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Effects of Gluteal Muscles Strengthening and Hip Flexor Stretching on Balance ad Agility Among Cricket Bowlers

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ABSTRACT

Background: The Fast Bowling In Cricket Consists Of Four Distinct Phases- Run Up, Pre-Delivery Stride, Delivery Stride And Follow Through. The Run Up Is A Phase Where The Bowler Walks Towards The Marker And Starts To Run Towards The Wicket. When The Player Takes A Leap Following The Run Marks The Beginning Of The Next Phase.In-Order To Achieve A Maximal Force Production In Running The Hip Flexors Has To Contract More In Order To Position The Limb Ahead Of The Body. The Objective Of The Study Is To Find Out The Effects Of Hip Flexor Stretching And Gluteal Muscle Strengthening On Balance And Agility Among Cricket Bowlers.

Materials And Methods: 40 Cricket Bowlers Were Chosen Based On The Inclusion And Exclusion Criteria And They Are Divided Into Two Groups. Control Group Is Provided With Usual Game Practice And Experimental Group Is Provided With Stretching And Strengthening Exercises. All The Players Were Pre Assessed With Agility And Balance Performances Using T Agility Test And Y Balance Test.

Results: Statistical Analysis Was Done, Which Shows No Significant Differences In Post- Test Comparison Of Experimental And Control Groups For Both The Balance And Agility Performance.

Conclusion: Thus, The Study Concludes That Hip Flexor Stretching And Gluteal Strengthening Exercises Does Not Improve The Dynamic Balance And Agility Performances In Cricket Players.

Keywords: *Running, Skill Performance, Flexibility, Gluteal Muscle Strengthening, Hip Flexor Strengthening*

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1. INTRODUCTION

In Fast Bowling there are four phases, Phase I is Run Up, Phase II consist of Pre delivery stride, Phase III consists of four distinct phases and Phase IV is Follow Through. The Phase I begins where the bowler walks towards the marker and starts to run towards the wicket [1]. When the player takes a leap following the run marks the beginning of the next phase. The earlier studies confirms that the runningspeed of a bowler have a strong impact on the ball releasing speed [2]. The

activation of both the gluteus medius and maximus will beat peak during the initial contact and toe off phase [3].

During Running, the changes occur in the running style, running speed and lower extremity activation. To achieve a maximal force production in running the hip flexors need to contract more to position the limb ahead of the body. The hamstring muscles will also be activated during running which acts as a cushion on loading impact to maximize the body's forward thrust [4].

The demand on the player's ability varies depend on physiological responses to each format. The cricket players usually demand skills of balance and agility. During the game practice the bowlers usually sprints long way before the release of the ball, during fielding the players has to highly sprint in order to reach the ball which requires high dynamic stability to the players [5,6]. The evidence suggests that there is a strong connection between the shortness of a muscle and postural balance. The iliopsoas muscle acts as a major hip flexor and it originates from the lumbar spine. More the compressive forces acting on the hip flexor musculature it causes the stiffness to the lumbar spine which in turn causes the low back pain to occur [7,8].

The evidence shows that the runners has significantly limited range of hip flexion. When the hip flexor muscles contracts and shortened more, the antagonist group of muscles becomes weak. Due to this mechanism the compensation of the load will be shifted to the nearby muscles which leads to injury problems. Increase in hip flexor tightness leads to diminished joint position sense which in turn reduces the balance [4].

Balance is an important component in the field of sports, any deficits in the balance due to intrinsic and extrinsic factors could lead to the lower extremity injuries such as ankle sprains, anterior cruciate ligament instability, anterior knee pain etc. There are various tools to quantify the flexibility among individuals, one of whichis the Y balance test which is most reliable tool in pre competition conditioning with the value of >0.90 considered to be an excellent [9]. Likewise, T agility test is proven to be most reliable test in finding out the performance of the player and the player's participation.

As mentioned previously when there is a limitation or tightness in the agonist group of muscles, the antagonist group of muscles will be underacting and there will be too much of reliance in the supporting group of muscles due to which many mechanical injuries tend to occur [4]. Increase in hip flexor tightness leads to diminished joint position sense which in turn reduces the balance. Hence there is a need to reduce the hip flexor stiffness and increase the gluteal muscle strength to prevent injuries and to improve the performance in athletes [4]. Hence, the main objective of the study is to stretch the shortened hip flexor muscles and to strengthen the antagonistic gluteal muscles and to find out how much does it create an impact on the agility and balance performance skills of cricket bowlers.

2. REVIEW OF LITERATURE

Wang et al. (2022) et al., stated that Gluteal activation exercises effectively bring the changes to the muscle performance in the knee joints of volleyball players and enhances the proprioception, balance and stability of the knee joint, which helps reducing the risk of knee joint injuries in volleyball players. [21]. Jordan et al. (2022) concluded that initiation of gluteal muscle activation exercises should be considered in improving the neuromuscular adaptation which helps in improvising gluteal muscles more during the rehabilitation process [22]. Andreas et al. (2021) It is advised to stretch the hip flexors for a maximum of 120 seconds to enhance performance, particularly in activities that need a large range of hip extension, such as gymnastics and dance. Another way to avoid injuries is to stretch your hip flexors. Due to the weakness of the hip flexors the force load will be actively shifted to the synergist muscle which is the rectus femoris which is then getting overloaded [23]. Raya et al. (2021) determined that although there is no much difference between the experimental group and control group in comparison but when comparing the loss of absence in game due to back pain is significantly getting reduced in the experimental group where the gluteal exercise program is performed than the control group where the burden values is higher. [24]. Christopher M. Connelly et al. (2020) concluded that the running related injuries are commonly linked to Gluteus Maximus and Medius activation and strength [25]. Buckthorpe et al. (2019) states that the treatment approaches to the gluteal muscle activation leads in correcting the pelvic alignment, improving antagonist muscle performance and strengthening and improvising the integrity in the joints [26]. Hussain Aslan et al. (2018) concluded that dynamic stretches helps in improving the hip extension range of motion in athletes [27]. Takuya et al. (2018) states that the hip extension exercises along with the ankle plantar flexion strength improves the agility performance in athletes[28]. Hina Gupta et al. (2016) states that the normative values for balance performance can be noted and it can be used in the injury prediction score [29]. Forrest et al. (2016) as the posterior muscles plays a crucial role in improving the fast bowling performance in which the force distribution is high[30]. Brandon M et al. (2016) states that the hip external rotation strengthening improves the dynamic balance on ipsilateral side of the lower limb after eight weeks of exercise protocol. [31]. Helen Bayne et. (2016) stated that the lower back injury in the fast bowlers is not only due to lowered muscle endurance but also due to the impaired lumbo-pelvic control which leads to severe back injuries[32]. Matthew Mills et al. (2015) determined that athletes with limited hip flexor range of motion have less gluteal muscular activation, leading to compensatory strain on the hamstring muscles [33]. P Ratan Khuman et al. (2014)displays that there is a comparative results in the balance performance among cricket, volleyball and football players. The soccer players exhibit superior balance compared to volleyball players, who in turn display greater balance than cricket players. [34] .

Christian J et al. (2014) concludes that in order to improve the gluteal muscle strength single leg squat workouts are more beneficial than the double leg squats which is further more improved by performing it in the Swiss ball [35]. Chatzopoulos et al. (2014) states that the dynamic stretching is mainly helpful in performing the balance and agility than that of the static balance performing group[36] Selkowitz et al. (2013) concluded that activation of gluteal muscle exercises are very important in initiating and improving the performance of the athletes. Any poor performance in the balance skill will lead to sustained injuries [37]. Olivier et al. (2013) suggests the lumbo pelvic control and balance is necessary for improvising the [38]. Hina Gupta et al 2016 helps to find out the normative datas for the cricketers which helps them to normative values . [39]

3. METHODOLOGY

This experimental study was done in Stumped cricket association in Chennai. The study was started in December 2021 and got over by May 2022. The study was approved by Institutional Ethical Committee, Reference Number 2903/IEC/2021. The patient information sheet was used to collect the demographic details, level of sports, medical history status from the players. The participants were chosen based on the inclusion and exclusion criteria. The players with the age group of 18-30 years, Regular cricket bowling practice for 1-2 years and more, with a positive Modified Thomas test, both right and left arm bowlers were included and the players who are not in regular practice of cricket, batsman and wicketkeeper, who are not willing to participate in the study, who have any lower extremity injuries or pain, orthopedic, neurological, cardiovascular abnormalities or surgeries, any history of participating in a proprioceptive or balance training programs in prior six months were excluded from the study. Based on inclusion and exclusion criteria fulfillment the subjects were divided into Group A (20) and Group B (20) based on the sampling method. The selected participants were divided into control group and experimental group. Group A (Experimental group) received Hip flexor stretching and gluteal muscle strengthening exercises whereas Group B (Control group) received conventional training exercises.

All the players were pre assessed with agility and balance performances using T agility test and Y balance test. All the exercises were carried out for 8 weeks with 3 times a week. Hip flexor stretching exercises include Modified Fencer stretch, Thomas stretch, Prone press up stretch, Prone stretch [10,11]. Each exercise were carried out for hold time of 30 seconds and rest time of 20 seconds. Gluteal strengthening exercises include bilateral squats, Thera band hip extension, Clam with foot elevation, Single leg gluteal bridge, Side plank with abduction, Bird dog exercise[12-14]. Each strengthening exercise was carried for 15 repetitions and 3 sets. Group B exercises include general warm up for 20 minutes, cricket specific drills for 40 minutes and cool down for 10 minutes.

4. STATISTICAL ANALYSIS

The statistical analysis of the study was determined using statistical package for social science (SPSS) version 20. The test for parametric measures such as paired t test was used for pre and post values in a group and independent t test was used for between group. ($P < 0.05$)

5. RESULTS

TABLE 1 - Y BALANCE TEST FOR CONTROL GROUP (RIGHT LEG)

Test	Mean	S.D	Mean difference	P value
Pre-test	82.83	11.12	0.86	0.009
Post-test	81.97	10.58		

Table 1 shows the pre and post test values of control group for left leg. The mean values for the pre test and post test are 82.83 and 81.97 respectively. The difference between the mean values are 0.86. The P value for the comparison of pre and post test Y balance test Control group for left leg is significant. P value is lesser than 0.05

TABLE 2

Y BALANCE TEST FOR CONTROL GROUP (LEFT LEG)

Test	Mean	S.D	Mean difference	P value
Pre-test	84.58	9.80	1.21	0.001
Post-test	83.37	9.14		

Table 2 shows the pre and post test values of Y balance test Control group for right leg. The mean values for the Pre test control group is 84.58 and the post test control group is 83.37. The difference between the mean values is 1.21. P value is 0.001 which is significant

TABLE 3

Y BALANCE TEST FOR EXPERIMENTAL GROUP (RIGHT LEG)

Test	Mean	S.D	Mean difference	P value
Pre-test	81.74	7.09	0.97	0.000
Post-test	82.71	6.75		

TABLE 3 shows the pre and post test values comparison of Y balance test Experimental group for right leg. The mean values of pre and post test values of the right leg are 81.74 and 82.71 respectively. The difference between the mean values are 0.97 respectively. The P value for the comparison between the pre and post test is 0.000 which is lesser than 0.05

TABLE 4

Y BALANCE TEST FOR EXPERIMENTAL GROUP (LEFT LEG)

Test	Mean	S.D	Mean difference	P value
Pre-test	78.88	7.44	1.33	0.000
Post-test	80.17	7.22		

TABLE 4 shows the pre and post-test values comparison of Y balance test Experimental group for left leg. The mean values for pre and post test includes 78.88 and 80.17 respectively. The difference between the mean values of pre and post test are 1.33 respectively. The P value is 0.000 which less than 0.05

TABLE 5

Y BALANCE TEST OF POST TEST COMPARISON AMONG CONTROL AND EXPERIMENTAL GROUP (RIGHT LEG)

Test	Mean	S.D	Mean difference	P value
Post test control	83.37	9.14	0.65	0.794

Post-test experimental	82.71	6.75		

TABLE 5 shows the post-test comparison of experimental group and control group for right leg. The mean values for the post tests of control and experimental group of the right leg are 83.37 and 82.71. The difference between the mean values are 0.65. The P value for the comparison of between groups post test is 0.794 which is greater than 0.05 (P > 0.05) thus the values are non-significant.

TABLE 6

Y BALANCE TEST OF POST TEST COMPARISON AMONG CONTROL AND EXPERIMENTAL GROUP (LEFT LEG)

Test	Mean	S.D	Mean difference	P value
Post-test control	81.97	10.57	1.79	0.569
Post-test experimental	80.17	7.22		

TABLE 6 shows the post test values comparison of experimental and Control group for left leg. The mean values for post test comparison between the control and experimental group are 81.97 and 80.17 respectively. The P value is 0.569 which is greater than 0.05. P > (0.05) hence is insignificant.

TABLE 7

AGILITY FOR CONTROL GROUP

Test	Mean	S.D	P value
Pre-test	10.53	0.60	0.808
Post-test	10.56	0.52	

TABLE 7 shows the pre and post test values of agility test of control group respectively. The mean values of pre and post test of control group are 10.53 and 10.56 respectively. The P value for the comparison of pre and post test is 0.808 (P> 0.05) which is insignificant.

TABLE 8

AGILITY TEST FOR EXPERIMENTAL GROUP

Test	Mean	S.D	P value
Pre-test	10.81	0.19	0.000
Post-test	10.63	0.18	

TABLE 8 shows the pre and post test values of agility test experimental group. The mean values of the pre and post test experimental group are 10.81 and 10.63 seconds respectively. The P value is 0.000 which is lesser than 0.05

TABLE 9

AGILITY FOR POST TEST OF CONTROL AND EXPERIMENTAL GROUP

Test	Mean	S.D	P value
Post-test control	10.56	0.60	0.578

Post-test experimental	10.63	0.18	

TABLE 9 shows the post test values comparison of control and experimental group of agility test, The mean values of post test values of control and experimental group are 10.56 and 10.63 seconds respectively. The P value for the post test group comparison is 0.578 and the P value is greater than 0.05 (P > 0.05), which is non significant.

6. DISCUSSION

The focus of the study is to find out how the hip flexor stretching exercises and gluteal muscle strengthening exercises plays an impact on the performance of the athletes. Due to the agonist - antagonist stretch shorten cycling of lower limb muscles, there will be a decline in the overall performance of the athletes . Following in relation to it will cause the overuse injuries to lower limb region also to the proximal and distal group regions.

The results of this study shows that there is a significant difference between pre and post-test values of the control group on right leg and there were no differences on left leg. A study results when comparing the static and dynamic stretching on balance, agility and movement time showed that there was a significant improvement on dynamic stretching than static stretching on movement time of the upper extremities [15]. In another study , the hip flexor muscle stretching was done to check the effects on performance parameters. The study concluded that single bout of hip flexor stretching for 120s had a positive effect on balance following dynamic stretching and jump performance following static stretching [16]. In this study stretches are performed in a static manner rather than in a dynamic and the duration of stretching was maintained for 30 seconds.

The post test results of both control and experimental group shows that the there were no statistical differences on both sides of the legs. The mean values of the experimental group were found to be lesser than that of the control group. A study conducted to check the effectiveness of dynamic stretching on range of motion and stiffness. The study concluded that there was sustained level of flexibility for the healthy volunteers who performed 10 sets of dynamic stretching, 15 repetitions per set[17]. In our study, only hip flexor muscle group is targeted for the stretching intervention and the exercises were performed for shorter duration of time.

A study in 2015 concluded that the gluteal muscle strengthening along with the lumbar stabilization exercise decreases the low back pain and increases the strength and balance ability[18]. As the dynamic balance is contributed by variety of muscle groups, in early stance the gluteus maximus, biarticular hamstrings and ankle dorsiflexors contribute to backward moment while soleus, gastrocnemius and rectus femoris contribute to forward moment. In late stance soleus and gastrocnemius generates angular momentum in various directions. Since this study is focused on strengthening the gluteal muscles, there were no big differences found between pre and post-test of the experimental and also between control and experimental group.

The results of the study reveals that there is no statistical differences between pre and post test of the control group agility performance and there is a significant differences and effectiveness in agility between pre and post experimental group. The post test comparison shows no significant changes and effectiveness in the agility performance between control and experimental group. the study on effectiveness of acute stretching on the agility performance. The stretching exercises were performed on the gastrocnemius, hamstrings, quadriceps, hip flexors, hip adductors, abductors and gluteal muscles. The study proves that in comparison to the static and dynamic stretching, the dynamic kind of stretching was proven to be effective in improving the agility skills[19]. Another study in which a correlation was made between the agility and flexibility among the runners, the results of the study provides that there were no significant correlation between the flexibility and agility performance[20]. The studies have also proven that the lower limb muscle strength especially hip extension and ankle plantar flexion have a strong correlation with the shuffling skills[18]. The hip extensors and ankle plantar flexors plays an important role in making the forward propulsion of the body. In this study, more focus have been provided on stretching the tightened hip flexor muscles and strengthening of the gluteal muscles. Although there shown improvement in intervention group, there are no changes seen between comparing groups.

The study has a limitation of minimal sampling size. If the sampling size were more the effectiveness of the protocol based on the significance level would have been different. Second limitation of the study was the protocol frequency and duration of the study can be taken into more number to see the better results. In further studies, strengthening the other muscle groups like core,hip adductors and hip abductors along with dynamic stretched can be added and the performance can be monitored.

7. CONCLUSION

Hence, the conclusion of the study is that there is a no improvement in the dynamic balance and agility performances in cricket players. Although the hip flexors and gluteal muscles plays an important role in the performance of balance and agility, there are other muscles group which are need to be trained as whole which brings out an improved performance

in dynamic balance and agility.

CONFLICT OF INTEREST: Nil.

REFERENCES

[1] S. Glazier P, Paradisis GP, Cooper SM. Anthropometric and kinematic influences on release speed in men's fast-medium bowling. Journal of Sports Sciences. 2000 Jan;18(12):1013–21.

[2] Bartlett RM, Stockill NP, Elliott BC, Burnett AF. The biomechanics of fast bowling in men's cricket: A review. Journal of Sports Sciences. 1996 Oct;14(5):403–24.

[3] [3] Hernández-Stender CL, Molina-Rueda F, Cuesta-Gómez A, Alguacil-Diego IM. Lower limb muscle activation during outdoor running: differences between sprinters, middle-distance and long-distance runners. Sports Biomechanics. 2021 Mar 31;1–12.

[4] Karen D, Green DS, Jensen GM, Savinar E. A Comparison of Muscular Tightness in Runners and Nonrunners and the Relation of Muscular Tightness to Low Back Pain in Runners. J Orthop Sports Phys Ther. 1985 Jun;6(6):315–23.

[5] Bartlett RM. The science and medicine of cricket: an overview and update. Journal of Sports Sciences. 2003 Sep;21(9):733–52.

[6] Duffield R, Carney M, Karppinen S. Physiological responses and bowling performance during repeated spells of medium-fast bowling. Journal of Sports Sciences. 2009 Jan;27(1):27–35.

[7] Robert GL, Callaghan SJ, Jeffriess MD. Acceleration kinematics in cricketers: implications for performance in the field. J Sports Sci Med. 2014 Jan;13(1):128–36.

[8] Khuman Pr, Kamlesh T, Surbala L. Comparison of static and dynamic balance among collegiate cricket, soccer and volleyball male players. Int J Health Allied Sci. 2014;3(1):9.

[9] Linek P, Sikora D, Wolny T, Saulicz E. Reliability and number of trials of Y Balance Test in adolescent athletes. Musculoskeletal Science and Practice. 2017 Oct;31:72–5.

[10] Winters MV, Blake CG, Trost JS, Marcello-Brinker TB, Lowe L, Garber MB, Wainner RS. Passive versus active stretching of hip flexor muscles in subjects with limited hip extension: a randomized clinical trial. Physical therapy. 2004 Sep 1;84(9):800-7.

[11] Starrett K, Cordoza G. Becoming a supple leopard: the ultimate guide to resolving pain, preventing injury, and optimizing athletic performance. Las Vegas: Victory Belt Publ; 2013. 400 p.

[12] Parr M, Price PD, Cleather DJ. Effect of a gluteal activation warm-up on explosive exercise performance. BMJ Open Sport Exerc Med. 2017 Jun;3(1):e000245.

[13] Raya-González J, García-Esteban S, Hume P, Castillo D. Effects of Gluteal Muscles Strengthening on Lower-Limb Injuries in Male Professional Handball Players: A Preliminary Study. Journal of Strength and Conditioning Research. 2021 Jun;35(6):1593–8.

[14] Selkowitz DM, Beneck GJ, Powers CM. Which Exercises Target the Gluteal Muscles While Minimizing Activation of the Tensor Fascia Lata? Electromyographic Assessment Using Fine-Wire Electrodes. J Orthop Sports Phys Ther. 2013 Feb;43(2):54–64.

[15] Chatzopoulos D, Galazoulas C, Patikas D, Kotzamanidis C. Acute effects of static and dynamic stretching on balance, agility, reaction time and movement time. J Sports Sci Med. 2014 May;13(2):403–9.

[16] Konrad A, Močnik R, Titze S, Nakamura M, Tilp M. The Influence of Stretching the Hip Flexor Muscles on Performance Parameters. A Systematic Review with Meta-Analysis. IJERPH. 2021 Feb 17;18(4):1936.

[17] Iwata M, Yamamoto A, Matsuo S, Hatano G, Miyazaki M, Fukaya T, Dynamic Stretching Has Sustained Effects on Range of Motion and Passive Stiffness of the Hamstring Muscles. J Sports Sci Med. 2019 Mar;18(1):13–20.

[18] Jeong UC, Sim JH, Kim CY, Hwang-Bo G, Nam CW. The effects of gluteus muscle strengthening exercise and lumbar stabilization exercise on lumbar muscle strength and balance in chronic low back pain patients. J Phys Ther Sci. 2015 Dec;27(12):3813–6.

[19] Van Gelder LH, Bartz SD. The Effect of Acute Stretching on Agility Performance. Journal of Strength and Conditioning Research. 2011 Nov;25(11):3014–21.

[20] Shivalingaiah J, Vernekar S, Naik A, Gowdar S. Effect of training on agility, flexibility, its correlation, and also its correlation with skin fold thickness and body mass index among runners. Natl J Physiol Pharm Pharmacol. 2016;6(6):505.

[21] Wang X, Zhao Z. Research on the Effects of Gluteal Activation Exercises on Volleyball Players' Knee Joint

Muscle Strength, Proprioception and Dynamic Balance : Poster. AESA-Conf [Internet]. 2022 Mar. 8 [cited 2025 Aug. 19];6(1):48-9.Availablefrom:https://journal.aesasport.com/index.php/AESAConf/article/view/329

[22] Cannon J, Weithman BA, Powers CM. Activation training facilitates gluteus maximus recruitment during weight-bearing strengthening exercises. J Electromyogr Kinesiol. 2022 Apr;63:102643. doi: 10.1016/j.jelekin.2022.102643. Epub 2022 Feb 9. PMID: 35189569.

[23] Konrad A, Močnik R, Titze S, Nakamura M, Tilp M. The Influence of Stretching the Hip Flexor Muscles on Performance Parameters. A Systematic Review with Meta-Analysis. Int J Environ Res Public Health. 2021 Feb 17;18(4):1936. doi: 10.3390/ijerph18041936. PMID: 33671271; PMCID: PMC7922112.

[24] [24] Raya-González J, García-Esteban S, Hume P, Castillo D. Effects of Gluteal Muscles Strengthening on Lower-Limb Injuries in Male Professional Handball Players: A Preliminary Study. J Strength Cond Res. 2021 Jun 1;35(6):1593-1598. doi: 10.1519/JSC.0000000000003620. PMID: 32398632.

[25] Connelly CM, Moran MF, Grimes JK. COMPARATIVE ANALYSIS OF HIP MUSCLE ACTIVATION DURING CLOSED-CHAIN REHABILITATION EXERCISES IN RUNNERS. Int J Sports Phys Ther. 2020 Apr;15(2):229-237. PMID: 32269856; PMCID: PMC7134357.

[26] Buckthorpe M, Stride M, Villa FD. ASSESSING AND TREATING GLUTEUS MAXIMUS WEAKNESS - A CLINICAL COMMENTARY. Int J Sports Phys Ther. 2019 Jul;14(4):655-669. PMID: 31440415; PMCID: PMC6670060.

[27] Aslan H, Buddhadev HH, Suprak DN, San Juan JG. ACUTE EFFECTS OF TWO HIP FLEXOR STRETCHING TECHNIQUES ON KNEE JOINT POSITION SENSE AND BALANCE. Int J Sports Phys Ther. 2018 Aug;13(5):846-859. Erratum in: Int J Sports Phys Ther. 2019 Apr;14(2):173. doi: 10.26603/ijspt20190173. PMID: 30276017; PMCID: PMC6159495.

[28] Sonoda T, Tashiro Y, Suzuki Y, Kajiwara Y, Zeidan H, Yokota Y, Kawagoe M, Nakayama Y, Bito T, Shimoura K, Tatsumi M, Nakai K, Nishida Y, Yoshimi S, Aoyama T. Relationship between agility and lower limb muscle strength, targeting university badminton players. J Phys Ther Sci. 2018 Feb;30(2):320-323. doi: 10.1589/jpts.30.320. Epub 2018 Feb 28. PMID: 29545704; PMCID: PMC5851373.

[29] Forrest M, Hecimovich M, Dempsey A. Lumbopelvic muscle activation patterns in adolescent fast bowlers. Eur J Sport Sci. 2016 Sep;16(6):677-84. doi: 10.1080/17461391.2015.1135985. Epub 2016 Feb 3. PMID: 26840913.

[30] Ness BM, Comstock BA, Schweinle WE. CHANGES IN DYNAMIC BALANCE AND HIP STRENGTH AFTER AN EIGHT-WEEK CONDITIONING PROGRAM IN NCAA DIVISION I FEMALE SOCCER (FOOTBALL) ATHLETES. Int J Sports Phys Ther. 2016 Dec;11(7):1054-1064. PMID: 27999720; PMCID: PMC5159630.

[31] Bayne H, Elliott B, Campbell A, Alderson J. Lumbar load in adolescent fast bowlers: A prospective injury study. J Sci Med Sport. 2016 Feb;19(2):117-22. doi: 10.1016/j.jsams.2015.02.011. Epub 2015 Mar 5. PMID: 25794969.

[32] Mills M, Frank B, Goto S, Blackburn T, Cates S, Clark M, Aguilar A, Fava N, Padua D. EFFECT OF RESTRICTED HIP FLEXOR MUSCLE LENGTH ON HIP EXTENSOR MUSCLE ACTIVITY AND LOWER EXTREMITY BIOMECHANICS IN COLLEGE-AGED FEMALE SOCCER PLAYERS. Int J Sports Phys Ther. 2015 Dec;10(7):946-54. PMID: 26673683; PMCID: PMC4675195.

[33] Khuman R, Kamlesh T, Devi L. Comparison of static and dynamic balance among collegiate cricket, soccer and volleyball male players. International Journal of Health & Allied Sciences. 2014 Apr 15;3:9–13.

[34] Barton CJ, Kennedy A, Twycross-Lewis R, Woledge R, Malliaras P, Morrissey D. Gluteal muscle activation during the isometric phase of squatting exercises with and without a Swiss ball. Phys Ther Sport. 2014 Feb;15(1):39-46. doi: 10.1016/j.ptsp.2013.02.006. Epub 2013 Jun 14. PMID: 23770356.

[35] Chatzopoulos D, Galazoulas C, Patikas D, Kotzamanidis C. Acute effects of static and dynamic stretching on balance, agility, reaction time and movement time. J Sports Sci Med. 2014 May 1;13(2):403-9. PMID: 24790497; PMCID: PMC3990897.

[36] Worthington PJ, King MA, Ranson CA. Relationships between fast bowling technique and ball release speed in cricket. J Appl Biomech. 2013 Feb;29(1):78-84. doi: 10.1123/jab.29.1.78. Epub 2012 Jul 6. PMID: 22813926.

[37] Selkowitz DM, Beneck GJ, Powers CM. Which exercises target the gluteal muscles while minimizing activation of the tensor fascia lata? Electromyographic assessment using fine-wire electrodes. J Orthop Sports Phys Ther. 2013 Feb;43(2):54-64. doi: 10.2519/jospt.2013.4116. Epub 2012 Nov 16. PMID: 23160432.

[38] Olivier B, Stewart AV, Olorunju SA, McKinon W. Static and dynamic balance ability, lumbo-pelvic movement control and injury incidence in cricket pace bowlers. J Sci Med Sport. 2015 Jan;18(1):19-25. doi: 10.1016/j.jsams.2013.10.245. Epub 2013 Oct 31. PMID: 24268569.

[39] Hina Gupta Normative Data of Dynamic Balance of Lower Extremities Using Y-Balance Test in Cricketers with 16-25 Years of Age IOSR Journal of Sports and Physical Education (IOSR-JSPE) 5, Volume 3, Issue 5 10.9790/6737-03050106