Comparing the effect of hip thrust performance against vertical and horizontal jumping after a 14-week intervention period

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Abstract

To date, there is a lack of substantial research on the hip thrust exercise, and in particular the correlation between the hip thrust exercise and both vertical and horizontal force production. This study seeks to address this gap, and contribute new knowledge on the hip thrust for research and practice. The aim of this study, therefore, is to discover the effects of hip thrust performance on vertical and horizontal jumping. To meet these objectives, this study used a 14-week intervention programme with 11 collegiate female athletes aged 18-24. The programme involved two resistance training sessions a week, that centred on the hip thrust exercise. Pre and post testing was used to measure the following: vertical squat jump, vertical countermovement jump, horizontal squat jump, horizontal countermovement jump and hip thrust 3 repetition maximum (3RM). This was a randomised within subject study. A repeated measures ANOVA was completed to compare participants' scores as well as the statistical significance ($p < 0.05$) between the pre and post testing results. It was hypothesised prior to the study that the horizontal jumps would improve more significantly than the vertical at the conclusion of the intervention. This was due to recent research that has argued that horizontal force has a stronger correlation with horizontal directional activities. However, in the end, this study found that *both* vertical and horizontal jumping improved substantially (ranging from 5.42% to 7.67%), with no statistically significant difference between the two ($p = 0.237$). This reveals the potential impact of horizontal exercises on vertical force production, and the wide ranging benefits of the hip thrust exercise for strength and conditioning programmes.

KEYWORDS: hip thrust exercise; horizontal movements; vertical movements; jumping; resistance training

Chapter 1. Introduction

In recent years, research has suggested an improvement in hip thrust performance could have a strong carryover effect towards exercises, such as acceleration, sprinting and horizontal jumps (3, 11, 40). In order to investigate this research the dynamic correspondence between hip thrust and horizontal and vertical jumping was assessed. The exercises mentioned above require the athlete to overcome the ground reaction forces (GRF) of gravity, reaction and friction in order for the athlete to move. For the athlete to overcome these forces he or she must apply a greater amount of force. According to the research, gravity is overcome by vertical force production and reaction and friction forces are overcome by horizontal force production (17). A study by Contreras et al. (11) published in 2017 found a hip thrust programme had more of an improvement in 10 and 20 meter sprint times than a front squat programme following a 6 week intervention. In addition, the effect towards horizontal jumping showed no definitive difference between either form of exercising (11). In the following introductory section, the rationale for this research project is discussed in detail, as well as the literature on which this research is based.

The hip thrust exercise, as discussed in research by Eckert et al. (15) and Contreras et al. (8), is a loaded horizontal resistance exercise which utilises the posterior chain hip extensor muscles, such as the glutes and the hamstrings, in order to execute the movement. The effects of the hip thrust can range from an increase in gluteus maximus size (hypertrophy) to an increase in strength and power (8, 15). Through an increase in strength and power of the hip extensor muscles, an increase in horizontal force production relative to the ground reaction forces has been found to be a correlating result (3, 14, 29). This increase may enable the athlete to overcome the reaction and friction forces acting on the body, through gravity and

the ground, as necessary in order for the athlete to move in a desired direction. As such this may lead to an increase in sprint performance and acceleration (3, 11, 14, 35).

In addition, according to research that explores the production of force, the direction in which the force is applied needs to be considered (31). Whether or not an exercise requires more horizontal or vertical force in order to perform to its maximum capacity is a common question asked when designing training programmes. According to the paper by Hunter et al. (19) on sprinting, it was found that vertical force needed to be greater to overcome gravity and braking forces in order to sprint at maximum velocity. Further expanding on this, a study by Randell et al. (31) found that if a greater production of horizontal force was applied in the acceleration phase, the athlete was able to reach the max velocity phase of a sprint much quicker. Therefore, in sports where short distances are common, for example 10-30 metre bursts in sports such as basketball, soccer and rugby, certain researchers would argue, based on dynamic correspondence, that an enhanced production of horizontal force would have a primary transfer effect to the specificity of the movements carried out by these athletes (1,13, 25, 31, 40).

This current argument stressing the importance of horizontal force contrasts with previous research, such as studies by Lopez-Segovia et al. (22) and Baker et al. (1) that maintain the importance of squatting for athletes. These studies focus on the training effect of squatting exclusively when measuring and training both vertical and horizontal force. Although squatting is a vertical directional exercise, they argue that it is a sufficient form of exercise to measure both vertical and horizontal force (1, 22). Adding to this, the squat exercise has been found to have strong correlation with max velocity sprinting and vertical jumping (7, 11, 30, 35, 38, 40). In other words, from this literature, it is possible to conclude that an increase in

vertical force dynamically corresponds better to max velocity sprinting. The rebound during max velocity sprinting may explain the transfer effect between vertical force based exercises.

At the same time, more recent research identifies a stronger correlation between horizontal movements when measured against shorter distances (6, 11, 31). In a study by Lockie et al. (21), it was found that athletes with superior ground contact forces had greater acceleration. In other words, these research studies highlight the need for investigation into the horizontal determinants that elicit better acceleration (6, 11, 21, 31). This contrasts from prior research that emphasises vertical (over horizontal) force production. Additionally, according to studies by Morrissey et al. (28), Sale et al. (34) and Wilson et al. (37), the movement specificity and mechanical similarity between the exercises used within a programme and the movements of the sport will have a better transfer effect to performance than non specific movements. These studies also found the direction of the force being applied relative to the athlete and the ground had a greater transfer effect to performance (28, 34, 37). This would suggest that sports that demand large productions of horizontal forces over short distances and/or in a short time frame, like rugby, soccer, and basketball, would greatly benefit from a programme of this kind. As such, athletes from these team sports were targeted in this study.

Based on an in-depth engagement with the relevant literature, the aim of this study is to investigate whether or not there are differences in improvements between horizontal and vertical jumping after a 14-week intervention programme with 11 collegiate female athletes that centred around the hip thrust exercise. It was hypothesised that: (a) the participants would see overall improvement in all 5 measures tested, the vertical squat jump, vertical counter movement jump, horizontal squat jump, horizontal counter movement jump and hip thrust strength, at the conclusion of the 14 weeks; and (b) that the horizontal jumps tested would have a more significant improvement than the vertical jumps after the 14-week intervention.

This hypothesis was based on the theory that an increase of horizontal force production has a better transfer effect to horizontal performance (5, 11, 31).

The specific jumping measures selected for this study were based on best practice according to the literature. In particular, Cronin et al. (12) found squat jump and countermovement jump both had strong correlations to acceleration and speed, therefore providing an inclusive measure from which to analyse the effects of a horizontal resistance training programme. The study deployed a variety of jumping styles as each style has different technique demands and produces different force outputs (24, 33, 39).

To conclude, while the effects of hip thrust exercises has been researched extensively in the past, the specific effect of a hip-thrust resistance programme on vertical and horizontal jumping is an under researched area (11, 31, 40). Therefore, this research project's exclusive focus on the influence of a horizontal plane movement makes a timely and much-needed addition to current research and practice. It is at the intersection of these academic debates that this research project is situated, as the study looks specifically at how a horizontal exercise, the hip thrust, effects horizontal and vertical movements in the form of jumping.

Chapter 2. Methods

The following section outlines the methods deployed in order to answer the study's key research aims. It includes details of the research approach, the participants who took part, the pre and post testing sessions as well as the training procedure carried out for the 14 weeks.

Experimental Approach to the Problem

This was a randomised within subject training study with no control group. The study was a repeated measure pre-post design. Each participant carried out a pre-determined hip thrust programme, performing two sessions per week for 14 weeks, totalling 28 sessions. Testing variables were recorded pre and post the training study. The variables measured were as follows: vertical and horizontal jump (VJ and HJ) in the form of squat jump (SJ) and countermovement jump (CMJ), in addition to 3 rep maximum (RM) hip thrust strength. The testing methods used in this study were reliable measures specifically related to the variables being tested (26).

Subjects

In order to be eligible for this study all participants were required to be female collegiate athletes, who were at least 18 years of age. They also had to have at least one year of experience in a sport that involved both horizontal and vertical jumping, such as soccer, basketball, and rugby. Participants also needed to be completely injury free. Females were chosen as they were the demographic the tester had more access to. Participants were acquired through the sports clubs of a single university in Ireland. Approval was requested and then granted from the university before contact was made with teams and athletes within their organisation. Contact was made initially by email. Those athletes who expressed interest in

taking part attended an in-person meeting and were then given information sheets regarding the study. 15 participants were obtained for the study and agreed to take part on a voluntary basis. Participants' signed consent forms prior to starting the study and characteristics for the participants can be seen in Table 1. This study was approved by the Research Ethical Committee at St. Mary's University in London.

Table 1. Participant Characteristics

N	Age (y)	Height (cm)	Weight (kg)
11	22 ± 2	165.45 ± 4.52	69.58 ± 12.19

Procedures

Pre-testing session

The pre-testing session began with each subject filling out the necessary paperwork (Par-Q, Consent form). Following this, participants listened to a brief presentation outlining the details of what the training session would involve, as well as an overview of the 14-week programme. Each two participants were randomly assigned a group (VJ vs HJ and SJ vs CMJ) by a coin toss. The first coin toss decided which form of jumping (VJ/HJ) participants begun with and the second coin toss decided which style of jumping (SJ/CMJ) they did first within each style. For convenience, the vertical jump and the squat jump were assigned heads for both tosses, and the horizontal jump and the countermovement jump were assigned tails. This was then followed by a 10 minute dynamic warm up, the jump tests and finally finishing with the 3RM hip thrust strength test. Details for each of these sessions are provided below.

Dynamic Warm Up

The 10 minute dynamic warm up targeted the lower body. It consisted of a range of mobility drills with particular focus on the hips and lower back. This was followed by glute activation work involving mini bands, in exercises such as clam shells and crab walks. This warm up

process was used before the pre and post testing sessions and before each of the 28 sessions throughout the training study.

Jump Tests

Both vertical and horizontal jump tests were carried out in the testing session. The vertical jumps were measured using a *'Probotics Vertical Jump Mat'* and the horizontal jumps were measured using an *'Atreq standing long jump mat 3.5m'* . The testing involved twelve jumps in total. Each participant performed 6 VJ broken into 3 SJ and 3 CMJ. In addition, each participant performed 6 HJ broken into 3 SJ and 3 CMJ. With jumps taking less than 5 seconds to complete a 30 second rest period was given between each jump giving a work to rest ratio of at least 1:6. The participants' best jump from each format was recorded for the study.

As mentioned, a *'Probotics Vertical Jump Mat'* was used to measure the participants' vertical jump scores. The participants stood on the mat with feet hip width apart and toes pointing forward. When prompted, they jumped as high as they could, and then landed on the mat with both feet. An arm swing was permitted during the jumps. The participants landed toe to heel with legs at full extension; this was to prevent any knee hugging to boost the length of time spent in the air during the descent of the jump. The participants had to land on the mat in order for the jump to be recorded. The jump mat measures the jump height in inches (In) and the flight time in seconds (s).

Additionally, a *'Atreq standing long jump mat 3.5m'* was used to measure the horizontal jumps. This is a standard mat 3.5 metres in length that has markings displaying the distance (in metres) throughout. The participants stood toes behind the start line, and then jumped forward as far as they could. Jumps were not counted if the participant fell over upon landing.

The participants' distance was measured from the start line to the heel of the foot furthest back. Metres (m) were used to record each HJ.

Participants were instructed on the technique required for the SJ and CMJ before carrying out the trial. For the SJ, the participants were advised to squat down as close to a parallel position as they could, pause for one second then extend explosively upwards into the air. For the CMJ, the participants were advised to start from a standing position. From there they were advised to squat down to a half squat position, half way between standing and the bottom parallel position, and then extend explosively upwards without pausing at the bottom position. Arm swing was permitted throughout both styles of jumping. Participants were given a practice attempt at each jump to ensure they were comfortable with the technique. The best score of each of these jumps was then recorded.

Hip Thrust 3RM

The participants followed the following hip thrust technique throughout testing as well as during the 14-week programme. They began by sitting on the floor beside a padded bench, or box. The bench was aligned with the mid region of the shoulder blades and the barbell was set up with large plates, technique or bumper plates, to lift the bar off the ground. Then the participants straightened the legs out and rolled the bar in over the crease of their hips, bending the legs until a 90 degree angle relative to the knee and the ground was achieved with a vertical tibia. The participant was in a seated position with the knees bent and the feet placed shoulder width apart. In order to provide a comfortable lifting experience, a barbell pad or cushioning of some sort, such as a towel or a mat, was placed between the barbell and the hip bone.

From this position, the participants were instructed to take a deep breath, brace the core and lift through the hip extensor muscles. The participants were advised to keep the spine in

neutral and not hyperextend during the uplift, while simultaneously keeping the knees over the toes, not allowing them to cave in. From here the participants pushed down into the ground through their heels driving the hips up. The back then hinges up onto the bench with the hips rising until the hips and torso were parallel with the ground while the feet were kept flat. Meanwhile, the leader of the study is observing the exercise closely and advises the participant to not go into hyperextension at this position of the exercise. The top level was held for one second then the hips were slowly lowered back down to the floor, in a controlled safe manner. The neck and head were kept in alignment with the spine in order to ensure maximum safety, enabling the exercise to be executed in a controlled manner throughout the movement.

The hip thrust 3RM was measured using a 'Push Band'. The 'Push Band' is a specific brand of accelerometer, sold by PUSH Inc. The 'train with push' band measures velocity in meters per second, determining the speed at which the bar moves. The 'Push Band' has been shown to be a very reliable and accurate measure of max strength (2).

The 'Push Band' is a piece of technical equipment, and during the pre and post hip thrust testing it was placed on the front of either forearm of the participants using the attached strap. The band was connected to the push app, which tracks and records the data being sent from the band. The velocity at which the bar moves was then recorded through the motion of the arm holding onto the bar. This allowed the leader of the study to see the training effect being executed during the desired movement. For example, for velocity training the leader is looking for figures of around 1.0 m/s, for max strength around 0.1 m/s and for 3RM around 0.2-0.3 m/s. This is best practice according to the Push Band manufacturers. For accuracy, the app requires that the specific exercise being done is selected, which in the case of this study was the barbell hip thrust. The weight that was being lifted was also entered into the app.

The participants followed the process below in order to ascertain their 3RM.

- Warm Up Set One:

10 repetitions @ 30kg

- Warm Up Set 2:

5 repetitions @ 10-20% increase of previous weight used

- Trial Set One:

3 repetitions @ 20-30% increase of previous weight used

- Trial Set Two (and beyond if necessary):

3 repetitions @ 10-20% increase of previous weight used

A successful trial was achieved when the athlete's hips reached parallel to the floor. For each successful trial, 10-20% of the previous weight was added until the athlete performed an unsuccessful attempt. After an unsuccessful effort, one more trial was attempted, with a 5-10% reduction from the previous weight. The percentage of weight added, approximately 10-20% each set, was determined by the difficulty or ease at which the participant carried out the previous set. Participants who had easier sets saw a higher percentage increase. The leader of the study supervised each session, in order to ensure the safety of the participants throughout the entire programme. The 3RM test was chosen over a 1RM test for safety reasons. All 3RM scores were measured in kilograms (kg).

14-week resistance training programme

As this was a within subject study, each participant carried out the same 14 week workout programme, the details of which are shown in Table 2. The programme involved two sessions a week or 28 sessions in total. Each session was primarily based around 6 hip thrust sets. In addition to these sessions, some upper body and core exercises were included. Incline

press, standard military press, bench press, bent over rows, bench pull and seated rows were the main upper body exercises that were included. Two of these alternate exercises were selected for each session, and participants carried out 4 sets of 8 repetitions for each. This was then followed by 4 sets of core exercises for the abdominals and lower back. Layout of each training session is shown in table 3.

Table 2. Hip Thrust Programme Layout

Week	Sets	Reps	Load
1	6	12	40% of 3RM
2	6	12	45% of 3RM
3	6	12	50% of 3RM
4	6	10	55% of 3RM
5	6	10	60% of 3RM
6	6	8	65% of 3RM
7	6	8	70% of 3RM
8	6	12	45% of 3RM
9	6	12	50% of 3RM
10	6	10	55% of 3RM
11	6	10	60% of 3RM
12	6	8	65% of 3RM
13	6	8	70% of 3RM
14	6	8	75% of 3RM

Table 3. Layout of each workout session during programme

Process	Day One	Day Two
1. Warm up	10 minute warm up	10 minute warm up
2. Hip thrust	6 sets of hip thrust	6 sets of hip thrust
3. Upper body - One exercise from the group	Incline Press or Military Press or Bench Press 4 sets x 8 reps each	Incline Press or Military Press or Bench Press 4 sets x 45 seconds
4. Upper body - One exercise from the group	Bent over row or bench pull or seated row 4 sets x 8 reps each	Bent over row or bench pull or seated row 4 sets x 45 seconds
5. Core work	Abdominal and / or lower back work 4 sets x 45 seconds	Abdominal and / or lower back work 4 sets x 45 seconds

Post-testing

Following the completion of the 14 weeks / 28 sessions, the post study testing was carried out by the study leader. This session was identical in format to the pre-testing session. First, the study leader explained the format of the session. This was followed by a 10 minute dynamic warm up. After the warm up, participants completed the jump testing and the hip thrust 3RM test. The jump tests, including both VJ and HJ, as well as SJ and CMJ, were carried out in the exact order the participants completed them during pre-testing. These results were then recorded.

Statistical Analysis

All data was stored and analysed using IBM SPSS (Statistical Package for Social Studies). A significance level for all analysis was set at $p < 0.05$. A repeated measures analysis of variance (ANOVA) was used to determine if there was any significant difference between the

pre and post measures of the variables tested, with Bonferroni post hoc testing done to compare the means (20).

As the vertical measures were collected in inches and the horizontal measures collected in metres, in order to compare the levels of improvement between vertical and horizontal jumping the jump scores had to converted to a similar measure. This alteration was done using the following formula; Individual jump score / the mean of the of the pre-jump group scores. From this a repeated measures ANOVA was again performed to measure the significance level of change between each style of jumping.

Chapter 3. Results

While there was an initial total of 15 collegiate female athletes who were recruited for this study, four participants ended up dropping out for various reasons. Two withdrew based on time restraints, one had a scheduling conflict and one left due to an illness (unrelated to the study). Therefore, 11 participants successfully completed the study, and attended each of the required sessions giving a 100% attendance rate. The volumes and intensities achieved by each athlete throughout the programme can be seen in table 4, table 5 and a summary of the totals in table 6.

Table 4. Hip Thrust volumes (Kg) achieved by each participant from week 1 to 14

	W1	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14**
1	2880	3240	3420	3150	3450	3000	3240	3240	3420	3150	3450	3000	3240	3480
2	3240	3420	3780	3450	3750	3240	3600	3420	3780	3450	3750	3240	3600	3840
3	2880	3060	3240	3000	3300	2880	3000	3060	3240	3000	3300	2880	3000	3240
4	2880	3060	3240	3000	3300	2880	3000	3060	3240	3000	3300	2880	3000	3240
5	3240	3420	3780	3450	3750	3240	3600	3420	3780	3450	3750	3240	3600	3840
6	2880	3240	3600	3300	3600	3120	3360	3240	3600	3300	3600	3120	3360	3600
7	3240	3420	3780	3450	3750	3240	3600	3420	3780	3450	3750	3240	3600	3840
8	2880	3240	3600	3300	3600	3120	3360	3240	3600	3300	3600	3120	3360	3600
9	3600	3960	4320	4050	4350	3720	4080	3960	4320	4050	4350	3720	4080	4320
10	2700	3060	3240	3000	3300	2880	3000	3060	3240	3000	3300	2880	3000	3240
11	2340	2700	2880	2700	2850	2520	2760	2700	2880	2700	2850	2520	2760	2880

Table 5. Exact Intensities (%) of hip thrust lifts during each session by each participant from week 1 to 14

	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1	42.1	47.3	50.0	55.2	60.5	65.7	71.0	47.3	50.0	55.2	60.5	65.7	71.0	76.3
2	42.8	45.2	50.0	54.7	59.5	64.2	71.4	45.2	50.0	54.7	59.5	64.2	71.4	76.1
3	44.4	47.2	50.0	55.5	61.1	66.6	69.4	47.2	50.0	55.5	61.1	66.6	69.4	75.0
4	44.4	47.2	50.0	55.5	61.1	66.6	69.4	47.2	50.0	55.5	61.1	66.6	69.4	75.0
5	42.8	45.2	50.0	54.7	59.5	64.2	71.4	45.2	50.0	54.7	59.5	64.2	71.4	76.1
6	40.0	45.0	50.0	55.0	60.0	65.0	70.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0
7	42.8	45.2	50.0	54.7	59.5	64.2	71.4	45.2	50.0	54.7	59.5	64.2	71.4	76.1
8	41.0	46.1	51.2	56.4	61.5	66.6	71.7	46.1	51.2	56.4	61.5	66.6	71.7	76.9
9	41.6	45.8	50.0	56.2	60.4	64.5	70.8	45.8	50.0	56.2	60.4	64.5	70.8	75.0
10	41.6	47.2	50.0	55.5	61.1	66.6	69.4	47.2	50.0	55.5	61.1	66.6	69.4	75.0
11	40.6	46.8	50.0	56.2	59.3	65.6	71.8	46.8	50.0	56.2	59.3	65.6	71.8	75.0

Table 6. Summary of volume and intensity achieved by each participant during the study

Participants	Min Volume (Kg)	Max Volume (Kg)	Avg Volume (Kg)	Min Intensity (%)	Max Intensity (%)	Average Intensity (%)
1	2880	3480	3240	42.11%	76.32%	58.46%
2	3240	3840	3540	42.86%	76.19%	57.82%
3	2880	3300	3077.143	44.44%	75.00%	58.53%
4	2880	3300	3077.143	44.44%	75.00%	58.53%
5	3240	3840	3540	42.86%	76.19%	57.82%
6	2880	3600	3351.429	40.00%	75.00%	57.50%
7	3240	3840	3540	42.86%	76.19%	57.82%
8	2880	3600	3351.429	41.03%	76.92%	58.97%
9	3600	4350	4062.857	41.67%	75.00%	58.04%
10	2700	3300	3064.286	41.67%	75.00%	58.33%
11	2340	2880	2717.143	40.63%	75.00%	58.26%

After completing the data analysis, the findings of the study showed beneficial effects of the programme with an increase in pre to post measures across all variables tested. The 14 week duration of the study had a significant effect on all measures, apart from the horizontal squat jump. This is shown in Table 7 below.

Table 7. Pre and Post-measures, Percentage of change and Significance level for all performance measures

	Pre	Post	Percentage of change(%)	Significance against time, p<0.05
VJCMJ (m)	0.39 ± 0.069	0.42 ± 0.056	+ 5.95	0.033
VJSJ (m)	0.39 ± 0.066	0.42 ± 0.058	+ 7.67	0.006
HJCMJ (m)	1.47 ± 0.18	1.55 ± 0.20	+ 5.95	0.016
HJSJ (m)	1.49 ± 0.21	1.57 ± 0.21	+ 5.42	0.051
Hip Thrust 3RM (kg)	97.95 ± 10.77	130.23 ± 20.69	+ 32.95	0.000

When analysing which jump style, vertical or horizontal, had the greater effect from the training study, no significant difference was shown between both ($p = 0.237$, where $p < 0.050$).

Chapter 4. Discussion

The results presented above illustrate that the training study was successful and that a hip thrust only programme had an equally beneficial influence on both vertical and horizontal jumping. Nevertheless, the overarching purpose of this study was to compare the effect of hip thrust performance against vertical and horizontal jumping. This was completed using a 14-week intervention study with 11 female collegiate athletes. During the intervention, participants received a resistance training programme twice a week that centred on the hip thrust exercise. The aim was to discern whether or not a hip thrust resistance focused programme would have a more significant effect on horizontal or vertical jumping at the conclusion of the intervention. In the following section, the hypotheses of the study are discussed in relation to the key findings and the relevant literature. In the end, this research project found that hip thrust performance has an equally beneficial effect on both horizontal and vertical jumping, and is a viable and important training method for strength and conditioning programmes.

The second hypothesis was the most central and innovative of the study's hypotheses. This project hypothesised that measurements for horizontal jumping would improve *to a greater extent* than that of vertical jumping as a result of a horizontal exercise programme. This was proven not to be the case. This hypothesis was based on current research that underlines the importance of horizontal resistance focused exercises in order to strengthen horizontal directional exercises, such as studies by Brughelli et al. (5), Contreras et al. (11) and Randell et al. (31). In contrast to this research, this study found *no significant difference* ($p = 0.237$, where $p < 0.050$) in vertical *and* horizontal jumping when comparing the effect of hip thrust on these exercises after a 14 week intervention. In other words, this study makes the argument that hip thrust performance dynamically corresponds to *both* horizontal *and* vertical

movements in a similar way, as tested through jumping. As such, this study suggests that new research that emphasises the benefit of horizontal exercises on horizontal force production over vertical force production, such as the recent study by Contreras et al. (11), needs further investigation. This study expands upon this research by maintaining that horizontal exercises also have an important impact on vertical movements and force production, and stresses that this correlation should be investigated further.

At the same time, the first hypothesis of this study was the following. At the conclusion of a training programme that focused exclusively on the hip thrust without any other lower body exercise, it was hypothesised that there would be an improvement to all variables measured: VJSJ, VJCMJ, HJSJ, HJCMJ, and the hip thrust 3RM. Overall, this was proven accurate, as there was positive percentage changes across the variables tested, ranging from 5.42%-7.67% for the vertical and horizontal jumps and 32.95% for the hip thrust 3RM (as was displayed in Table 7). This demonstrated a positive performance outcome of a horizontally loaded programme, as all participants improved their results. According to the data analysis, there was a statistically significant improvement in all variables apart from horizontal squat jump, which was marginally just outside the level of significance ($p = 0.051$, where $p < 0.050$) (as was shown in Table 7). Due to the miniscule nature of this result the explanation would perhaps appear to be due to a lack of training experience by the athletes in this type of movement. This study therefore illustrates that clear beneficial effects can be achieved from a resistance training programme focused on hip thrust performance as was originally hypothesised.

There are several studies that emphasise the importance of squatting within training programmes, and in particular the effect of a squat programme (a vertical direction exercise) on vertical jumping (1, 7, 22). These studies found that the vertical jump results benefited more than horizontal (1, 7, 22). This research, while very important, has a limited potential

impact on athletes that play team-based sports that require both vertical and horizontal force to achieve maximum performance. A 2017 paper by Zweifel (40) maintains that certain vertically loaded exercises, including but not limited to the back squat, are used often in strength and conditioning programmes in order to improve an athlete's sport performance outcomes, such as their sprinting and jumping abilities. These exercises have been discussed time and time again. Zweifel makes the point that while there is an abundance of research on vertically loaded exercises, these exercises may not in fact be as beneficial to advanced sports athletes because they over-emphasise vertical movements (40). Zweifel therefore suggests the need to look closer at the impact of horizontally loaded activities, and their potential value for advanced athletes (40). This study therefore suggests looking at both vertical and horizontal movements is key to a successful resistance training programme.

Unsurprisingly, those researchers who do explore horizontally loaded movements in strength and conditioning tend point to the importance and necessity of horizontally dominated exercises. For example, there have been several studies that found the hip thrust in particular (a horizontal exercise) activated hip and knee extensor muscles to a more significant level as compared to the back squat (9, 4, 11). Along this same vein, a study by Haff et al. (18) found that similar power output was produced by both the squat and the deadlift, which is another example of a hip dominant exercise. A study by Mendiguchia et al. (27) found that the hip thrust greatly strengthens the hamstrings, which has a positive correlation with sprint performance, a horizontal movement. From this research it is therefore possible to draw the conclusion that increased hip thrust strength is a justified and valuable method of improving horizontal force production.

The key findings of this study refute claims that hip thrust dynamically corresponds to horizontal force production better than it corresponds to vertical force production when comparing jumping styles. The criteria investigated within this study show no significant

difference between horizontal and vertical improvements. This result creates a foundation to counter some of the mechanically weak arguments that imply that horizontal exercises improve horizontal force more so than vertical force. In research by Contreras et al (11), Randell et al (31) and Zweifel (40) they all suggest 'possible' benefits of hip thrusting to improving horizontal force. When dynamic correspondence is looked at in greater detail, it can be argued that consideration of the direction of forces relative to the athlete, rather than the global frame (the earth) are the most important aspect of training (17). Although the hip thrust is classified as a horizontally based exercise, when the movement and direction of forces are looked at it is evident that these factors are working in a vertical plane.

Further explanation for why the second hypothesis was not successful is perhaps evident when looking at the region of force production. Vertical movements create a greater amount of force, and this has been discussed extensively in the literature. To date, the majority of the research that has been done, comparing both vertical and horizontal movements, have concluded that vertically loaded exercises produce a greater amount of force (5, 11, 12). This may explain why in this study, the participants' vertical jumping scores improved to the same degree as their horizontal jumping scores.

In addition, this research provides further insight and new knowledge on the importance of looking at how horizontal exercises (like the hip thrust) can have a positive impact on vertical force production. From this, as mentioned previously, this research project maintains the overarching importance of incorporating both horizontal and vertical exercises in an effective training programme. This also has connections with other research in this field exploring the most advantageous design and implementation of trainings for strength and conditioning coaches. For example, Los Arcos et al. (23), found greater improvements in a strength and conditioning programme when horizontal exercises were included. Specifically, their study included tests for vertical countermovement jumps and sprint performance of male soccer

players (23). This research project supports these conclusions, and highlights the particular importance of horizontal resistance programmes in strength and conditioning. It has also been argued that the most effective training programme involves some elements of explosive weight training (36, 32). This is achieved by incorporating explosive weight exercises to the training plan. The hip thrust is generally performed with a high exertion of force and energy. This study contributes to this literature by stressing the importance of the hip thrust, an explosive movement, to overall strength and conditioning programmes. This study's findings that all versions of jumping improved as the result of a hip thrust focused programme highlight how hip thrusting is a viable method to bring a programme to an optimal level.

In the end, there were three main limitations to the study that are worth mentioning. The first was the difficulty in acquiring participants. Finding athletes at the collegiate level who had the time and the willingness to participate in a programme almost exclusively built on the hip thrust proved to be more challenging than expected. Several expressed interest in the beginning but could not commit in the end. The second limitation was the length of the study. It was difficult finding participants who could commit to all 14 weeks required. These athletes, as mentioned previously, are also full time third-level university students, and have many academic demands in addition to their athletic commitments. Finally, the third limitation was the restrictions within the study, and in particular the fact that participants were prohibited from performing any additional resistance training during the 14 week intervention. Some chose not to take part in the end as they wanted more variety in their training, specifically involving lower body exercises. However, at the conclusion of the training, the 11 participants were very pleased and proud of the progress they made from the study. They provided positive feedback and expressed gratitude for having been able to take part.

This study has strong transferable potential. Future research could repeat this study while taking on board the research limitations. In addition, it would perhaps be beneficial to replicate the study on a larger scale, with more athletes, in order to support the main findings. The study could also be deployed with additional and diverse demographics of athletes, such as male participants, or professionals. According to the primary results of this training study, a hip thrust focused programme has a vital role to play within the strength and conditioning community, and should be prioritised in future research projects and training studies.

Practical Applications

When designing strength and conditioning programmes, coaches strive to enable their athletes to gain the most from their training. What this study demonstrates is that a hip thrust centred programme has many benefits for athletes, specifically those in team based sports, that are looking to improve their horizontal and vertical directional movements simultaneously, specifically their jumping abilities. In addition, because it is not as technically demanding as other exercises such as the squat (10), a hip thrust programme could potentially be useful for less experienced athletes such as adolescents, or first time trainees, as well as those athletes suffering from certain injuries who are unable to perform a squat. There are many practical training benefits to incorporating the hip thrust exercise into strength and conditioning programmes at all levels.

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Appendix A: Consent Form

Intervention study: Comparing the effect of hip thrust performance against vertical and horizontal jumping after a 14 week intervention period

I would like to invite you to take part in a research study. Please take the time and read the following information sheet clearly. It will explain why the research is being done and why you have been invited to take part. Should anything be unclear or you have further questions please feel free to contact me. Take your time on deciding whether you would like to participate or not. Thank you for reading this.

What is this research about?

The aim of this study is to establish if there are greater benefits to horizontal or vertical jumping following an intervention study based around hip performance. This research is being carried out by myself, David Fitzpatrick. I am currently undertaking a Masters in Strength and Conditioning and this research study is my final year project.

Are you suitable to take part? Why have you been invited?

In order to partake in this study, you need to meet the following three criteria: (1) you are a collegiate female athlete; (2) who have a minimum experience of one year, in a sport that contains an aspect of jumping (basketball, rugby, soccer, GAA, etc) and gym work and (3) you must be 18 years or older. You have been contacted to take part as I believe you match the above criteria and are therefore an ideal candidate for this study. Participation is completely voluntary so should you choose not to take part that is completely acceptable. Should you agree to be a participant but then change your mind and want to withdraw, you are free to do so. A withdrawal slip, located at the bottom of the consent form, will need to be signed and returned to myself, David, and that will complete your removal from the project.

What will taking part involve?

Should you agree to take part the study will involve your participation for 16 weeks. Week one involves one, non-invasive, testing sessions, that will take up to approximately 1 hour of your time. This will then be followed a designed training program lasting 14 weeks, two workouts per week, followed by the final week involving one post-testing session identical to the initial testing session. Testing will be done in one session and will be approximately 60 minutes in length. You will begin with a conventional warm up, followed by 3 progressively heavier hip thrust sets before completing

the hip thrust 3RM test, this will be followed by a 10 minute rest period, before beginning the battery of jump tests. Jump tests will begin with the 6 horizontal jumps (3SJ; 3 CMJ) followed by the 6 vertical jumps (3SJ; 3 CMJ). There will be a 30 second rest period between each jump and a 3 minute rest period between the horizontal and vertical jump test. Pre-testing will be done in week 1 and post-testing will be done in week 16. You will be required to carry out two pre-designed workouts a week for the duration of 14 weeks. Each workout will be one hour in duration. You will have to complete a PARQ form before you can participate in the study to ensure you are fit and healthy and capable of completing the requirements of the study.

Are there any risks involved?

You should be aware that there is a risk of injury throughout this study, in particular during testing when you will be aiming to lift near maximum and jump to you maximum ability. These exercises pose a greater risk than normal training as you will be asking your body to push itself to a near maximum ability increasing the possibility of an injury occurring. However, I will attempt to minimise any chance of injury by making time for you to properly warm up on both days. This should help ensure that the body is prepared and able to carry out the sessions in a safe and secure manner.

What will happen to the data? What are the benefits of taking part?

The results of this project will be available to you and all participants who take part that wish to have access to their results. You will all be made anonymous, so you will not be identifiable in the final research output. All information collected will be stored in a secure manner and will only be available to the researcher and the supervisor of the research. Partaking in this study could reveal some very useful information regarding your performance abilities in the hip thrust exercise, and possible transfer effect to performance.

Your participation in the study will be greatly valued. Thank you for taking the time to read this participant information sheet.

You will be given a copy of this form to keep together with a copy of your consent form.

Appendix B: Participant Consent Form

Participant Consent Form

Name of Participant: _____

Title of the project: Comparing the effect of hip thrust performance against vertical and horizontal jumping after a 14 week intervention period.

Main investigator and contact details:
David Fitzpatrick

Supervisor:
Daniel Cleather

1. I agree to take part in the above research. I have read the Participant Information Sheet which is attached to this form. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.

2. I understand that I am free to withdraw from the research at any time, for any reason and without prejudice.

3. I have been informed that the confidentiality of the information I provide will be safeguarded.

4. I am free to ask any questions at any time before and during the study.

5. I have been provided with a copy of this form and the Participant Information Sheet.

Data Protection: I agree to the University processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me.

Name of participant (print)……..
Signed……..…… Date…….....

If you wish to withdraw from the research, please complete the form below and return to the main investigator named above.

Title of Project: Comparing the effect of hip thrust performance against vertical and horizontal jumping after a 14 week intervention period.

I WISH TO WITHDRAW FROM THIS STUDY

Name: _____
Signed: _____

Appendix C: PAR-Q Form

CONFIDENTIAL MEDICAL HISTORY / PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q) FORM

This screening form must be used in conjunction with an agreed Consent Form.

Full Name: Date of Birth:
Height (cm): Weight (kg):

Have you ever suffered from any of the following medical conditions? If yes please give details:

	Yes	No	Details
Heart Disease or attack	☐	☐	_____
High or low blood pressure	☐	☐	_____
Stroke	☐	☐	_____
Cancer	☐	☐	_____
Diabetes	☐	☐	_____
Asthma	☐	☐	_____
High cholesterol	☐	☐	_____
Epilepsy	☐	☐	_____
Allergies	☐	☐	_____
Other, please give details	☐	☐	_____

Do you suffer from any blood borne diseases? If yes please give details;

Please give details of any **medication** you are currently taking or have taken regularly within the last year:

Please give details of any **musculoskeletal injuries** you have had in the **past 6 months** which have affected your capacity to exercise or caused you to take time off work or seek medical advice:

Other Important Information

During a typical week approximately how many hours would you spend exercising?

If you **smoke** please indicate how many per day:

If you drink **alcohol** please indicate how many units per week:

Are you currently taking any **supplements or medication?** Please give details:

Is there any reason not prompted above that would prevent you from participating within the relevant activity?

By signing this document I agree to inform the relevant individual(s) of any change(s) to my circumstances that would prevent me from participating in specific activities.

Participant Signature: Date:

Test Coordinator* Signature: Date:

**Test coordinator: The individual responsible for administering the test(s)/session and subsequent data collection*

Appendix D: Signed Ethics Approval

St Mary's University Twickenham London

Approval Sheet

Name of applicant: David Fitzpatrick Name of supervisor: Daniel Cleather Programme of study: MSc. Strength and Conditioning Title of project: Comparing the effect of hip thrust performance against vertical and horizontal jumping after a 14 week intervention period.

Supervisors, please complete section 1 or 2. If approved at level 1, please forward a copy of this Approval Sheet to the School Ethics Representative for their records.

SECTION 1 Approved at Level 1 Signature of supervisor (for student applications)..... Date.....
SECTION 2 Refer to School Ethics Representative for consideration at Level 2 or Level 3 Signature of supervisor..... ..... Date.....04/12/17.....
SECTION 3 To be completed by School Ethics Representative Approved at Level 2 Signature of School Ethics Representative: Date: 29.01.18
SECTION 4 To be completed by School Ethics Representative. Level 3 consideration required by the Ethics Sub-Committee (including all staff research involving human participants) Signature of School Ethics Representative..... Date..... Level 3 approval – confirmation will be via correspondence from the Ethics Sub-Committee