International Journal of Physical Education, Sports and Health 2024; 11(4): 323-327

P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (RJIF): 5.38
IJPESH 2024; 11(4): 323-327

www.kheljournal.com
Received: 19-05-2024
Accepted: 24-06-2024

Amrita Mishra
Assistant Professor, Akash Institute of Physiotherapy, Karnataka, India

Belle Sharvani
Associate Professor, Akash Institute of Physiotherapy, Karnataka, India

Corresponding Author:
Amrita Mishra
Assistant Professor, Akash Institute of Physiotherapy, Karnataka, India

Comparison of proprioceptive neuro-muscular facilitation and mulligan stretching on hamstring tightness in recreational football players

Amrita Mishra and Belle Sharvani

DOI: https://doi.org/10.22271/kheljournal.2024.v11.i4f.3439

Abstract
Background: Due to increasing popularity of football in India, youngsters have taken football as recreational sports. Because of the lack of proper training there is a high chance of getting injury. Short hamstring have been identified with various lower limb injuries.
Purpose: The purpose was to compare the effectiveness of proprioceptive neuromuscular facilitation and mulligan stretching on sprint, agility and flexibility.
Method: Eighty two subjects were taken based on the inclusion criteria and allocated into two groups, Group A (PNF stretching) and Group B (Mulligan TSLR Stretching) of forty-one of each, using purposive sampling technique. The total stretching session was given 3 times a week for 6 consecutive weeks. Sprint using 40-yards dash test, agility using Illinois agility test and flexibility using active knee extension test was measured. Data was analysed using descriptive and interferential statistics.
Results: Between the group comparisons / Parametric ANOVA (F-test), pretest AKE for right leg (degrees) (F-test = 0.06183, Not Significant, $p>0.05$), AKE for left leg (degrees) (F-test = 0.05725, Not Significant, $p>0.05$), 40 Yards dash test (seconds) (F-test = 13.073, Significant, $p>0.05$), Illinois Agility (Seconds) (F-test = 0.07236, Not Significant, $p>0.05$). Post-test AKE for right leg (degrees) (F-test = 163.040, Significant, $p<0.001$), AKE for left leg (degrees) (F-test = 356.961, Significant, $p<0.001$), 40 Yards dash test (seconds) (F-test = 20.180, Significant, $p<0.001$), Illinois Agility (Seconds) (F-test = 4.4444, Significant, $p<0.0001$).
Conclusion: The mulligan TSLR group were better than the PNF stretching group in improving flexibility and ROM.

Keywords: Hamstring tightness, proprioceptive neuromuscular stretching (PNF), Mulligan traction straight leg raise (MTSLR), knee range of motion

Introduction
Ability of the muscle to lengthen, allowing a joint to move throughout the range is known as muscle flexibility [1]. Flexibility is one of the standard components for prevention of injuries and for rehabilitation as well. Clinicians and sports medicine specialists routinely survey hamstring tightness (i.e., hamstring flexibility) since short hamstring have been identified with various lower limb injuries [2].
During the previous years in India, football among numerous youngsters has been rapidly promoted as a recreational sport. As football is a game that includes extraordinary physical quality, such adolescents, who are not under experts guidance are at the risk of getting exposed to musculoskeletal injuries because of lack of appropriate warm-up and stretching's and cool down techniques [3]. The performance of the football players are affected by muscular power output or strength [4].
The key features which are required while playing football include agility, co- ordination, speed/speed endurance, balance, power, flexibility, and strength [5]. High intensity sprinting is an important component for scoring a goal in football game [6]. While looking for athletes overall physical fitness, hamstring flexibility is one of the greatest concern which has a significant impact on athletes performance due to hamstring injuries [7].
To function at an optimal level and for the players to be less prone to injuries, flexibility is an important component to maintain especially for the lower extremity because of the greater usage of the lower extremity muscles while playing football [8]. There are different phases of

loading in the limb based on the type of movement [9]. There are the muscles which are assessed to determine any deficits in flexibility of recreational football players [10].

Bhagyashree K. Kolie et al. concluded that 82% of football players with hamstring tightness where females being high in number than males [11].

Due to the hamstring tightness, the performance in the game is affected. PNF been proved better than static stretching in football players [1]. Mulligan TSLR is more effective than Mulligan BLR in improving flexibility and performance [9]. Young football players with great hamstring flexibility will have better performance in tests of sprinting [2].

There is a dearth in studies comparing the effects of PNF and mulligan TSLR stretching among the Amateur football players and that is where the need arises to compare the effects of PNF and mulligan TSLR stretching among the College Level Football Players.

There has been a great importance of muscle stretching for prevention of injuries, as well as skill development and physical capacity [12]. Stretching techniques will improve flexibility [13]. Although various stretching techniques are available [14]. PNF is been proved effective [15] interestingly Mulligan TSLR technique is also proved effective in improving hip joint range which is limited due to hamstring shortening [16].

There are many physical benefits provided by stretching which include improved muscular flexibility, improved muscular performance, improvement in energy expenditure for a given speed, avoid injury, prevention of muscle soreness, promotion of healing process [17]. Therefore, the study aimed to compare the effectiveness of PNF contract-relax and mulligan TSLR stretching upon hamstring tightness in recreational football players.

Materials and Methods

Study design was made as two groups pre-test, post-test experimental. The procedure was explained to the participants and informed consent was signed by the participants. After obtaining the ethical approval from the ethical committee (Ref: EC–MPT/20/PHY/002) eighty-two subjects based on inclusion criteria were allocated into two groups of 41 participants in each group. The study was conducted in Krupanidhi Group of Institutions and the duration of the study was from March 2020 to March 2021. The inclusion criteria were recreational football players [26], tightness of hamstring muscle evaluated under active knee extension test, with age limit of 18-23 years, both the genders were included. Subjects with muscle soreness, hamstring spasm or tendinopathy during last 6 months, neurological involvement of lower limb, Radiculopathy of lower limb were excluded from the study [19, 1]. Pre-test was done using active knee extension test for flexibility, 40-yards dash test for sprint, Illinois Agility test for agility was done.

The treatment was one session per day, three days a week for six weeks. Group-A was provided with PNF stretching and Group-B was provided Mulligan traction straight leg raise stretching. After 6 weeks of treatment protocol post-test was done using active knee extension test for flexibility, 40-yards dash test for sprint, Illinois Agility test for agility was done.

Procedure

PNF Stretching

Contract relax (Group-A) technique was given. The subject was lying supine the hip and knee was maintained at 90° then the subject was guided to perform the SLR. SLR was performed until the subject feel the stretch of hamstring muscle. Then maintaining the same position for 15 seconds, the therapist supported the leg of participants at ankle. After that the subject was instructed to perform the continuous contraction of muscles for 6sec and performing hip extension. The resistance was applied at the ankle. After this the subject was asked to perform resisted hip flexion. The participant was maintaining hip flexion for 6seconds. 30 seconds rest was given at the end of each repetition of the above procedure. Total three repetitions were given for each leg and continuous instruction were given [10, 23].

Mulligan traction straight leg raise stretching

In supine lying traction was applied to treatment leg while taking the leg through the pain free range. Along the longitudinal axis, traction force was applied while the knee remains extended. At the same time the limb was passively moved through the pain free range and take it back to the resting position. No pain was ensured during the procedure. The direction of the leg raise was adjusted if the subject complains of pain. Pain free three repetitions was given to each subject with 30seconds rest in between the repetitions [7].

Outcome measures

- Active knee extension test
- 40-yards dash test
- Illinois agility test

Active Knee Extension Test (AKE)

In supine lying, the pelvis of the participant was stabilized with the help of the stabilization strap. A rectangular frame was placed then the hip and knee was maintained at 90º with the reference to the rectangular frame.

The fulcrum of goniometer was at the lateral condyle of femur, stable arm pointing towards the greater trochanter and the other arm pointing lateral malleolus. The participant was then asked to extend the knee and maintain the position for 2-3 seconds and the goniometer reading was recorded [5].

Illinois Agility Test

The field was 10metres long and 5metres wide (the distance between the start and finish position). Four cones were placed at the focal points of testing zone at the distance of 3.3metres apart. The beginning, finish, and two turning locations were all stamped with four cones. The participants were asked to do the test while lying the face down with their hands at shoulder level. The trial began with a “GO” instruction, and the participant ran as quick as could be expected under the circumstances. The trial ended when the participant crossed the finish line without tripping over any cones [19].

40 Yards Dash Test

The participant ran with a full speed 40yards sprint on the field. The time was recorded for sprint on hand held stop watch. For each participant, the average time was recorded to the hundredth of a second [27].

Statistical analysis

Statistical analysis was done Parametric ANOVA test for within the groups and within the groups respectively.

The data was analyzed using the SPSS version 29.0

Results

After analyzing the data, the results obtained showed that there was an significant improvement in Group-A (PNF

stretching group) on the outcome measures of flexibility (active knee extension test), sprint (40-yards dash test) and agility [table-1] (Illinois agility test). There was also significant improvement in Group-B (Mulligan TSLR group) on flexibility, sprint, agility[table-2]. The results obtained after the analysis of parametric ANOVA between the groups showed that there was a significant improvement in all the three parameters in Group-B (Mulligan TSLR stretching); active knee extension test right (129.512±10.02), active knee extension test left (130.43±7.53), 40-yards dash test(6.124±0.558), Illinois agility(17.72±1.55), than Group-B (PNF stretching) active knee extension test right (107.67±4.41), active knee extension test left (105.95±3.46), 40-yards dash test(6.736±0.670), Illinois agility(18.47±1.65) [table-3]. Improvement was significant in flexibility assessed using active knee extension test with the score of 129.512 degrees for right leg and 130.43degrees for left leg than the PNF stretching group with the score of 107.67 degrees for right leg and 105.95 degrees for left leg. Significant improvement was also seen in sprint in Group-B with the score of 6.124 seconds than the Group-A with the score of 6.736 seconds. Improvement in agility was seen in Group-B with the score of 17.72 seconds than 18.47 seconds of Group-A

Table 1: Range, mean, and SD of outcome measures of group-a (PNF stretching)

Tests	Pre test mean (S.D)	Post test mean (S.D)	t-value	p-valve	Significance
AKE (Right)	102.40(4.12)	107.67 (4.41)	20.125	<.00001	Significant
AKE (Left)	102.121(3.60)	105.95 (3.46)	20.143	<.00001	Significant
40 yards dash	6.85(0.681)	6.736 (0.670)	-8.243	<.00001	Significant
Illinois agility	18.61(1.67)	18.47 (1.65)	-6.025	<.00001	Significant

The above table shows the significance difference in the scores between pre and post test in Group A

Table 2: Range, mean, and SD of outcome measures of group-B (mulligan TSLR)

Tests	Pre test Mean (S.D)	Post test mean (S. D)	t-value	p-valve	Significance
Ake(right)	102.29 (3.69)	129.512 (10.02)	19.37	<.00001	Significant
Ake(left)	102.760 (4.02)	130.43 (7.53)	26.637	<.00001	Significant
40 yards dash	6.347 (0.59)	6.124 (0.558)	-8.8315	<.00001	Significant
Illinois agility	18.51 (1.50)	17.72 (1.55)	-12.0371	<.00001	Significant

The above table shows the significance difference in the scores between pre and post test in Mulligan TSLR group

Table 3: Comparison of pre test and post test outcome measures among recreational football players ib between the groups

S. no.	Groups	Pre test				Post test			
		AKE right	AKE left	40 yards dash test	Illinois agility	AKE right	AKE left	40 yards dash test	Illinois agility
1	PNF	102.40 (4.12)	102.121 (3.60)	6.85 (0.681)	18.61 (1.67)	107.67 (4.41)	105.95 (3.46)	6.736 (0.670)	18.47 (1.65)
2	Mulliga NTSLR	102.29 (3.69)	102.7 60(4.02)	6.347 (0.59)	18.51 (1.50)	129.512 (10.02)	130.43 (7.53)	6.124 (0.558)	17.72 (1.55)
Between groups comparisons/Parametric ANOVA (f-test)		F-test = 0.01683, not Significant, P=0.8971 $P>0.05$	F-test = 0.5725, not Significant, P=0.4514 $P>0.05$	F-test = 0.7318, not Significant, P=0.5211 $P>0.05$	F-test = 0.07236, Not Significant, P=0.7886 $P>0.05$	F-test = 163.040, Significant, $P<0.0001$ $P<0.05$	F-test = 356.961, Significant, $P<0.0001$ $P<0.05$	F-test = 20.180, Significant, P=0.000023 $P<0.05$	F-test = 4.4444, Significant, P=0.03814 $P<0.05$

Significant difference is seen between Mulligan and PNF stretching pre-test and post-test but Mulligan stretching shows much more improvement than PNF stretching

Discussion

Muscle flexibility plays a significant role for prevention of injuries. Flexibility is regarded as one of the most important factor in injury prevention and rehabilitation. F. Garcia-Pinillos et al. (2015) [2] mentioned in his study sprints, agility, jumps, shorts or tackles are important events while playing football because of high intensity works [4].

The aim of the study was to compare the effectiveness of PNF contract-relax and mulligan stretching upon hamstring tightness in recreational football players.

PNF contract relax and Mulligan TSLR stretching both techniques showed significant improvement on hamstring flexibility, sprint and agility. There are only few studies reported comparing PNF contract relax and Mulligan TSLR stretching. The study was an attempt to find out significant difference between the PNF and Mulligan stretching on sprint, agility and flexibility among the Recreational Football players. The results in this study showed that there was a significant difference between PNF stretching and Mulligan stretch groups. However, the increased flexibility, sprint and agility achieved was greater with Mulligan stretch than for PNF stretch.

Between the groups ANOVA pretest AKE for right leg (degrees) (F-test = 0.06183, Not Significant, $p>0.05$), AKE for left leg (degrees) (F-test = 0.05725, Not Significant, $p>0.05$), 40 Yards dash test (seconds) (F-test = 13.073, Significant, $p>0.05$), Illinois Agility (Seconds) (F-test = 0.07236, Not Significant, $p>0.05$). Post test AKE for right leg (degrees) (F-test = 163.040, Significant, $p<0.001$), AKE for left leg (degrees) (F-test = 356.961, Significant, $p<0.001$), 40 Yards dash test (seconds) (F-test = 20.180, Significant, $p<0.001$), Illinois Agility (Seconds) (F-test = 4.4444, Significant, $p<0.0001$).

Jesudas Mazumdar et al. (2014) compared mulligan TSLR technique versus muscle energy technique in their study and showed Mulligan TSLR and MET are beneficial in reducing hamstring tightness at the end of 3 weeks intervention. MET showed higher statistical significance (13.69±7.46) whereas, in this study it was proved that mulligan TSLR was effective with significant improvement (129.512±10.02). Outcome measure was active knee extension ROM using universal Goniometer [21].

Monalisa pattnaik et al. (2012) compared Mulligan TSLR and dynamic soft tissue mobilization and control group found in their study that mulligan traction straight leg raise greater increase (1, 28, 0.05 = 2.823, p = 0.000) in active ROM of

knee extension and passive SLR in ROM improvement was not significant in the control group. Outcome measure used to measure hamstring extensibility was the AKE test and passive SLR [6].

Ramachandran. S et al. (2018) mentioned in his study both PNF hold relax and PNF contract relax antagonist contract stretching were helpful in improving hamstring extensibility, however the PNF contact relax antagonist stretching approach (134.66±1.29) was superior to the PNF hold relax stretching approach (130.66±3.71). Both groups reported increased hamstring extensibility as a result of the study. With a significant difference of $P<0.001$, group-B with contract relax agonist was found to be more effective in improving hamstring flexibility. Similarly, in this study the PNF contract relax (107.67±4.41) was in proximity with the study. Outcome measure was active knee extension ROMv [13].

Zutshi K et al. (2010) determined the efficacy of PNF stretching techniques for developing hamstring flexibility, as well as a comparison of the efficacy of two PNF stretching techniques (Hold Relax and Contract Relax- Antagonist Contract) using AKE test as an outcome measure. Results were analyzed using ANOVA which demonstrated subjects in group B (contract relax) (165.26±8.9) showed a considerable increase in hamstring flexibility when compared with those of group A (hold relax) (157±7) at the end of three weeks. Likewise, in this study the flexibility of the hamstrings improved significantly due to PNF stretching contract relax (107.67±4.41) [23].

Dafda Renuka H. (2019) compared the effect of the PNF technique's Hold-Relax and Agonist Contraction on hamstring muscles flexibility. The flexibility of the hamstring muscles improved in group A ($t = -7.94$, $p<0.05$) and Group-B ($t = -4.75$, $p<0.05$) when compared to the agonist contraction technique, the hold and relax technique was more effective in enhancing hamstring muscle flexibility. It was studied that Hold-Relax technique was more effective, however, in this study contract relax technique ($t = 19.37$, $p < 0.00001$) demonstrated significant improvement in hamstring extensibility [32].

Mulligan traction straight leg raise stretch resulted in increased flexibility due to change in viscoelastic property which occurs with "creep", in which the strain in the muscle tendon unit decreased over time. The hamstring muscle reacted to the viscoelastic change in tension by contraction [6].

Another factor that the hamstring muscle inhibiting him might add on to the lengthening of the hamstring muscle during Mulligan Traction Straight leg raise stretching. During stretching different receptors applied an inhibitory influence on the firing of lower limb alpha motor neurons [5].

When traction is applied to the lower limb, Golgi Tendon Organs around the spine, knee and hip are likely to activate different segmental reflex pathways. Simultaneously, Large amplitude stretching's such as straight leg raise, stimulate the Golgi tendon organs. There might be inhibition of the activity of muscle lengthening during information processing during straight leg raise by hosing the afferent action of type II muscle spindles or by using 1-b fibers to reduce motor neuron excitability. Inhibition of the hamstring muscle will now be able to directly identify progress in flexibility [6].

PNF stretching also proved to be effective in improving hamstring muscle extensibility but not significantly greater than Mulligan TSLR due to physiological change like decrease in Hoffman's (H) reflex amplitude. Various presynaptic and post synaptic changes are liable for decline in H-reflex reaction. Autogenic decrease in la-afferent induced by presynaptic inhibition where as post synaptic the Golgi tendon organs cause autogenic inhibition, afferent current inhibition via Renshaw loop and post synaptic inhibition [11].

Mulligan Traction straight leg raise can provide effective therapeutic stretching option for increasing flexibility. The results proved that mulligan TSLR was better compared to stretch tolerance than the PNF stretching in improving limited range of motion for hamstring muscle.

Limitations and suggestions

The study was conducted on 82 subjects in order to generalize these findings, it can be done with larger samples. The subjects were healthy and pain free. The results of this study was among the asymptomatic recreational football players. The further studies are recommended to be done on equal number of male and female. It is recommended to compare with other techniques to know the efficacy of intervention.

Conclusion

The interventions in each group were individually effective in improving outcome measures of young adults.

But, the intervention in Group-B (mulligan TSLR stretching) were better than the interventions in Group-A (PNF stretching) in improving Flexibility, Sprint and Agility.

References

1. Kaur M, Paul R, Kumar S, Arora R, Arora L. A randomized controlled trial to compare the effectiveness of static stretching versus PNF stretching of hamstring muscles following superficial heat in athletes. Int J Sci Res Publ. 2014 Jul 4;4(7).
2. García-Pinillos F, Ruiz-Ariza A, Moreno del Castillo R, Latorre-Román PA. Impact of limited hamstring flexibility on vertical jump, kicking speed, sprint, and agility in young football players. J Sports Sci. 2015 Jul 21;33(12):1293-1297.
3. Bhosale N, Yeole U, Chogle A, Khatri S. Assessment of lower extremity flexibility in recreational football players.
4. Gajdosik R, Lusin G. Hamstring muscle tightness: reliability of an active-knee-extension test. Phys Ther. 1983 Jul 1;63(7):1085-1088.
5. Zakaria A, Melam G, Buragadda S. Efficacy of PNF stretching techniques on hamstring tightness in young male adult population. World J Med Sci. 2012;7(1):23-26.
6. Singh BK, Pattnaik Monalisa, Mohanty DP. A comparative study of Mulligan traction straight leg raise and dynamic soft tissue mobilization to increase hamstrings flexibility. IOSR J Nurs Health Sci. 2016;05(04):80-88.
7. Yıldırım MS, Ozyurek S, Tosun ÖÇ, Uzer S, Gelecek N. Comparison of effects of static, proprioceptive neuromuscular facilitation and Mulligan stretching on hip flexion range of motion: a randomized controlled trial. Biol Sport. 2016 Mar;33(1):89.
8. Weerasekara I, Kumari HM, Weerarathna N, Withanage C, Wanniarachchi C, Mariyanayagam Y, et al. The prevalence of hamstring tightness among the male athletes of University of Peradeniya in 2010. J SLSAJ. 2012;12:56-58.
9. Pratishtha K, Jagga V. Effect of Mulligan stretching techniques (TSLR and BLR) on biceps femoris muscle and pelvic rotation by using surface EMG and bubble inclinometer respectively. J Exerc Sci Physiother. 2012

Jun;8(1):39.
10. Deguzman L, Flanagan SP, Stecyk S, Montgomery MM. The immediate effects of self-administered dynamic warm-up, proprioceptive neuromuscular facilitation, and foam rolling on hamstring tightness. Athl Train Sports Health Care. 2018 May 16;10(3):108-116.
11. Lempke L, Wilkinson R, Murray C, Stanek J. The effectiveness of PNF versus static stretching on increasing hip-flexion range of motion. J Sport Rehabil. 2018 May 1;27(3):289-294.
12. Richman ED, Tyo BM, Nicks CR. Combined effects of self-myofascial release and dynamic stretching on range of motion, jump, sprint, and agility performance. J Strength Cond Res. 2019 Jul 1;33(7):1795-1803.
13. Sivagnanam R, Jibipaul N, Senthilkumar S, Sudhakar S. Comparative effect of PNF stretching technique on hamstring flexibility; c2018.
14. Lim W. Optimal intensity of PNF stretching: maintaining the efficacy of stretching while ensuring its safety. J Phys Ther Sci. 2018;30(8):1108-1111.
15. Arshadh M. Effect of different muscle stretching techniques on hamstring muscle flexibility in amateur soccer players; c2016.
16. Islamoglu I, Atan T, Unver S, Cavusoglu G. Effects of different durations of static stretching on flexibility, jumping, speed and agility performance. Anthropologist. 2016 Mar 1;23(3):454-461.
17. Kurt C, Fırtın İ. Comparison of the acute effects of static and dynamic stretching exercises on flexibility, agility and anaerobic performance in professional football players. Turk J Phys Med Rehabil. 2016 Jul 1;62(3).
18. Kapadia PD, Meshram VK. A comparative study on immediate effects of traction straight leg and bent leg raise on hamstring muscle flexibility in normal individuals. IJAR. 2019;5(4):274-278.
19. Altmann S, Ringhof S, Neumann R, Woll A, Rumpf MC. Validity and reliability of speed tests used in soccer: a systematic review. PLoS One. 2019;14(8).
20. Guiser ZJ. Examination of hamstring flexibility and maximal sprint speed.
21. Mazumdar J, Shrivas JK. A comparison between Mulligan traction straight leg raise technique vs muscle energy technique on hamstring tightness in asymptomatic male. Int J Physiother Res. 2014;2(2):412-417.
22. Kirmizigil B, Ozcaldiran B, Colakoglu M. Effects of three different stretching techniques on vertical jumping performance. J Strength Cond Res. 2014 May 1;28(5):1263-1271.
23. Nagarwal AK, Zutshi K, Ram CS, Zafar R, Hamdard J. Improvement of hamstring flexibility: a comparison between two PNF stretching techniques. Int J Sports Sci Eng. 2010;4(1):25-33.
24. Craig KL, Goman DM, Shields ML, Stewart JL. The effects of hamstring stretching on vertical jump in healthy young adults.
25. vanDoormaal MC. The relation between hamstring flexibility and hamstring injuries in male amateur soccer players [Master's thesis].
26. Sudhakar S, et al. Effect of blood pressure regulating gene polymorphisms on the endurance capacity of athletes. Biomedicine. 2018;38(2):267-273.
27. Hachana Y, Chaabène H, Nabli MA, Attia A, Moualhi J, Farhat N, et al. Test-retest reliability, criterion-related validity, and minimal detectable change of the Illinois agility test in male team sport athletes. J Strength Cond Res. 2013 Oct 1;27(10):2752-2759.
28. Mann JB, Ivey PJ, Brechue WF, Mayhew JL. Validity and reliability of hand and electronic timing for 40-yd sprint in college football players. J Strength Cond Res. 2015 Jun 1;29(6):1509-1514.
29. Jung J, Choi W, Lee Y, Kim J, Kim H, Lee K, et al. Immediate effect of self-myofascial release on hamstring flexibility. Phys Ther Rehabil Sci. 2017;6:45-51. DOI:10.14474/ptrs.2017.6.1.45.
30. Tsolakis C, Douvis A, Tsigganos G, Zacharogiannis E, Smirniotou A. Acute effects of stretching on flexibility, power, and sport-specific performance in fencers. J Hum Kinet. 2010 Dec 1;26:105-114.
31. Dafda Renuka H. A study to compare efficacy of hold-relax and agonist contraction of proprioceptive neuromuscular facilitation technique on hamstring muscle flexibility in healthy female–an interventional study. Exec Editor. 2019 Jan;13(1):43.
32. Hasebe K, Okubo Y, Kaneoka K, Takada K, Suzuki D, Sairyo K. The effect of dynamic stretching on hamstrings flexibility with respect to the spino-pelvic rhythm. J Med Invest. 2016;63(1.2):85-90.
33. Goral K. Examination of agility performances of soccer players according to their playing positions. The Sport Journal; c2015. DOI:10.17682/sportjournal/2015.004.
34. Makhlouf I, Chaouachi A, Chaouachi M, Ben Othman A, Granacher U, Behm DG. Combination of agility and plyometric training provides similar training benefits as combined balance and plyometric training in young soccer players. Front Physiol. 2018 Nov 13;9:1611.
35. Barbosa GD, Dantas GA, Silva BR, Pinheiro SM, Santos HH, Vieira WH. Intra-rater and inter-instrument reliability on range of movement of active knee extension. Motriz: Rev Educ Fis. 2017 Mar;23(1):53-59.
36. Hollis J. The effects of static stretching of the hamstring muscles in a warm-up on performance among football players: a systematic literature review.
37. Desai R, Palekar T, Deshpande A. Carryover effect of Mulligan traction straight leg raise in individuals with hamstring tightness. Glob J Res Anal. 2017 May;6(5).
38. Pratishtha K, Jagga V. Effect of Mulligan stretching techniques (TSLR and BLR) on biceps femoris muscle and pelvic rotation by using surface EMG and bubble inclinometer respectively. J Exerc Sci Physiother. 2012 Jun;8(1):39-42.