogenesis OR muscle hypertrophy OR hypertrophy OR hypertrophies OR electromyography OR electromyographies OR surface electromyography OR electromyographies, surface OR electromyography, surface OR surface electromyographies OR electromyogram OR electromyography OR muscle strength OR power output OR force OR strength OR horizontal forces OR maximum speed OR fast movement)).

The inclusion criteria were: (a) descriptive studies, (b) studies using physically trained participants, (c) studies that analyzed muscle activation using normalized EMG signals or as a percentage of maximal voluntary isometric contraction (MVIC) during BHT exercise and their respective comparisons and (d) studies that analyzed the acute or chronic transfer of the effects of BHT exercise to horizontal displacement activity. Studies with insufficient data, review, samples formed by ill individuals, poor data presentation, unclear or vague descriptions of protocols applied and with more than one exercise per group were excluded.

Authors WKN, TLV and EFG independently performed the analysis of the data, with a subsequent meeting to decide on the inclusion in the final text of the eligible articles. First, a pre-reading was performed to become familiar with the terminology used in the studies. Then, each article was re-read and the following information was extracted: (1) intervention exercises, (2) sample size, (3) gender, (4) age, (5) experience time, (6) type of study, (7) outcomes and (8) main findings. From this moment, the studies were separated into two types of analysis: (1) neuromuscular recruitment and (2) analysis of the practical transfer of the intervention. Included in this study were articles that analyzed these outcomes separately. Regarding the EMG signal, all articles analyzed reported the MVIC protocol used. These protocols used isometric contraction against a combined resistance for each muscle examined. Likewise, all included articles used surface EMG and reported muscle activation of each muscle separately.

In relation to performance transfer, articles of an acute (potentialization post-activation) and chronic nature (duration between 6 and 8 weeks) were included. The analyzed tests included horizontal jumps and sprints with varying distances (10-150 m).

**Results**

**Search results**

Three independent reviewers identified a total of 498 articles in the initial survey. Two hundred and thirty-five articles were duplicates, which left 263 articles included for analysis. After sorting the title/abstract and full text, 252 articles were eliminated because they did not meet the inclusion criteria, leaving a total of 11 articles selected for review (Figure 1). However, during the review process of this manuscript, a new article was published and included in the final analysis of the study on November 22nd, totaling 12 articles in this systematic review. Of which, five of these studies compared neuromuscular activity of the BHT with other exercises or variations (Andersen et al., 2018; Collazo García et al., 2018; Contreras et al., 2015; 2017; Williams et al., 2018) and eight studies verified the functional transfer for practical activities (Bishop et al., 2017; Contreras et al., 2017; Della Iacono et al., 2018; Della Iacono and Seitz, 2018; Lin et al., 2017; Loturco et al., 2018; Williams et al., 2018; Zweifel et al., 2017). Although there was no time limit as an inclusion criterion, all articles included here were published between the years 2015 and 2018. After the quality analysis, all studies were classified as having good/excellent methodological quality (grades 6-8).
Muscle activation

Data referring to general studies description and main findings and neuromuscular activity are presented in Table 1 and 2. The gluteus maximus muscle showed greater activation in the BHT (independent of the analysis being of mean or peak activation, isometric or dynamic) compared to squatting (Contreras et al., 2015; Williams et al., 2018), barbell deadlift (Andersen et al., 2018) and hex bar deadlift (Andersen et al., 2018). When comparing BHT with other variations, such as American (shorter hip joint amplitude with posterior pelvic tilt) and elastic bands resistance, the results demonstrated that BHT elicited higher excitation levels only for the analysis of the EMG amplitudes of the upper gluteus maximus fibers (Contreras et al., 2017). However, Collazo Garcia et al. (2018) showed that BHT with feet external rotation presented higher gluteus maximus excitation than traditional BHT.

As for the biceps femoris muscle, the BHT presented a greater neuromuscular excitation than the squat exercise (Contreras et al., 2015). On the other hand, the traditional deadlift exercise demonstrates greater activation of biceps femoris compared to BHT (Andersen et al., 2018). Comparing the positioning of the feet during the BHT exercises, the variation with feet forward showed higher values of neuromuscular excitation for the biceps femoris and semitendinosus muscles than the traditional BHT variation (Collazo Garcia et al., 2018). As for the gluteus medius muscle, there were no differences between BHT exercise variations (Collazo Garcia et al., 2018).

Regarding the variations in the positioning of the feet of the BHT, placing the feet forward has shown to decrease the excitatory activity of the rectus femoris, vastus lateralis and vastus medialis muscles compared to traditional BHT (Collazo Garcia et al., 2018).

Figure 2 presents the EMG mean activity among the muscles mobilized in the BHT, measured by each study included here. Although the studies used different intensities to evaluate muscular excitation, the following values were demonstrated. The mean EMG activity of gluteus maximus and biceps femoris muscles varied between 55 and 105% MVIC and 40 and 85% MVIC, respectively.
Table 1. Description of data extracted from each article regarding neuromuscular activity, in relation to subtopics: type of intervention, sample, gender, age, experience time, type of study, outcomes, main findings and PEDro quality scale score (0-8).

<table>
<thead>
<tr>
<th>Reference</th>
<th>Intervention</th>
<th>Sample (n)</th>
<th>Gender</th>
<th>Age (years)</th>
<th>Experience (years)</th>
<th>Type of study</th>
<th>Outcomes</th>
<th>Main findings</th>
<th>PEDro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contreras et al. (2015)</td>
<td>Barbell hip thrust versus back squat</td>
<td>13</td>
<td>Female</td>
<td>28.9±5.11</td>
<td>7.0±5.8</td>
<td>Acute</td>
<td>Activity EMG of the muscles gluteus maximus upper and lower fibers, biceps femoris and vastus lateralis</td>
<td>Hip thrust ↑ EMG significantly for gluteus maximus muscle (both portions) and biceps femoris</td>
<td>7</td>
</tr>
<tr>
<td>Contreras et al. (2016)</td>
<td>Hip thrust Variations (traditional, American and band)</td>
<td>13</td>
<td>Female</td>
<td>28.9±5.11</td>
<td>7.0±5.8</td>
<td>Acute</td>
<td>Activity EMG of the muscles gluteus maximus upper and lower fibers, biceps femoris and vastus lateralis</td>
<td>Variation with full amplitude demonstrated ↑ EMG for mean and peak activation of the upper gluteus maximus fibers</td>
<td>7</td>
</tr>
<tr>
<td>Andersen et al. (2018)</td>
<td>Barbell hip thrust versus straight and hex bar deadlift</td>
<td>13</td>
<td>Male</td>
<td>21.9±1.6</td>
<td>4.5±1.9</td>
<td>Acute</td>
<td>Activity EMG of the muscles gluteus maximus upper and lower fibers, biceps femoris and erector spinae</td>
<td>Barbell hip thrust: ↑ EMG gluteus maximus Deadlift straight bar: ↑ EMG biceps femoris * there was no difference for erector spinae</td>
<td>7</td>
</tr>
<tr>
<td>Williams et al. (2018)</td>
<td>Barbell hip thrust versus back squat Split squat</td>
<td>12</td>
<td>Male</td>
<td>25.0±4.0</td>
<td>4.0±1.0</td>
<td>Acute</td>
<td>Activity EMG of the muscle gluteus maximus</td>
<td>Significantly ↑ EMG in the Barbell hip thrust</td>
<td>7</td>
</tr>
<tr>
<td>Collazo Garcia et al. (2018)</td>
<td>Barbell hip thrust feet position variations (original hip thrust, pull hip thrust [PHT], rotation hip thrust [RHT], and feet away hip thrust [FHT])</td>
<td>7</td>
<td>Male</td>
<td>29.4±4.6</td>
<td>Not indicated</td>
<td>Acute</td>
<td>Activity EMG of the rectus femoris (RF), vastus medialis (VM), vastus lateralis (VL), gluteus maximus (GMax), gluteus medius (GMed), biceps femoris (BF), and semitendinosus (ST) muscles</td>
<td>Significant differences in EMG in all muscles except for the gluteus medius, where no differences were observed among variations. In comparison with the original variation: RHT = ↑ Gmax FHT = ↑ BF, ST and ↓ RF, VM, VL</td>
<td>7</td>
</tr>
</tbody>
</table>

Gluteus medius presented mean EMG activity of 45% MVIC. As for semitendinosus muscle, mean EMG activity was about 35% MVIC. For the vastus lateralis the average EMG activity remained between 35 and 100% MVIC. Rectus femoris and vastus medialis presented mean excitation of 5 and 35% MVIC, respectively. Erector spinae muscle presented approximately 85% MVIC. This large variation in the mean EMG activity found for some muscles was due to the large load variance used to evaluate each condition.

**Motor performance**

Data from studies evaluating the efficiency of BHT on functional transfer for practical activities are presented in Table 3.

As for the acute transfer, four studies demonstrated a significant improvement in the sprint times (Dello Iacono et al., 2018; Dello Iacono and Seitz, 2018; Loturco et al., 2018; Williams et al., 2018). As for the chronic transfer, two studies have shown improved sprint time (Contreras et al., 2017; Zweifel et al., 2017), whereas two other studies have failed to present such an effect (Bishop et al., 2017; Lin et al., 2017).

**Discussion**

According to the data presented here, BHT exercise can induce a high neuromuscular activity of the hip extensor muscles, especially the gluteus maximus, in comparison with the more traditional exercises. In addition, variations in the positioning of the feet during the execution of the BHT may present different levels of excitation of the muscles associated with the joints of the knee and hips. Beyond this, BHT causes a significant acute transfer for high-speed activities and horizontal displacement. On the other hand, there is still controversy about the effects of chronic training of BHT on long-term sports performance. It is not surprising that BHT has provoked greater EMG activity in the gluteus maximus muscle compared to the other exercises.
(Andersen et al., 2018; Contreras et al., 2015; Williams et al., 2018). Worrell et al. (2001) showed that when testing the maximum isometric torque of hip extension in a dynamometer, the gluteus maximus EMG activity was higher with the hip at 0° extension (exactly the end of the concentric phase of the BHT). In addition, knee flexion (about 90° angle) during the hip-raising phase induces a hamstrings insufficiency (lower force production), requiring a greater effort of the gluteus maximus muscle to generate sufficient torque for hip extension (Know and Lee, 2013). According to Collazo Garcia et al. (2018), lowering the flexion angle of the knees by placing the feet forward would increase the neuromuscular demands of the hamstrings without changing gluteus maximus excitation. Regardless of, it seems that the shorter the muscle length (as the top concentric phase of the BHT), the greater the potential levels of EMG activity of the gluteus maximus (Robertson et al., 2008). This fact can be explained by the anatomical nature of the gluteus maximus muscle architecture, associated with the angle of the position in which the volunteers remain for the maximum voluntary isometric contraction test used for normalization of the EMG signal. Thus, the greater the levels of hip extension, the closer the Z-lines of the sarcomeres would be, increasing the levels of force production, and reaching the highest levels of EMG measured along the movement tested. In addition, the concept of the specificity principle applies directly in this case, whose association between the EMG test normalization test and the BHT exercise amplitude reaches its closest values. Collazo Garcia et al. (2018) also demonstrated that the greater the distance between the feet during BHT, the greater the activity of the gluteus maximus muscle, suggesting that the production of force tending to the frontal plane causes a greater excitation of this muscle.

Table 2. Description of data regarding neuromuscular activity in each article included, in relation to exercise type and normalized EMG activity (values expressed as mean and/or peak %MVIC) of upper and lower portions of gluteus maximus, gluteus medius, semitendinosus, biceps femoris, rectus femoris, vastus lateralis, vastus medialis and erector spinae muscles.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Exercise</th>
<th>Upper Gluteus Maximus</th>
<th>Lower Gluteus Maximus</th>
<th>Gluteus Medius</th>
<th>Semitendinosus</th>
<th>Biceps Femoris</th>
<th>Rectus Femoris</th>
<th>Vastus Lateralis</th>
<th>Vastus Medialis</th>
<th>Erector Spinae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contreras et al. (2015)</td>
<td>Back Squat</td>
<td>29% mean 85% peak</td>
<td>45% mean 130% peak</td>
<td>15% mean 37% peak</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Barbell Hip</td>
<td>69% mean 87% peak</td>
<td>172% peak 216% peak</td>
<td>41% mean 87% peak</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>99% mean 216% peak</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Thrust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Contreras et al. (2016)</td>
<td>Barbell Hip</td>
<td>69% mean 87% peak</td>
<td>172% peak 216% peak</td>
<td>41% mean 87% peak</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>99% mean 216% peak</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Thrust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>American</td>
<td>57% mean 90% mean</td>
<td>157% peak 200% peak</td>
<td>44% mean 99% peak</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>87% mean 177% peak</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Hip Thrust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Band Hip</td>
<td>49% mean 79% mean</td>
<td>120% peak 185% peak</td>
<td>37% mean 89% peak</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>93% mean 185% peak</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Thrust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Andersen et al. (2018)</td>
<td>Barbell Hip</td>
<td>108% mean 98% mean</td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>Upper 110% mean  Lower 68% mean</td>
<td>n/a</td>
<td>Upper 93% mean  Lower 83% mean</td>
</tr>
<tr>
<td></td>
<td>Thrust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Deadlift</td>
<td>95% mean 95% mean</td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>Upper 115% mean  Lower 100% mean</td>
<td>n/a</td>
<td>Upper 88% mean  Lower 90% mean</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Hex bar</td>
<td>Deadlift</td>
<td>85% mean 90% mean</td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>Upper 80% mean  Lower 85% mean</td>
<td>n/a</td>
<td>Upper 83% mean  Lower 85% mean</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Williams et al. (2018)</td>
<td>Back Squat</td>
<td>69% mean and 100% peak</td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Split Squat</td>
<td>69% mean and 100% peak</td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Barbell Hip</td>
<td>105% mean and 130%</td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>thrust</td>
<td>peak</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Collazo Garcia et al.</td>
<td>Original</td>
<td>55% mean 47% mean</td>
<td>32% mean 41% mean</td>
<td>6% mean</td>
<td>27% mean 35% mean</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Barbell Hip</td>
<td>66% mean 60% mean</td>
<td>50% mean 61% mean</td>
<td>5% mean</td>
<td>24% mean 21% mean</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Thrust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Rotation Hip</td>
<td>86% mean 65% mean</td>
<td>33% mean 43% mean</td>
<td>5% mean</td>
<td>29% mean 29% mean</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Thrust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Feet away</td>
<td>51% mean 48% mean</td>
<td>70% mean 72% mean</td>
<td>3% mean</td>
<td>11% mean 11% mean</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>
Table 3. Description of data extracted from each article regarding functional transference, in relation to subtopics: type of intervention, sample, gender, age, experience time, type of study, outcomes, main results and PEDro scale score (0-8).

<table>
<thead>
<tr>
<th>Reference</th>
<th>Intervention</th>
<th>Sample (n)</th>
<th>Gender</th>
<th>Age (years)</th>
<th>Experience (years)</th>
<th>Type of study</th>
<th>Outcomes</th>
<th>Main findings</th>
<th>PEDro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contreras et al. (2017)</td>
<td>Barbell hip thrust (HT) versus front squat (FS)</td>
<td>24</td>
<td>Male</td>
<td>15.49±1.16</td>
<td>1 year</td>
<td>Chronic (6 weeks)</td>
<td>Sprints of 10 and 20 meters; Vertical and horizontal jumps; Isometric mid-thigh test</td>
<td>Hip thrust presented better ES for sprints of 10 and 20 meters and isometric half-thigh test</td>
<td>8</td>
</tr>
<tr>
<td>Dello Iacono et al. (2018)</td>
<td>Barbell hip thrust 50%RM versus 85%RM</td>
<td>18</td>
<td>Male</td>
<td>19.8±0.3</td>
<td>Elite handball players with 2.6 ± 0.8 years of experience</td>
<td>Acute</td>
<td>10 and 15 meters sprint time</td>
<td>Both strategies statistically reduce the time in the measured distances</td>
<td>7</td>
</tr>
<tr>
<td>Bishop et al. (2017)</td>
<td>Barbell hip thrust versus control</td>
<td>21</td>
<td>Male and female</td>
<td>Intervention group: 27.36±3.17</td>
<td>University athletes with at least 1 year of experience</td>
<td>Chronic (8 weeks)</td>
<td>40 meters sprint time</td>
<td>The hip thrust did not shorten the time on the benchmark test</td>
<td>7</td>
</tr>
<tr>
<td>Zweifel et al. (2017)</td>
<td>Barbell hip thrust versus back squat and deadlift</td>
<td>26</td>
<td>Male and female</td>
<td>22.15±2.2</td>
<td>Not quoted</td>
<td>Chronic (6 weeks)</td>
<td>10 and 40-yard sprint</td>
<td>Hip thrust reduced the time of the 40-yard sprint</td>
<td>6</td>
</tr>
<tr>
<td>Lin et al. (2017)</td>
<td>Barbell hip thrust versus control</td>
<td>20</td>
<td>Male</td>
<td>19.9±0.8</td>
<td>College baseball players with at least 1 year of experience</td>
<td>Chronic (8 weeks)</td>
<td>Horizontal jump; Sprint 30 meters</td>
<td>No significant difference reported</td>
<td>7</td>
</tr>
<tr>
<td>Loturco et al. (2018)</td>
<td>Barbell hip thrust versus vertical exercises</td>
<td>16</td>
<td>Male and female</td>
<td>21.8±3.0</td>
<td>World-class athletes</td>
<td>Acute</td>
<td>Vertical jump; Sprints of 10, 20, 40, 60, 100 and 150 meters</td>
<td>Performance in the hip thrust was associated with the Maximum acceleration phase</td>
<td>7</td>
</tr>
<tr>
<td>Dello Iacono e Seitz (2018)</td>
<td>Barbell hip thrusts 85%RM versus optimal power loads</td>
<td>18</td>
<td>Male</td>
<td>19.3±0.2</td>
<td>Professional soccer players with 2.1 ± 0.3 years of experience</td>
<td>Acute</td>
<td>5, 10 e 20 meters sprints</td>
<td>Both loads tested improved the test time, with the maximum power development load being even more efficient.</td>
<td>7</td>
</tr>
<tr>
<td>Williams et al. (2018)</td>
<td>Barbell hip thrust versus back squat and split squat</td>
<td>12</td>
<td>Male</td>
<td>25.0±4.0</td>
<td>4.0±1.0</td>
<td>Acute</td>
<td>Maximum sprints on the non-motorized treadmill; A horizontal and vertical force</td>
<td>Sprint peak velocity correlated with horizontal and peak ground reaction force only in hip thrust exercise</td>
<td>7</td>
</tr>
</tbody>
</table>

Similarly, it was evidenced that the EMG activity of the biceps femoris muscle was significantly higher in the BHT compared to squating (Contreras et al., 2015). A number of studies have shown that squating and its variations exhibits lower hamstring demands compared to measurements made on the quadriceps femoris (Escamilla et al., 2001; McCaw et al., 1999; Marchetti et al., 2018). It is possible to relate the bi-articular nature of the hamstring muscles to this lower EMG activity (Contreras et al., 2015). While squats involve the extension of the hip during concentric phase, for which the hamstrings are a primary motor, it also involves the extension of the knee, to which the
hamstrings are antagonists. Thus, the hamstring EMG activity is lower when the combined hip and knee extension is performed in comparison to the isolated hip extension (Yamashita, 1988). Such a situation occurs because the hamstrings change length in the BHT compared to performing simultaneous hip and knee extension that occurs in the various types of squats. This same effect (lower hamstring activity compared to other recruited muscles) is evidenced for other multi-joint exercises, such as lunges and leg press (Escamilla et al., 1998; Machado et al., 2017; Marchetti et al., 2018). According to Know and Lee (2013), the greater the angle of knee flexion, the lower the myoelectric activity of the hamstrings would be. This action occurs during all multi-articular exercises, thus explaining the different and lower levels of hamstring excitation found in these types of exercises. On the other hand, in the BHT exercise, there is virtually no knee extension movement, keeping the muscle tension levels of the hamstrings associated only with hip extension. Collazo Garcia et al. (2018) present a strategy to further increase the levels of neuromuscular excitation of the hamstring muscles (biceps femoris and semitendinosus), by positioning the feet further, enabling a greater level of stretching and increased muscle tension.

The fact that the traditional deadlift presented greater activation of the biceps femoris than BHT was due to the mechanical difference between the two (Andersen et al., 2018). At the beginning of the concentric phase of the traditional deadlift, the lever arm of the hip joint, in relation to the load, is longer, creating greater stress in the extensor muscles of the hip (Andersen et al., 2018). Thus, as the deadlift exercise reaches greater ranges of motion compared to BHT, there is a greater demand for work from these muscle groups. For this, the greater the distance traveled (greater work), the greater the myoelectric activity measured. On the other hand, in the BHT, the mechanical demand for the gluteus maximus and hamstring muscles is higher at the end of the movement than at the beginning (Contreras et al., 2015; 2017). Another possible explanation could be the initial muscle length, wherein the traditional deadlift, the knees are more extended at the beginning of the movement compared to the BHT, increasing the muscles' ability to generate force. Know and Lee (2013) demonstrated that the excitation of the hamstrings is greater in 0° of knee flexion, decreasing progressively until 110°. If you take into account that the knee flexion angles in the deadlift are smaller than in the BHT, it is easy to understand the higher EMG values found in the deadlift. According to the authors, two factors explain this: first, when the connective tissue is previously extended by the greater muscular stretching, this causes an increase of the passive tension, increasing the active tension for the muscular contraction; and second, the tension-length relationship of the sarcomeres, creates an ideal interaction for the generation of force by the actin and myosin bridges (Know and Lee, 2013).

In contrast, the vastus lateralis muscle exhibited similar EMG activity between the squat and BHT (Contreras et al., 2015). However, we could hypothesize that the BHT exercise would present less myoelectric activity of the vastus lateralis muscle in comparison to the squatting. Squatting is well known for causing high levels of quadriceps femoris EMG activity compared to other lower limb exercises (Schwanbeck et al., 2009; Wilk et al., 1996). Contreras et al. (2015) justify their findings through a concern with the statistical methods used, indicating a probable risk of type I error during the post hoc test used by using the Holm-Bonferroni correction instead of the more conservative Bonferroni correction. However, it is also possible that the different muscles that form the quadriceps femoris may present different levels of EMG activity during BHT (Collazo Garcia et al., 2018). Nevertheless, the different loads used by the studies included in this study make it difficult to compare the variations of BHT and other studies (Collazo Garcia et al., 2018; Contreras et al., 2015; 2017). Even so, the heavier loads used in the BHT, compared to squat types, could also have led to the significant differences found in the vastus lateralis muscle, whose function would be to stabilize (isometrically) the knee during the execution of BHT. Further, Collazo Garcia et al. (2018) presented that the muscle excitation sequence during the BHT exercise is the gluteus maximus, gluteus medius, biceps femoris, semitendinosus, vastus lateralis, vastus medialis, and rectus femoris. Therefore, according to them, the hamstrings: quadriceps coactivation ratio increases when variations are performed (Collazo Garcia et al., 2018).

Andersen et al. (2018) demonstrate similar EMG of erector spinae muscles between BHT and traditional and hex bar deadlift exercises. The results obtained here were expected since several other studies have already presented similar results analyzing other exercises (Camara et al., 2016; Gullett et al., 2009; Yavuz et al., 2015).

The maximum velocity required in activities such as sprinting seems to be dependent on horizontal and vertical force production (Brughelli and Cronin, 2011; Kuitunen et al., 2002; Loturco et al., 2018; Nummela et al., 2007; Williams et al., 2018). Williams et al. (2018) demonstrated high neuromuscular activity of the gluteus maximus muscle, along with a positive correlation between peak sprint speed and anteroposterior horizontal force with peak ground reaction force only in the BHT compared to two types of the barbell squat. Testing the effects of post-activation potentiation of different training loads on the BHT, Dello Iacono et al. (2018) and Dello Iacono and Seitz (2018) demonstrated improved speed in both professional handball and soccer athletes. Additionally, Loturco et al. (2018) indicate that the post-activation potentiation of the BHT is more associated with the acceleration phase (0 to 10 m) than with maximum velocity phases (distances greater than 40 m). These results suggest that the high recruitment of the hip extensor muscles can potentiate the acceleration for horizontal displacements in short duration tests such as sprinting. In this sense, Loturco et al. (2018) indicate that the near-perfect associations found between different loads of BHT and all velocities evaluated in the acceleration phase (up to 60 m) represent an important input for the development of optimal sprint training interventions.

According to the review done here, it is clear that the results of the chronic studies are divided as to the efficiency of this exercise beyond the acute phase, demonstrat-
ing both improvement (Contreras et al., 2017; Zweifel et al., 2017) as “no effect” (Bishop et al., 2017; Lin et al., 2017) over 6 and 8 weeks of training. The pilot study by Zweifel et al. (2017) demonstrated greater effect sizes for BHT after 6 weeks of training with varying loads (30-100% RM). Corroborating, Contreras et al. (2017) showed better results in the 10 and 20 m tests with BHT training compared to the front squat. In contrast, Lin et al. (2017) and Bishop et al. (2017) failed to transfer strength gains into more practical results. This variability of results may be associated with the different training loads used in each study. Zweifel et al. (2017) and Contreras et al. (2017) used load variation over the training time (30-100% RM), while Lin et al. (2017) and Bishop et al. (2017) used higher loads (6-12RM). It is known that sub-maximal loads demonstrate greater transference to sports activities that depend on higher power output. Thus, lighter and submaximal loads may be ideal for this outcome. In addition, the included chronic studies used samples of athletes composed of different sports specialties, and this may also have directly affected the results of the study, since the sprint technique may have varied among the different samples.

Finally, future studies should investigate whether the high levels of muscle activation of the hip extensor muscles seen in the BHT, transfer into results of muscle hypertrophy, and the optimal relationship of the BHT training load and its transfer to sprint performance. Outcomes such as these are still cause for much debate.

Conclusion

Through the studies included in this systematic review, we reached the following conclusions: a) the mechanics of the BHT favors the greater activation of the extensor muscles of the hip compared to more conventional exercises, b) regardless of the variation of BHT used, the muscle excitation sequence is gluteus maximus, erector spinae, hamstrings, and quadriceps femoris; c) the post-activation potentiation (acute effects) of the BHT is significant, improving short sprint time, and d) although training with submaximal BHT loads can improve sprint times, further investigations are needed.

Acknowledgements

We would like to thank everyone that supports this work. The experiments comply with the current laws of the country in which they were performed. The authors have no conflicts of interests to declare.

References


**Key points**

- Barbell hip thrust exercise presents greater activation of the hip extensor muscles compared to more conventional exercises.
- Post-activation potentiation of the barbell hip thrust is significant, improving short sprint time.
- Barbell hip thrust training with sub-maximal loads can improve sprint times.

---

**AUTHOR BIOGRAPHY**

**Walter Krause Neto**

**Employment**

Personal trainer and Postdoctoral fellow of São Judas Tadeu University.

**Degree**

PhD

**Research interests**

Exercise physiology, biomechanics, musculoskeletal disorders, peripheral nervous system morphology, neurodegenerative diseases, aging and strength training adaptations

**E-mail:** wild_krause@hotmail.com

---

**Thais Lima Vieira**

**Employment**

Personal trainer and military firefighter.

**Degree**

Bachelor of Physical Education.

**Research interests**

Exercise physiology and strength training adaptations

**E-mail:** thapaixao@gmail.com

---

**Eliane Florencio GAMA**

**Employment**

Master’s and PhD Advisor at São Judas Tadeu University

**Degree**

PhD

**Research interests**

Musculoskeletal disorders, neurodegenerative diseases, morphology/anatomy, body perception/image and strength training adaptations

**E-mail:** elfgama@profiaeliane.net

---

**Walter Krause Neto**

Rua Taquari, 546 - Mooca Unit - P.O box 03166-000 - São Paulo, SP – Brazil