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Comparing the activity pattern of the Lumbo-pelvic Musles in plyometric exercises and eccentric hamstring exercises during prone hip Extention test in hamstring strain injuries

Surya Ramesh Boddu[1], TN Suresh[2*]
[1] Students, SRM College of Physiotherapy, SRM Institution of Science and Technology, Kattankulathur, Tamil Nadu, India
[2] Vice Principal, SRM College of Physiotherapy, SRM Institution of Science and Technology, Kattankulathur, Tamil Nadu, India

Abstract
Background: Hamstring strain injury is a very common injury in sports like basket ball, hockey, football and athletes. In hamstring strain injuries due to change in muscle length and strength will leads to altered recruitment pattern of lumbo-pelvic muscles activation. The present study is about the effect of activity pattern of lumbo-pelvic muscles in plyometric exercises and eccentric hamstring exercises during prone hip extension test in hamstring strain injuries.
Objective: To compare the activity pattern of the ipsilateral erector spinae, contralateral erector spinae, gluteus maximus, medial and lateral hamstring muscles in hamstring strain injuries in plyometric exercises and eccentric hamstring exercises during prone hip extension test.
Study Design: Experimental study.
Procedure: Thirty players with acute hamstring strain injury were conveniently divided in to two groups: Group A (plyometric group) and Group B (eccentric group) for 8 weeks exercise program. The outcome measures are through EMG study.
Results: The findings showed that there is a significant difference between both the groups at p value less than 0.005.
Conclusion: Eccentric hamstring exercises showed statistically significant improvement in activity pattern of lumbo-pelvic muscles than Plyometric exercises.

Keywords: plyometrics, eccentric hamstring exercises**,** hamstring strain injury, EMG study, prone hip extension test

Introduction

Hamstring strain is a common injury in sports like football, basketball, sprinters and hockey which involve sprinting, kicking, high-speed skilled movements and jumping actions. It is a frustrating injury well known to physiotherapists, coaches, and athletes due to its prolonged periods of recovery, acute functional loss of performance, and subsequent increase of reoccurrence in athletes [1, 2, 3]. A recent review indicated hamstring strain injuries have the highest recurrence rate in sports, ranging from 12 to 31% [4, 5, 6]. Hamstring strain injuries are caused due to a stretch, tear, or rip in the muscle or adjacent tissues of biceps femoris, semitendinosus or semimembranosus. It occurs mostly during the terminal swing phase, just before foot strike, during sprinting [6, 7, 8].

A muscle strain is defined as an excessive stretch, which leads to muscle fiber damage and disrupts the integrity of vascular and connective tissue structures. A muscle is commonly strained or torn during acceleration or deceleration. Specifically the previous injured athletes are more than twice as likely to be injured again, suggesting that post injury changes to the muscle and altered movement patterns may persist that contributes to increased risk of recurrence [9, 10, 11].

During the decades the approach of assessment and treatment of musculoskeletal pain has been changed from exercises targeting at strength alone. The balancing exercises of agonists and antagonists in coordinated way of activation of muscles have been delivered [12].

Due to the change in muscle length and strength can also lead to altered recruitment pattern of movement and muscle activation, pain and movement disorders [13, 14, 15]. Several authors had been shown altered recruitment pattern of lumbo-pelvic muscles such as gluteal muscles, trunk extensors, trunk flexors and hip extensors in lumbo-pelvic disorders [16, 17, 18].

Prone hip extension test (PHE) is commonly and widely used to access the muscular activity pattern of the lumbo-pelvic area [19]. In Prone Hip Extension Test, subjects lie in prone position and lift the chosen leg off the bed to 10 degrees of hip extension by keeping the knee straight [23]. Good reliability has been reported during prone hip extension test. Both timing (onset time) and amplitude of muscle activity are commonly calculated using electromyography (EMG) to investigate muscular activation patterns in musculoskeletal disorders [20, 21]. The normal movement pattern also can be changed if the muscle activity is increased or decreased and delayed during the movements [22, 23].

The activity pattern of muscles during prone hip extension in normal people without any hip pain or back pain will show the order of activation from medial hamstrings, followed by lateral hamstrings and gluteus muscles [24-27]. Early activation of the spinal erector and hamstrings muscles and decreased or delayed activation of the gluteal muscles has been interpreted as an indication of faulty muscle activation [12, 28].

Hamstring muscle weakness or tightness has been reported in athletes sustained with hamstring strain injury, it is possible that altered muscle activity pattern may exist during prone hip extension in this subjects [29].

Plyometric exercises are defined as eccentric loading immediately followed by a concentric contraction. Plyometric exercises improve the landing and cutting biomechanics by increasing the muscle activation and improving the neuro muscular effectiveness [31]. Plyometric training is an established technique for enhancing athletic performance but may also facilitate beneficial adaptations in the sensorimotor system that enhance dynamic restraint mechanisms and correct faulty jumping or cutting mechanics [32, 33].
Eccentric exercises increase the optimum length tension development in the muscles by increasing the length of the muscle fibres. It is characterised by active lengthening of muscle fibres, in which the force of contraction increases as the speed of contraction increases. It has been argued that, hamstring injuries can be prevented by increasing the optimal length of tension by eccentric exercises [35].

Methodology
- **Study Design:** Experimental study
- **Study Type:** Comparative
- **Sampling Method:** Simple random technique
- **Sample Size:** 30 players
- **Setting:** S.R.M University
- **Study Duration:** 2 months

Materials to be used
- EMG machine
- Electrode gel
- Micro pore
- Couch
- Hurdle hops
- Towels
- Digital metronome
- Plyometric box

Fig 1: EMG Machine

Fig 2: Plyometric table

Fig 3: hurdles

Fig 4: Micropore

Fig 5: Gel bottle

Fig 6: Towels

Procedure
Samples were selected based on the inclusion and exclusion criteria. The purpose of the study was explained to the subjects and signed printed informed consent form was taken.
A group of 30 players with a history of hamstring strain injury from football, hockey, basketball and sprinters were selected randomly and divided them in to two groups as group-A plyometric group and group-B eccentric group.
In group-A plyometric group the athletes are trained with five types of plyometric exercises for 8 weeks and 3 days in a week. In group-B eccentric group the athletes are trained with five eccentric exercises for 8 weeks and 3 days in a week.
A pre-test and post test result of EMG activity pattern is taken for both the groups on ipsilateral erector spinae(IES), contralateral erector spinae(CES), gluteus maximus(GM), medial hamstrings(MH) and lateral hamstrings(LH) during Prone Hip Extension Test (PHE).
The subjects are asked to lift the chosen leg off the bed to 10 degrees of hip extension whilst keeping the knee straight, as soon as they heard the command “lift”.
The equipment was set to the following parameters.
1. 500mv
2. Sweep speed 500 ms/ div
3. 200HZ to 2KHZ

The amplitude values for all the five muscles are taken individually by placing the electrodes on their marked placements.
The Electrode placement to collect EMG signals was as follow: For the erector spinae muscles ES, bilaterally at least 2 cm lateral to spinous process of L3 parallel to the vertebral column on the muscle belly; for the gluteus maximus GM, at the midpoint of a line running from S2 to the greater trochanter; for the lateral hamstring HAM, laterally on the mid distance between gluteal and popliteal fold; and for the medial hamstring HAM, medially on the mid distance between gluteal and popliteal fold.
The maximum voluntary electrical activity (MVE) for each muscle was calculated for use during normalization. Testing procedure to calculate maximum voluntary electrical activity were similar to those described for manual muscle testing of the muscles, as described by Kendall *et al.* [20].

Fig 7: Prone hip extension test

Group A: Plyometric exercises
- Group A 15 subjects will be trained with plyometric exercises for 8 weeks and 3 days in a week.

Phase 1: (1-4 Weeks)

S. No	Plyom Etric Exercises	Metronome Set	Sets
1	Double-leg sagittal plane hurdle hop	60 BPM	2
2	Single-leg sagittal plane hurdle hop	60 BPM	2
3	Box jump	60 BPM	2
4	Linear acceleration wall drill	60 BPM	2
5	Knee tuck jump	60 BPM	2

Phase 2: (5-8 Weeks)

S. No	Plyom etric exercises	Metronome set	Sets
1	Double-leg sagittal plane hurdle hop	60 BPM	3
2	Single-leg sagittal plane hurdle hop	60 BPM	3
3	Box jump	60 BPM	3
4	Linear acceleration wall drill	60 BPM	3
5	Knee tuck jump	60 BPM	3

Fig 8: Double-leg sagittal plane hurdle jump

Fig 9: Single-leg sagittal plane hurdle jump

Fig 10: Box Jumps

Fig 11: Linear acceleration wall drill

Fig 12: Knee tuck jump

Group B: Excentric Exercises

- Group B (15 subjects) will be trained with Excentric exercises for 8 weeks and 3 days in a week.

Phase 1: (1-4 Weeks)

S. No	Excentric Exercises	Repititions	Sets
1	Eccentric box drops	10	2
2	Nordic hamstring exercise	10	2
3	Weighted lunge box	10	2
4	Towel pulls	10	2
5	Eccentric resisted pushes	10	2

Phase 2: (5-8 Weeks)

S. No	Excentric Exercises	Repititions	Sets
1	Eccentric box drops	15	3
2	Nordic hamstring exercise	15	3
3	Weighted lunge box	15	3
4	Towel pulls	15	3
5	Eccentric resisted pushes	15	3

Starting Position **Ending Position**

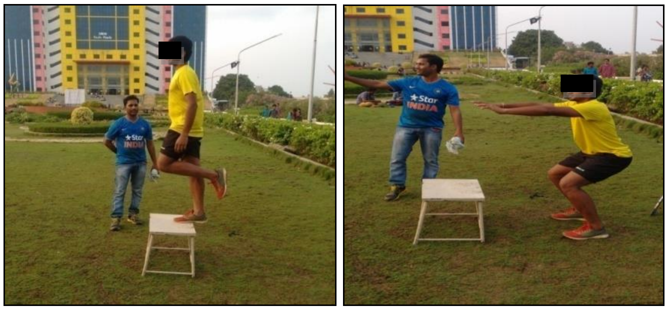

Fig13: Eccentric box jumps

Fig 14: Nordic hamstring exercises

Starting Position **Ending Position**

Fig 15: Weighted lunge box

Fig 16: Towel Pulls

Fig 17: Eccentric resisted pulls

Data Analysis

The recorded data were tabulated. The data was analyzed using statistical package for social science (SPSS) to present the findings of effectiveness of plyometrics exercises and eccentric hamstring exercises during prone hip extension test in hamstring strain injuries. Data analysis was done with SPSS Software version 20.0. "p" value was set at less than 0.05 as significance for all analysis, "paired t" test was done.

Table 1: Comparison between pre and post among the plyometric group

Paired Samples Statistics						
Plyometric Group		Mean	N	SD	Paired t Test	P Value
Pair 1	Pre IES	6.165	15	1.953	1.695	0.112 NS
	Post IES	5.926	15	1.969		
Pair 2	Pre CES	6.409	15	2.295	1.346	0.200 NS
	Post CES	6.104	15	2.231		
Pair 3	Pre GM	9.036	15	2.433	4.974	0.001 ***
	Post GM	6.591	15	0.765		
Pair 4	Pre MEDHAM	5.987	15	1.590	2.276	0.039 *
	Post MEDHAM	5.281	15	0.861		
Pair 5	Pre LAT HAM	5.301	15	1.206	0.237	0.816 NS
	Post LAT HAM	5.222	15	0.682		

*** and * There is a statistical significance difference between Pre and Post test for GM and MEDHAM at 95% ($P < 0.05$)

NS- Not statistical significance difference between pre and post for IES, CES and LAT HAM at 95% ($P > 0.05$)

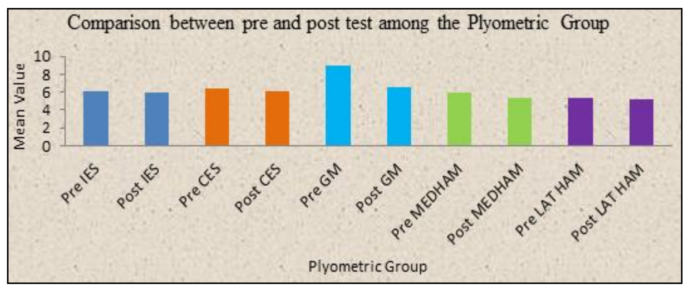

Fig 18: Comparative mean values for pre and post test in group-a plyometric group

Table 1A: Correlation

Paired Samples Correlations				
Plyometric Group		N	Correlation (r)	Sig. Level
Pair 1	Pre IES & Post IES	15	0.961	0.001 ***
Pair 2	Pre CES & Post CES	15	0.925	0.001 ***
Pair 3	Pre GM & Post GM	15	0.774	0.001 ***
Pair 4	Pre MEDHAM & Post MEDHAM	15	0.667	0.007 **
Pair 5	Pre LAT HAM & Post LAT HAM	15	0.149	0.595 NS

*** - There is Statistical significance Correlation Between pre and Post test for IES, CES, GM and MEDHM at 95% ($P < 0.05$)

NS – Not statistical significance correlation Between pre and Post test for LATHAM at 95% ($P > 0.05$)

Table 2: Comparison between pre and post among the eccentic group

Paired Samples Statistics						
Eccentic Group		Mean	N	SD	Paired t Test	P Value
Pair 1	Pre IES	7.124	15	1.685	2.745	0.016 **
	Post IES	6.400	15	1.511		
Pair 2	Pre CES	5.781	15	0.514	4.175	0.001 ***
	Post CES	6.496	15	0.329		
Pair 3	Pre GM	8.011	15	1.515	3.838	0.002 ***
	Post GM	10.876	15	3.147		
Pair 4	Pre MEDHAM	4.997	15	0.652	5.178	0.001 ***
	Post MEDHAM	5.876	15	0.725		
Pair 5	Pre LAT HAM	5.381	15	0.821	4.096	0.001 ***
	Post LAT HAM	5.969	15	0.834		

*** and * * There is a statistical significance difference between Pre and Post test for IES, CES, GM, MEDHAM and LATHAM at 95% (P < 0.05)

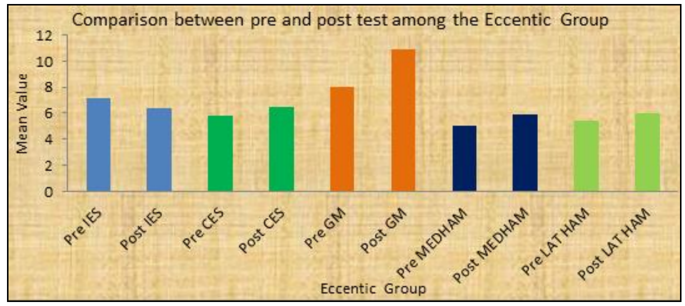

Fig 19: Comparative mean vaues for pre and post test in group-beccentric group

Table 2: A Correlation

Paired Samples Correlations				
Eccentic Group		N	Correlation (r)	Sig. Level
Pair 1	Pre IES & Post IES	15	0.801	0.001 ***
Pair 2	Pre CES & Post CES	15	-0.193	0.491 NS
Pair 3	Pre GM & Post GM	15	0.404	0.136 NS
Pair 4	Pre MEDHAM & Post MEDHAM	15	0.549	0.034 *
Pair 5	Pre LAT HAM & Post LAT HAM	15	0.774	0.001 ***

*** - There is Statistical significance Correlation Between pre and Post test for IES, MEDHAM, and LATHAM at 95% (P < 0.05)

NS – Not statistical significance correlation Between pre and Post test for CES and GM at 95% (P> 0.0)

Table 3: Group Statistics

	Group	N	Mean	SD	Independent t Test	P Value
Pre IES	Plyometric group	15	6.165	1.953	1.440	0.161 NS
	Eccentric group:	15	7.124	1.685		
Pre CES	Plyometric group	15	6.409	2.295	1.034	0.310 NS
	Eccentric group:	15	5.781	0.514		
Pre GM	Plyometric group	15	9.036	2.433	1.385	0.177 NS
	Eccentric group:	15	8.011	1.515		
Pre MEDHAM	Plyometric group	15	5.987	1.590	2.231	0.034 NS
	Eccentric group:	15	4.997	0.652		
Pre LAT HAM	Plyometric group	15	5.301	1.206	0.212	0.833 NS
	Eccentric group:	15	5.381	0.821		
Post IES	Plyometric group	15	5.926	1.969	0.739	0.466 NS
	Eccentric group:	15	6.400	1.511		
Post CES	Plyometric group	15	6.104	2.231	0.672	0.507 NS
	Eccentric group:	15	6.496	0.329		
Post GM	Plyometric group	15	6.591	0.765	5.122	0.001 ***
	Eccentric group:	15	10.876	3.147		
Post MEDHAM	Plyometric group	15	5.281	0.861	2.046	0.050 NS
	Eccentric group:	15	5.876	0.725		
Post LAT HAM	Plyometric group	15	5.222	0.682	2.685	0.012 *
	Eccentric group:	15	5.969	0.834		

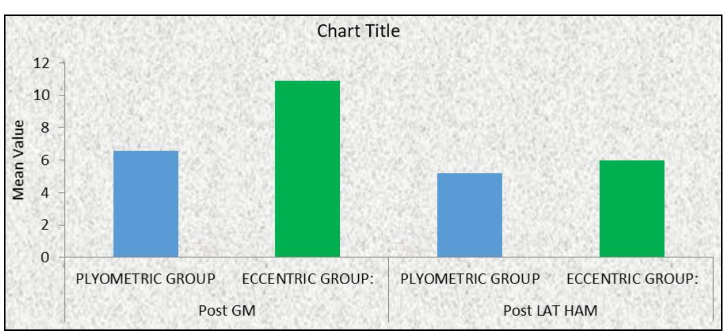

Fig 20

Results

According to table 1, the muscle firing pattern for plyometric group during the pre test and post test shows the mean values for, ipsilateral eretor spinae(IES) in pre test is 6.165 and post test was 5.926. Hence, the mean value for ipsilateral erector spinae(IES) is statistically not significant. The mean values for contra lateral erector spinae(CES). The mean value for contraleteral erector spinae(CES) during pre-test is 6.409 and post-test is 6.104. This shows that the contraleteral erector spinae is statistically not significant. The mean value for gluteus maximus (GM) during pre-test is 9.036 and post test is 6.591. It shows that the gluteus maximus (GM) is statistically significant. The mean value for medial hamstring(MED HAM) during pre-test is 5.987 and post test is 5.281. this shows that the medial hamstring is statistically significant. The mean values for lateral hamsting (LAT HAM) during pre-test are 5.301 and post test is 5.222. This shows that the lateral hamsting (LAT HAM) is statistically not significant.

According to table 2, the muscle firing pattern for eccentric group during the pre test and post test shows the mean values for, Ipsilateral erector spinae(IES) in pre-test is 7.124 and post test is 6.400. This shows that the ipsi lateral erector spinae(IES) is statistically significant. The mean value for contraleteral erector spinae(CES) during pre-test is 5.781 and post-test is 6.496. This shows that the contraleteral erector spinae(CES) is statistically significant. The mean value for gluteus maximus (GM) during pre-test is 8.011 and post test is 10.876.This shows that the gluteus maximus (GM) is statistically significant. The mean value for medial hamstring (MED HAM) during pre-test is 4.997 and post-test is 5.876. This shows that the medial hamstring (MED HAM) is statistically significant. The mean value for lateral hamstring (LAT HAM) during pre-test is 5.381 and post-test is 5.969. This shows that the lateral hamstring (LAT HAM) is statistically significant.

Discussion

The review of existing literature regarding the role of plyometrics and eccentric hamstring exercises on improvement of recurrent hamstring injuries reveals confusion about which technique is more effective in improving the activity pattern of lumbo- pelvic and hamstring muscles in individuals with hamstring strain injuries. There is no study has been compared about effectiveness in activity pattern of these two exercises in hamstring strain injuries during prone hip extension test. The current study compared the muscular activation pattern of lumbo-pelvic and hamstring muscles in hamstring strain injuries during prone hip extension test in individuals trained with plyometrics and eccentric hamstring exercises. The results of this study showed that there was only statistically significant improvement seen in Gluteus maximus (GM) and Medial hamstrings (MED HAM) in plyometric group but the eccentric group showed statistically significant improvement to all the muscles. These findings demonstrate that there is a significant difference between both the groupsat p value less than 0.005.Hence, we reject null hypothesis and accept alternate hypothesis.

According to the review of literature hamstrings are thought to act as transducers of power. Hamstring muscle dysfunction followed by strain injury may cause the gluteus maximus to be overactive. Both of these two actions may predispose an athlete to re-injury. Lumbo-pelvic dysfunction and disorders has been associated with HAM strain [59].

Some investigators, have shown altered muscular activation pattern of the erector spinae, gluteal maximus, and hamstring muscles during prone hip extension (PHE) subjects with and without low back pain [21, 24]. Considering the association between hamstring strain and lumbo-pelvic abnormality or dysfunction in low back pain athletes, participants are excluded in study with low back pain athletes. Plyometric exercises can improve the speed, agility and neuro muscular coordination in athletes by concentric contraction of muscles followed by eccentric contraction Chimera *et al.* [60]. Hence, in present study the athletes had improved the strength only in GM and MED HAM thigh muscles due to hamstring activation plyometric exercises but there is no improvement seen in erector spinae muscles. Several authors have stated that the optimum angle of torque development should be considered when attempting to rehabilitate hamstring injuries (Brockett *et al*., 2004). When an activated muscle is lengthened beyond its optimum length (i.e. the descending limb of the length-tension relationship), it is thought to be in a vulnerable position for injury (Brockett *et al*., 2004). Furthermore, if this optimum length can be increased through training the muscle is thought to be stable over a greater range of motion (Brockett *et al*., 2004) [56].

It has been well established that eccentric exercise can shift the optimum length to longer muscle lengths (Bowers *et al*., 2004; Kilgallon *et al*., 2007) [57, 58]. The present study supports about the lumbo-pelvic altered activity pattern can be corrected in acute hamstring strain injuries in eccentric training athletes, due to increase in length of the muscles, strength and flexibility. It shows that the lumbo-pelvic altered activity pattern can be corrected well in hamstring injuries by eccentric training exercises comparing to the plyometric training exercises.

Conclusion

The study concluded that firing patterns for both the groups, Group A(plyometric group) and group B(eccentric group) showed a great improvement but group A is significantly improved only in gluteus maximus (GM) and medial hamstring(MED HAM) muscles and group B is statistically improved the firing pattern in all the ipsi lateral erector spinae (IES), contralateral erector spinae(CES), gluteus maximus (GM), medial hamstring (MED HAM) and lateral hamstring (LAT HAM) muscles. Hence, the results shows that the group B(eccentric group) is yielded satistically more improved than group A(plyometric group).

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