

1 **Activation of the *Gluteus Maximus* during Performance of the Back Squat, Split Squat**
2 **and Barbell Hip Thrust and the Relationship with Maximal Sprinting**

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ABSTRACT

The purpose of this research was to compare muscle activation of the *gluteus maximus* and ground reaction force between the barbell hip thrust, back squat, and split squat and to determine the relationship between these outcomes and vertical and horizontal forces during maximal sprinting. Twelve male team sport athletes (age 25.0 ± 4.0 years, stature 184.1 ± 6.0 cm, body mass 82.2 ± 7.9 kg) performed separate movements of the three strength exercises at a load equivalent to their individual three repetition maximum. The ground reaction force was measured using force plates and the electromyography (EMG) activity of the upper and lower *gluteus maximus* was recorded in each leg and expressed as percentage of the maximum voluntary isometric contraction (MVIC). Participants then completed a single sprint on a non-motorized treadmill for the assessment of maximal velocity, horizontal and vertical forces. Although ground reaction force was lower, peak EMG activity in the *gluteus maximus* was higher in the hip thrust than the back squat ($p = 0.024$; 95%CI = 4 – 56%MVIC) and split squat ($p = 0.016$; 95%CI = 6 – 58%MVIC). Peak sprint velocity was correlated with both anterior-posterior horizontal force ($r = 0.72$) and peak ground reaction force during the barbell hip thrust ($r = 0.69$) but no other variables. The increased activation of *gluteus maximus* during the barbell hip thrust and the relationship with maximal running speed suggests that this movement may be optimal for training this muscle group in comparison to the back squat and split squat.

Keywords: *strength training, bilateral exercises, unilateral exercises, ground reaction force, electromyography*

INTRODUCTION

48

49 Axial loaded strength exercises such as the back squat are often regarded as a fundamental
50 component of strength programs designed to increase lower body strength and power (28, 43).
51 Traditional squatting exercises can be further sub-divided into bilateral and unilateral
52 derivatives, although they appear to be equally as efficacious for developing power and lower
53 body strength (29, 41). Nevertheless, these movements do not always improve sprint speed
54 (20). During maximal sprinting, ground contact appears to occur with the hips in a neutral to
55 slightly extended position, with the gluteus musculature shown to be the biggest contributor to
56 hip extension torque (17, 23). This position is not replicated by traditional squatting exercises
57 and this lack of movement specificity between the back squat and sprinting mechanics may
58 explain conflicting reports within the literature regarding its ability to improve running speed
59 (9, 20). Whilst exercises that elicit vertical forces initiate the gluteal muscles (particularly the
60 *gluteus maximus*) in a hips-flexed position, activation is reduced when the hips are neutral or
61 slightly extended (11). If strength and or force production in this position is a limiting factor
62 when sprinting, the back squat may not be the most suitable exercise to prescribe.

63

64 Conversely, horizontal force production is a key component in the optimization of acceleration
65 and maximal sprint speed (5, 7, 25, 33, 38) highlighting the importance of incorporating
66 exercises that develop horizontal forces in training programs. Indeed, when used in
67 combination with exercises that promote vertical force production, horizontally orientated
68 exercises have been shown to improve sprint speed and peak power (2, 31). Whether the effect
69 of exercises that utilize horizontal force expression can stimulate improvements in maximal
70 sprint speed without the inclusion of traditional squatting exercises has yet to be elucidated.
71 Recent research, however, has proposed the use of the barbell hip thrust as an alternative means
72 of training the posterior chain musculature of the lower body (11, 12). This exercise has been

73 shown to elicit greater *gluteus maximus* and hamstring activation when compared to the back
74 squat in strength trained females and higher anterior-posterior horizontal forces (12). The
75 barbell hip thrust allows strength to be developed with the hips in an extended position and via
76 a horizontal force production which may be of greater relevance to sprinting (17) (Fig. 1).
77 Although this approach would appear to contravene the training philosophy of specificity, it
78 does conform to the theory of dynamic correspondence; whilst not identical to the activity of
79 sprinting, the barbell hip thrust replicates the muscular patterns, synchronicity and energy
80 production involved during training (40).

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82 *****INSERT FIGURE 1 NEAR HERE*****

83

84 Despite recent research (11, 12, 14) comparing the barbell hip thrust with other bilateral
85 strength exercises and its relation to physical parameters including sprint acceleration and jump
86 performance, to our knowledge, there are no comparisons between unilateral strength exercises
87 and the barbell hip thrust. Furthermore, previous research has not determined whether there is
88 any relationship between *gluteus maximus* activity and/or force production during strength
89 exercises or maximal sprinting. The primary aim of the present study, therefore, was to
90 determine the difference between muscle activation and force production during the bilateral
91 squat, unilateral split squat, and barbell hip thrust. A secondary objective was to determine the
92 association of the aforementioned dependent variables with speed, and horizontal and vertical
93 forces during maximal sprinting. The experimental hypothesis was that the barbell hip thrust
94 would elicit higher mean and peak *gluteus maximus* activity when compared to the back squat
95 and split squat and these variables would be more strongly associated with parameters of
96 maximal running performance.

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METHODS

Experimental Approach to the Problem

In the first part of this experiment, measurements of ground reaction force and electromyography (EMG) of the *gluteus maximus* were recorded in team sport athletes during three repetition maximum efforts of the barbell hip thrust, bilateral squat and unilateral split squat. Data were then analyzed to determine whether there were any differences between the three different exercises. In the second part of the experiment, participants completed a single maximal sprint effort on a non-motorized treadmill while speed, horizontal force, and vertical force were measured. Data were then analyzed to assess whether there was any association between the variables of muscle activation and force measured during the three different strength exercises with metrics of maximal running performance.

Subjects

Twelve male team-sport athletes volunteered to participate in the study (age 25.0 ± 4.0 years; stature 184.1 ± 6.0 cm; body mass 82.2 ± 7.9 kg) who had 4.0 ± 1.0 years of strength training experience. Subjects had experience in all three exercises, however were utilized to varying degrees by each individual within their own training regimes. Inclusion criteria required participants to be aged between 18 and 35 years, have a minimum of 3 years resistance training experience and able to safely perform each of the three exercises with external load. All participants provided written informed consent and the study was approved by the School of Science and Sport Ethics Committee at University of the West of Scotland.

127

128 *Procedures*129 Assessment of three repetition strength

130 Participants performed three repetition maximum testing on each resistance exercise.

131 Participants performed a standardized warm-up comprising dynamic movement patterns

132 designed to target the gluteal musculature including external resistance via the use of mini-

133 bands. Immediately after the warm-up, participants completed submaximal loads in each of the

134 three exercises to determine the three repetition maximum as advocated by Baechle and Earle

135 (3). This procedure incorporated 5 to 10 repetitions with a light to moderate load, progressing

136 to heavier sets of three repetitions, until the three repetition maximum was determined. The

137 order in which the exercises were assessed was randomized and participants were allowed to

138 self-select recovery time between exercises. The barbell back squat was performed with feet

139 placed slightly wider than shoulder width apart with the bar secured across the upper trapezius

140 musculature (3). Subjects descended until the top of the thigh was deemed parallel to the floor,

141 which was continually cued by the researcher throughout the lifts. The barbell split squat was

142 performed with the same bar position but in a split stance, with the forward foot placed flat on

143 the floor and the rear knee slightly flexed to allow for a heel raised foot position on the trailing

144 leg. The barbell hip thrust was performed with the subject's upper back pressed against a

145 weights bench, with feet placed slightly wider than shoulder width apart and the bar positioned

146 across the hips, as advocated by Contreras and colleagues (11).

147

148 Maximal voluntary isometric contraction assessment

149 Participants completed the aforementioned warm up before performing progressive, sub

150 maximal lifts until they felt prepared to perform their three repetition lift as determined during

151 the initial trial. To prepare the subject for electrode placement their skin was shaved using a

152 Bic[®] hand razor and sterilized with an alcohol swab to reduce electrical impedance (1, 39). A
153 pair of Ag-AgCl surface conductive gel electrodes (Blue Sensor, Ambu) were then applied
154 with an inter-electrode distance of 2 cm in alignment with the fiber direction of the *gluteus*
155 *maximus* using positional guidelines described elsewhere (19). Electrodes were attached to
156 both the upper and the lower segment of the *gluteus maximus* on both sides of the body. A line
157 was drawn between the posterior superior iliac spine and the greater trochanter; the upper
158 electrode was placed approximately 5 cm above and laterally to the midpoint of this line given
159 the diagonal direction the muscle fibers course. The lower electrode was positioned
160 approximately 5 cm below and medially to the same line. Electrodes were secured to the skin
161 with tape to avoid movement artefacts (26). Maximum voluntary isometric contraction (MVIC)
162 testing was then performed for the *gluteus maximus* musculature using a standing glute squeeze
163 technique (4, 13). This value was used as a reference for the normalization of data.

164

165 EMG and force assessment during resistance exercises

166 On completion of MVIC testing, participants rested for four minutes before completing the
167 barbell hip thrust, unilateral split squat, and bilateral squat in a randomized order using a basic
168 counterbalanced design. Participants were instructed to complete a three repetition maximum
169 lift for each exercise according to loads previously established with four minutes rest between
170 exercises (3). Two fixed and embedded force plates (AMTI Optima 400600, Boston, USA)
171 were used to measure ground reaction force at a sampling rate of 1000 Hz calibrated according
172 to the manufacturer's guidelines. Participants were instructed to place one foot on each of the
173 force plates for the bilateral squat and barbell hip thrust. For the split squat, participants were
174 required to position their forward leg onto the force plate; for the split squat 3 Rep Max lifts
175 were completed on both legs. A portable squat rack was set up in front of the force plates for
176 the bilateral and unilateral split squats. The barbell hip thrust was performed with the upper

177 back supported on a 17 inch high bench as indicated in Figure 1. An EMG system (Myon AG
178 320, Schwarzenberg, Switzerland) was used to collect raw EMG signals at 1000 Hz which
179 were filtered using Myon proEMG software. EMG signals for all 3 repetitions of each set were
180 filtered using a 10 to 450 Hz bandpass filter and smoothed using root mean square (RMS) with
181 a 50 millisecond window (15). The EMG data are presented as the mean of the four EMG
182 electrode sites for each of the three exercises to allow comparisons between unilateral and
183 bilateral data. Mean and peak data were normalized to MVIC collected during the pre-
184 assessment glute squeeze. Force plate data are presented as the mean of both legs for each of
185 the three exercises to allow comparisons between unilateral and bilateral data.

186

187 Maximal sprint assessment

188 Following the strength assessments participants rested for 10 minutes before performing a
189 maximal linear sprint on a Woodway Force non-motorized treadmill (Woodway Force 3.0,
190 Waukesha, USA). Participants performed three submaximal warm up sprints to habituate
191 themselves with the treadmill. After a five minute rest they were instructed to complete a
192 maximal effort sprint during which maximal horizontal and vertical forces and velocity were
193 determined.

194

195 *Statistical Analysis*

196 All statistical analyses were conducted using Statistical Package for the Social Sciences (SPSS
197 22.0, IBM Corp, Armonk, NY, USA). The distribution of the data were first assessed using a
198 Shapiro Wilk test. One way repeated measure ANOVAs were used to compare mean and peak
199 EMG values between strength exercises. Differences in ground reaction forces were assessed
200 between strength exercises and between legs using a two way repeated measures ANOVA.
201 Any significant main effects were further analyzed by applying Bonferroni corrections for

202 pairwise comparisons. Effect sizes (M1-M2/SD) were calculated using Cohen's d values and
203 defined as small (0.20), medium (0.50) and large (0.80) (11). Pearson product-moment
204 correlations were also used to determine the relationship between peak sprinting velocity and
205 selected variables. Statistical significance was accepted at $p < 0.05$ and 95% confidence
206 intervals (95% CI) are presented with p values.

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RESULTS

Exercise Loads

211 The three repetition maximum exercise loads for the barbell hip thrust (157 ± 29 kg, 1.9 ± 0.3
212 x body mass) were higher than both the back squat (117 ± 39 kg, 1.4 ± 0.3 x body mass, $p =$
213 0.001) and the split squat (68 ± 23 kg, 0.8 ± 0.2 x body mass, $p < 0.001$). The three repetition
214 maximum loads for the back squat was higher than the split squat ($p < 0.001$).

215

Mean Activation

217 The barbell hip thrust displayed higher mean *gluteus maximus* activation than both the back
218 squat ($d = 1.29$; $p = 0.005$; 95% CI = 10 – 55 %MVIC) and split squat ($d = 1.24$; $p = 0.006$;
219 95% CI = 9 – 54 %MVIC, Fig. 2a). There was no difference in mean *gluteus maximus*
220 activation between the squat and split squat ($d = 0.05$; $p = 1$; 95% CI = 11 – 13 %MVIC).

221 *****INSERT FIGURE 2a NEAR HERE*****

222

Peak Activation

224 The barbell hip thrust displayed higher peak *gluteus maximus* activation than both the squat (d
225 = 1.08 ; $p = 0.024$; 95% CI = 4 – 56 %MVIC) and split squat ($d = 1.08$; $p = 0.016$; 95% CI = 6

226 – 58 %MVIC, Fig. 2b). There was no difference in peak *gluteus maximus* activation between
227 the squat and split squat ($d = 0.07$; $p = 1$; 95% CI = 15 – 19 %MVIC).

228 ***INSERT FIGURE 2b NEAR HERE***

229

230 Peak Ground Reaction Force

231 There were no difference in peak ground reaction force between left and right legs in any three
232 of the strength exercises (Fig. 3) Peak force in the right foot was lower in the barbell hip thrust
233 compared to the back squat ($d = 2.98$; $p < 0.001$; 95% CI = 416 – 1012 N) and the split squat
234 ($d = 2.24$; $p < 0.001$; 95% CI = 412 - 740 N). Peak force in the left foot was also lower in the
235 barbell hip thrust compared to the back squat ($d = 2.80$; $p < 0.001$; 95% CI = 596 – 1130 N)
236 and the split squat BSS ($d = 1.80$; $p < 0.001$; 95% CI = 412 - 740 N). Peak force was higher in
237 the back squat than compared to the split squat in the left leg (ES = 0.66; $p = 0.019$; 95% CI =
238 45 – 534 N) but not the right leg ($p = 0.18$).

239

240 ***INSERT FIGURE 3 NEAR HERE***

241

242 Maximal Sprinting

243 Peak anterior-posterior horizontal force during sprinting was significantly correlated to peak
244 velocity ($r = 0.72$, $p = 0.008$) but there was no relationship between peak vertical force and
245 peak velocity ($r = 0.232$, $p = 0.47$). Peak force during the barbell hip thrust was significantly
246 correlated with peak sprint velocity ($r = 0.69$, $p = 0.014$). There was a weak relationship
247 between maximal sprint velocity and peak force in both the bilateral squat and the unilateral
248 split squat, but neither reached statistical significance ($r = 0.52$, $p = 0.086$; $r = 0.53$, $p = 0.076$,
249 respectively). Peak *gluteus maximus* activation for each exercise was not correlated with peak
250 sprint speed (all $p > 0.05$).

251 ***INSERT FIGURE 4 NEAR HERE***

252 ***INSERT FIGURE 5 NEAR HERE***

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DISCUSSION

256 The objective of the present study was to compare muscle activation of the *gluteus maximus*
257 and ground reaction force between the barbell hip thrust, back squat, and split squat and to
258 determine the relationship between these outcomes and vertical and horizontal forces during
259 maximal sprinting. In agreement with our experimental hypothesis, the barbell hip thrust
260 elicited significantly higher mean and peak *gluteus maximus* activation than the back squat and
261 the split squat when performing three repetition maximum lifts despite a lower peak ground
262 reaction force in this movement. The data supports recent research with female athletes that
263 demonstrated a higher *gluteus maximus* activation in the barbell hip thrust compared to the
264 back squat (12). The present study further extends these findings by demonstrating that peak
265 sprint velocity is significantly correlated with both peak horizontal sprint force and peak barbell
266 hip thrust force.

267

268 The results of the present study align with Contreras and colleagues findings and suggest that
269 greater peak and mean activation of the *gluteus maximus* occurs in the barbell hip thrust
270 compared to the back squat. Recent extensive pilot studies by Contreras and colleagues have
271 suggested that the *gluteus maximus* elicits peak EMG activation at the shortest muscle length
272 in hip hyperextension (12). Several researchers have concluded that peak *gluteus maximus*
273 activation during the back squat occurs on the ascendancy from the bottom of the lift in a hip's
274 flexed position and that activation increases with load (45). However, Contreras and colleagues
275 (12) found that during isometric holds of both the barbell hip thrust (fully extended position)

276 and back squat (fully flexed position), the former produced significantly greater mean and peak
277 EMG activation in the *gluteus maximus*.

278

279 Although there have been numerous studies comparing unilateral to bilateral strength exercises,
280 to the knowledge of the authors, this is the first study to compare a unilateral exercise to the
281 barbell hip thrust. The results showed that while there were no differences between the two
282 squat movements, the barbell hip thrust elicited significantly greater *gluteus maximus*
283 activation than the split squat. The similarity in *gluteus maximus* activation between the squat
284 movements may appear surprising given that peak ground reaction force and the summated
285 total load across both front limbs in the semi-unilateral split squat was higher than in the
286 bilateral back squat (1.6 vs 1.4 x body mass, respectively). Given that an increased load has
287 been shown to increase muscle activation (37), it may be presumed that the additional load
288 during the split squat would have produced higher *gluteus maximus* activation than in the back
289 squat. In this instance, however, the unilateral strength exercise produced similar EMG
290 activation of the *gluteus maximus*. These findings are similar to that of Jones and colleagues
291 (22) who found no difference in *gluteus maximus* activity between unilateral and bilateral
292 exercises despite discrepancies in relative load. Muscle activity was not measured in the
293 support leg in either the present study or in previous work (22) which may explain some of this
294 disparity and highlights the necessity for further research in this area.

295

296 Training with traditional squat movements does not always lead to an improvement in maximal
297 sprinting speed (20) although this is often a desired outcome given several studies have
298 demonstrated enhancements in this ability (27, 41). Given that sprint velocity appears to be
299 more dependent on horizontal force production than vertical force production (5, 24, 36), this
300 is perhaps not surprising. Indeed, in the present study, horizontal force production was

301 significantly correlated with maximal sprint velocity. Furthermore, the data presented here
302 demonstrates that peak barbell hip thrust ground reaction force was significantly correlated
303 with maximal sprint velocity. While the vertically oriented back squat and split squat elicited
304 higher ground reaction forces than the barbell hip thrust, the correlation between these values
305 and maximal sprinting speed did not reach statistical significance. Although speculative, this
306 suggests that force production during the barbell hip thrust may be associated with sprint
307 performance in team sport athletes. Furthermore, horizontal anteroposterior based exercises
308 such as the barbell hip thrust may be more effective for improving maximal sprint speed than
309 either squat movement. Indeed, Contreras and colleagues (14) reported that a six week barbell
310 hip thrust training intervention led to improved 20 m sprint times with no improvement in a
311 group completing back squat training. This presents a compelling case that the orientation of
312 force application is an important factor in determining maximal sprint performance. Squats and
313 their derivatives are clearly staples in the field of strength and conditioning, however,
314 understanding how movement mechanics accentuate force development is becoming an
315 important factor in exercise selection.

316

317 Despite a positive relationship between horizontal sprint force and maximal sprint velocity,
318 *gluteus maximus* activation was not correlated with maximal sprint velocity. This perhaps is
319 not surprising given Morin and colleagues findings that generation of horizontal force during
320 sprinting was linked with a better activation of the hamstring muscles just prior to ground
321 contact (34). Since the barbell hip thrust and back squat both produce significantly greater
322 *gluteus maximus* activation when compared to *biceps femoris* (11) the lack of correlation
323 between muscle activation and sprint velocity in this study is perhaps to be expected. On the
324 other hand, muscle activation during a hamstring dominant exercise may be more strongly
325 associated with maximal sprint performance.

326

327 The assessment of sprint performance in this study was conducted using a non-motorized
328 treadmill. Although this treadmill is regarded as a valid and reliable means of assessing short
329 sprint performance (21) some may question how closely it replicates sprinting outdoors. For
330 example, running on a treadmill eliminates air resistance which is likely to be meaningful
331 during sprinting exercise (42). Furthermore, given the individual is tethered at the hips and has
332 to manually move the treadmill belt with their feet, one could argue this encourages an inclined
333 position, decreasing the involvement of the postural musculature. However, McKenna and
334 Riches (30) demonstrated that individuals use similar sprinting technique on the non-motorized
335 treadmill to over ground sprinting. Furthermore, Morin and colleagues (35) reported that
336 individuals performing sprint accelerations on the non-motorized treadmill produce similar
337 physical and technical movements to outdoor sprint accelerations.

338

339 In the present study only two force plates were used, both positioned beneath the feet during
340 the barbell hip thrust exercise. However, at the top of the lift, it is likely that a large portion of
341 the vertical force will be exerted through the bench itself. As such, we would suggest that in
342 future research, an additional plate is placed under the bench or structure supporting the back
343 in order that the ground reaction forces can be more fully quantified. A further potential
344 limitation of the present study was the use of surface EMG to measure muscle activity. The
345 limitations of this technique have been discussed extensively by De Luca (15) and include
346 muscle fiber movement, cross talk from adjacent musculature, extrinsic factors such as volume
347 of subcutaneous fatty tissue and that electrodes may not detect all active motor units.
348 Additionally, EMG peaks may potentially be artefacts given that the EMG signal not only
349 includes muscle movement information but also noise components which are unpreventable
350 despite efforts being made to filter out these unwanted components (15). To reduce potential

351 cross talk, the surface electrodes were positioned within the middle of the muscle belly of the
352 *gluteus maximus* and applied in parallel arrangement to the muscle fibers, with a center to
353 center inter-electrode distance of 2 cm. Further to this, the upper and lower *gluteus maximus*
354 have been shown to activate uniquely (12). However, since in the current study data from these
355 musculature were averaged it has not been possible to determine how the upper and lower
356 fibres correlate with sprinting independently. Despite some of the positive findings in the
357 present study between commonly utilized strength exercises and sprinting, the data obtained is
358 mechanistic in nature therefore the authors suggest future training studies are required to show
359 transference to sprinting and to verify the proposed theories.

360

361

362

PRACTICAL APPLICATIONS

363 Given maximal sprint speed is correlated with horizontal force production but not vertical
364 production, utilizing exercises which develop force in the horizontal plane may provide
365 superior transfer to sprint based performance. Furthermore, the present study has demonstrated
366 maximal sprinting speed to be correlated with peak force production during the barbell hip
367 thrust but neither of the two vertical squat movements. Applied practitioners can incorporate
368 the barbell hip thrust into their strength programs based on data indicating it has the capacity
369 to elicit greater *gluteus maximus* activity than both the back squat and split squat and that it is
370 more likely to lead to a greater increase in horizontal force production. Based on this data it is
371 proposed that performing anteroposterior strength exercises such as the barbell hip thrust as
372 well as focusing on methods to increase horizontal force during sprinting may be effective in
373 improving maximal sprint performance. During maximal sprinting, it appears toe off at ground
374 contact occurs with the hips in a slightly hyperextended position, which could be a key
375 component as to why barbell hip thrust force production is a better indicator of maximal sprint

376 velocity (17, 23). This is not to suggest that the barbell hip thrust should be used as a
377 replacement for more traditional vertical orientated exercises given they have also been shown
378 to improve sprint performance (28, 44).

379

380

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382

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FIGURE LEGENDS

Figure 1. Diagram annotated to show equipment and positional requirements of the Barbell Hip Thrust (permission given by the participant for photographs to be included in this publication)

Figure 2a). Mean *gluteus maximus* EMG activation for all three exercises expressed as a percentage of the maximum isometric voluntary contraction. Data are presented as mean \pm standard deviation. * = significantly greater than the back squat. \diamond = significantly greater than the split squat.

Figure 2b). Peak *gluteus maximus* EMG activation for all three exercises expressed as a percentage of the maximum isometric voluntary contraction. Data are presented as mean \pm standard deviation. * = significantly greater than the back squat. \diamond = significantly greater than the split squat.

Figure 3). Peak ground reaction force in each leg for all three exercises. Data are presented as mean \pm standard deviation. \dagger = significantly greater than the hip thrust. \diamond = significantly greater than the split squat.

Figure 4). Correlation between peak anterior-posterior horizontal force during sprinting and peak sprint velocity.

582 **Figure 5).** Correlation between peak force during the barbell hip thrust and peak sprint
583 velocity.

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Bench "13"-19" in height as recommended by Contreras (2011)

Trunk musculature braced prior to concentrically raising the bar and throughout the lift

Upper back fixed to bench

Chin tucked to allow safe alignment with spine

Raise bar until torso reaches approx. parallel with floor

Hands evenly spaced on the bar

Feet positioned approx. shoulder width apart

Thick pad is positioned directly in centre of bar to ensure symmetry

Neutral pelvis – no excessive lumbar hyperextension









