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Neurodynamic sliding versus PNF stretching on hamstring flexibility in collegiate students: A comparative study

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Abstract
Background: Muscular flexibility is an important aspect of normal human function. Limited flexibility has been shown to predispose a person to several musculoskeletal overuse injuries and significantly affect a person's level of function. Objective of the study was to compare the effectiveness of PNF (hold-relax) and Neurodynamic sliding technique for improving hamstring flexibility.
Materials and Methods: 60 participants with hamstring tightness were allocated into two groups (30 participants in each group). The outcome measure used was AKE test. Subjects of group A were treated with PNF hold relax stretching, whereas the subjects of group B were treated with Neurodynamic sliding technique. For both experimental groups, the technique was performed three times a week for a total training period of four weeks.
Results: The results demonstrated significant improvement in hamstring flexibility for subjects of group A when compared with those of group B (P = 0.01) at the end of four weeks.
Conclusion: Although the study supports the experimental hypothesis that PNF (Hold-Relax) stretching technique is more effective than Neurodynamic sliding technique for improving hamstring flexibility.

Keywords: Hamstring flexibility, PNF stretching, neurodynamic sliding, active knee extension test

1. Introduction
Musculotendinous strains are among the most prevalent, as well as the most frustrating, groups of injuries for athletes and health care professionals [1]. Hamstring strain injuries are common in sporting area, and frequently occur in activities which involve running, sprinting, jumping or kicking (Best and Garrett, 1996; Clanton and Coup; 1998) [2]. As documented in several studies, incidence rates of hamstring strains range between 7.7% and 30% (Bennel *et al*, 1998) with relatively high recurrence rates between 18% and 34% (Upton *et al*, 1996 and Heiser *et al* 1984) [3]. Injury surveillances have found hamstring injuries to be the most common injury in athletics (especially in sprinters) (McLennan and McLennan, 1990; Bennell and Crossley, 1996) [4], soccer (Woods *et al*., 2004), Australian Rules football (Orchard and Seward, 2002), cricket (Orchard *et al*., 2002a; Stretch, 2003), touch football (Neumann *et al*., 1998) and hurling (Watson,1996), whilst they are very common in rugby league (Gabbett, 2003) and rugby union (Targett, 1998). Using an injury definition as that preventing player participation in a match, as a percentage of total injuries occurring, prevalence has been measured between 11% (Stretch, 2003) and 15% (Orchard *et al*., 2002a) in cricket, 11% (Dadebo *et al*., 2004) [5] and 12% (Woods *et al*., 2004) in soccer and 16% in Australian Rules football (Orchard and Seward, 2003).
Limited flexibility has been shown to predispose a person to several musculoskeletal overuse injuries and significantly affect a person‟s level of function [6]. Muscular tightness is frequently postulated as an intrinsic risk factor for the development of a muscle injury. Lack of flexibility has been suggested as a predisposing factor to hamstring strains [7]. Worrell and Perrin (1992) proposed a theoretical model for hamstring strains, suggesting that they result from a complex interaction of four etiologic factors: warm-up, strength, fatigue, and flexibility. To prevent muscle injuries, stretching exercises before sports activities are usually recommended.

Reasons for stretching relate to beliefs that stretching exercises will increase flexibility and decrease muscle stiffness [8]. Maintaining normal muscle length requires regular stretching to prevent muscle stiffness and benefit from the decreased risk of musculoskeletal injuries and enhance physical performance. Previous studies concerning muscle stiffness suggests that, at a given muscle length, cyclic stretching will reduce the force that is placed upon the muscle and associated connective tissue [9]. Theoretically, less tension will be applied within the musculotendinous tissue when it is subjected to the changes in joint motion that accompany sport or recreational activity. Thus, the potential for musculotendinous strain throughout the normal range of motion will be reduced by elongation of the musculotendinous unit.

Numerous stretching techniques have been developed, reported and applied by physical therapists, coaches and athletic trainers. Four methods of stretching have been emerged: 1) Ballistic stretching, 2) Static stretching 3) PNF stretching and 4) Neurodynamic sliding. All four methods have been shown to increase ROM immediately after stretching.

Neurodynamics encompasses interactions between mechanics and physiology of the nervous system. Changes in neural mechanics or physiology may lead to pathodynamics. Altered posterior lower extremity neurodynamics could arguably influence resting muscle length and lead to changes in the perception of stretch or pain. Providing movement or stretching could lead to changes in the neurodynamics and modification of sensation and could help to explain the observed increase in flexibility. The mechanosensitivity of the neural structures in the posterior leg, thigh, buttock, and vertebral canal may play a part in determining the flexibility of the hamstring muscles. Protective muscle contraction of the hamstring muscles found in the presence of neural mechanosensitivity may account for hamstring tightness and thereby predispose the muscle to subsequent strain injury. Neurodynamic sliding interventions are thought to decrease neural mechanosensitivity and it is shown that the inclusion of these interventions in the management of hamstring flexibility could be beneficial [10].

Villafane JH, Silva GB, Fernandez-Carnero J conducted the study to evaluate whether neurodynamic mobilization of the median nerve improves pressure pain threshold (PPT) and pinch and grip strength in patients with secondary thumb carpometacarpal osteoarthritis (TCOA). Fifteen patients with secondary TCOA (13 women and 2 men) between 70 and 90 years old were received by neurodynamic therapy for 4 sessions over 2 weeks this case series were monitored by using PPT measured by algometry as PPT at the trapeziometacarpal (TM) joint, tubercle of the scaphoid bone, and the cuneiform apophysis of the hamate bone. And they found that median nerve mobilization decreased pain in the TM joint and increased grip strength in this group of patients with TCOA [11].

Oskay D, Meriç A, Kirdi N, Firat T, Ayhan C, Leblebicioglu G conducted the study to describe the effect of nerve mobilization techniques in the standard conservative management of cubital tunnel syndrome (CTS). Seven patients with CTS participated in this study. Conservative treatment using neurodynamic mobilization with patient education and activity modification demonstrated some long-term positive results [12].

Proprioceptive Neuromuscular Facilitation (PNF) is a more advanced form of flexibility training that involves both the stretching and contraction of the muscle group being targeted. PNF stretching was originally developed as a form of rehabilitation. While there are several variations of PNF stretching, they all have one thing in common; they facilitate muscular inhibition. Various PNF stretching techniques based on Kabat"s concept are: Hold Relax, Contract Relax, and Contract Relax Antagonist Contract (CRAC) etc. The Hold Relax (HR) technique involves an isometric contraction of the shortened muscle against maximum resistance followed by relaxation phase [13].

O'tlora, Cartwright A, Wade CD, Hough AD, Shum GL conducted the study on efficacy of static stretching and PNF stretch on hamstrings length after a single session and concluded that passive stretching or PNF results into increase in hamstring flexibility as hamstring as hamstring (agonist) contract PNF is more effective than an static stretching session. Therefore a single PNF are more relevant in sporting environment [14].

Considering the importance of hamstring flexibility in general and athletic population, maintaining the flexibility of hamstring muscle is of utmost importance for health care professionals and to achieve this goal one needs to know the most effective and efficient technique to gain hamstring flexibility. Numerous investigations established PNF techniques are more effective than traditional stretching exercises for range of motion or flexibility enhancement [15].

Nagarwal A.K., Zutshi K, Ram C. S., Zafar R conducted the study to compare the effectiveness of two PNF stretching techniques (Hold Relax and Contract Relax- Antagonist Contract) for improving hamstring flexibility. Hamstring flexibility for each group was measured using the active knee extension (AKE) test. Subjects of group A were treated with PNF hold relax stretching, whereas the subjects of group B were treated with PNF CRAC technique. Both the techniques viz. PNF Hold Relax and PNF-CRAC are almost equal in their clinical effectiveness for improving hamstring flexibility and that either of the techniques may be used in clinical practice for improving hamstring flexibility [16].

Numerous studies have shown the individual effectiveness of Neurodynamic sliding and PNF in improving the flexibility of hamstring muscle but there are very few studies which shows the superiority of one technique with respect to the other, hence the purpose of the study is to compare the effectiveness of Neurodynamic sliding versus PNF (Hold-Relax) technique in improving the hamstring flexibility in collegiate students.

2. Materials and Methods

The study was conducted at Padmashree physiotherapy college, Bangalore. Ethical clearance was obtained from institutional ethical committee, Padmashree Institute of Physiotherapy, Bangalore as per ethical guidelines for biomedical research on Human subjects, 2000 ICMR, New Delhi. The study design was a pre-post experimental study. 60 participants with age ranging 20-30 years, both genders and subjects with hamstring tightness [17]- as defined by limitation of 20 degree or more from full knee extension as determined by active knee extension test were included in the study. Subjects with history of neck trauma, history of fracture, disc hernia/protrusion, chronic low back pain, history of surgery were excluded from the study. Prior to participation, a written informed consent was taken from all subjects and subjects were informed about study protocol. Standard full circle goniometer, cross bar made of PVC pipe, straps, foam mattress, marker, paper, stop watch materials were used for the study. All the subjects were undergone a pre-treatment examination to assess hamstring tightness using the AKE test.

Subjects were assessed for hamstring tightness using the AKE test [18]. The subject was in supine position with hips in 90 degree flexed and knee flexed. A PVC cross bar was used to maintain the proper position of hip and thigh. The testing was done on the right lower extremity and subsequently the left lower extremity and the pelvis were strapped down the table to stabilize the pelvis and control any accessory movements. Landmarks used to measure hip and knee range of motion is greater trochanter, lateral condyle of femur and the lateral malleolus which were marked by a skin permanent marker. The fulcrum of the goniometer was centred over the lateral condyle of the femur with the proximal arm secured along the femur using greater trochanter as a reference. The distal arm was aligned with the lower leg using the lateral malleolus as a reference. The hip and knee of the extremity being tested was placed into 90 degree flexion with the anterior aspect thigh in contact with the horizontal bar of the PVC frame at all times to maintain hip in 90 degrees of flexion. Then subject was asked to extend the right lower extremity as far as possible until a mild stretch sensation was felt. A full circle goniometer was used to measure the angle of knee flexion. Three repetitions were performed and an average of the three will be taken as the final reading for knee flexion range of motion (hamstring tightness). Then the patients were randomly assigned into two groups of 30 each, using a simple random distribution into 2 intervention groups: group A- PNF- Hold- Relax stretching group (30 subjects) and group B- Neurodynamic sliding group (30 subjects).

In group A the subjects were in supine position with their non-dominant lower extremity strapped down the table. Pre-determined time intervals for stretching, contracting and relaxing were used to standardize the method utilizing a stop watch. For each stretch, the therapist stretched the hamstring muscle by passively flexing the hip with knee fully extended, allowing no hip rotation. The dominant leg was rested on the therapist right shoulder. The hamstring muscle was stretched until the subject first reports a mild stretch sensation; this position was held for 7 sec. Next, the subject then isometrically contracted the hamstring muscle for 3 sec by attempting to push his leg down towards the table against the resistance of the therapist. Following this, the subject was asked to relax for 5 sec. The therapist then passively stretched the muscle until a mild stretch sensation is reported. This stretch was held for 7sec. This sequence was repeated 5 times with each sequence separated from each by a 20 second interval. The treatment was given for 3 times per week for period of 4 weeks. And in group B

Subjects received sciatic Neurodynamic sliders performed in supine. All the 30 subjects were in supine position with their cervical and thoracic spine was maintained in flexion. Sliders involve the application of movement/ stress to the nervous system proximally while releasing movement/ stress distally and then reversing the sequence. Concurrent hip and knee flexion were alternated dynamically with concurrent hip and knee extension. The therapist alternated the combination of movement depending on the tissue resistance level. This combination of movements was performed for 30 seconds, 6 times on their dominant leg for a total stretching time of 180 seconds. The treatment was given for 3 times per week for period of 4 weeks.

Data analysis was performed using SPSS software (version17). Alpha value was set at 0.05. Descriptive measures such as range mean and standard deviation was used to assess the hamstring flexibility in both the groups before and after the experiment. Unpaired t-test was used to find out significant difference among demographic variable such as age, duration and baseline variable such as ROM. Mann-whitney U test was used to find the significant difference among base line variable such as VAS. Chi-square test was performed to find out the gender difference among both groups. Paired t-test was used to find out significant difference within group for ROM/ Active knee extension test. Unpaired t-test was used to find out significant difference between groups for ROM (AKE). Wilcoxon’s signed rank sum test was used to find out significant difference within group for VAS (pain). Mann-whitney U test was used to find out significant difference between groups for VAS (pain).

3. Results & Discussion

3.1 Results

Base line characteristics of 60 subjects for both groups are shown in Table 1.

Table 1: Baseline data for demographic variables

Variable	Group A	Group B	p- value
Age	24.00±1.72	23.16±2.13	0.101
Gender- M/F	22/8	21/9	0.774
Dominance- L/R	3/27	3/27	1.00

The Chi-square test was used for distribution of college students according to gender and dominance in both groups**.** There was no significant difference in the proportion of subjects with hamstring tightness in both the groups i.e. $p>0.05$. The difference in mean age of group A and group B was not significant difference. Thus the demographic variables were homogeneous in both the groups.

Table 2: Pre and post data within group

Groups	Pre		Post		p- value
	AKE	VAS	AKE	VAS	
Group A	146.57±1.56	6.13±0.77	148.63±1.67	5.13±0.81	0.00
Group B	144.63±2.14	5.03±0.85	146.07±2.03	4.53±0.62	0.00

The paired t- test and Wilcoxon test was carried out and also, the pre and posttest were compared for active knee extension ROM and VAS for pain and it showed significant improvement with p value < 0.05

Table 3: Pre and post data between groups

Variables	Group A	Group B	p-value
AKE	148.63±1.67	146.07±2.03	0.001
VAS	5.13±0.81	4.53±0.62	0.004

The mean difference in AKE score in group A was 148.63 with SD of 1.67 and mean difference in AKE score in group B was 146.07 with SD of 2.03 which was statistically significant (p=0.001).

For the group A the mean reduction in VAS score was 5.13 with SD of 0.81 and in group B mean reduction in VAS score was 4.53 with SD of 0.62 which was statistically significant (p=0.004).

3.2 Discussion

The study was aimed to compare the effects of PNF (hold-relax) stretching and Neurodynamic sliding on hamstring flexibility in collegiate students. The baseline demographic variables were homogeneous in nature in both the groups. In group A there were 22 male subjects and 8 female subjects. Similarly, in group B there were 21 male subjects and 9 female subjects. The mean age in group A, was 24.00 with SD of 1.72 and in group B the mean age was 23.16 with SD of 2.13.

In group A, the mean AKE have improved significantly. Possible explanation for the improved hamstring flexibility for the subject in group A could be because of viscoelastic nature of the muscle, and also Knott. M. and Voss. D. (1968) proposed that the golgi tendon organ is a nerve receptor found in tendons. This receptors fires when tension increases in the tendon, this tension can be due to stretch or contracting muscle when the golgi tendon organ fires a signal is sent to the spinal cord causing the agonist muscle to relax [19]. During PNF stretching (hold-relax) autogenic inhibition of the target muscle takes place. For example Moore and colleagues (1991) approved the theoretical basis of PNF stretching and proposed that the relax portion of hold-relax maneuver should be applied quickly after the hold position. Therefore the results of this study can be correlated with the popular belief that PNF stretching techniques lead to relaxation/inhibition of the stretched muscle via the two physiological mechanisms proposed by Sherrington (1940) namely reciprocal inhibition and autogenic inhibition [20].

In group A, the mean VAS score have showed significant improvement. This is in accordance to the study by Cristina Breitschwerdt and colleagues found that stretching of the hamstring muscles, either unilateral or bilateral, exerts an immediate hypoalgesic effect, i.e., an increase in pressure pain threshold levels. The mechanism behind this is that muscle stretching also activates descending inhibitory pathways [21].

In group B the mean AKE have improved significantly. This is in accordance to “Sensory theory” proposed by Weppler and Magnusson suggested that muscle flexibility and its response to sudden stretch have more to do with perceptions of stretch and pain than the biomechanical effects of muscle tissue itself [22]. This proposal was supported in a study by Aparicio and colleagues which demonstrated that a suboccipital muscle inhibition technique altered hamstring flexibility when compared to a placebo intervention. The fact that such a distant technique (suboccipital region) could have an immediate effect on the flexibility in the hamstrings may tend support to the “Sensory theory” limiting flexibility of the posterior thigh structures. It seems reasonable to attribute the observed increase in hamstring tissue flexibility following the suboccipital muscle inhibition technique to changes in the subject’s perception of stretch or pain [23].

The mean VAS score showed the significant improvement in group B which could be explained due to involvement of central and peripheral modulatory mechanisms, such as activation of muscle and joint mechanoreceptors that involve centrally mediated pathways, like the periaqueductal grey in the midbrain, or non-opioid serotonergic and noradrenergic descending inhibitory pathways [24].

When compared to both the groups, group A showed significant improvement in increasing flexibility then group B. In group A the post mean AKE score was 148.63 with SD of 1.67 and in group B the post mean AKE score was 146.07 with SD of 2.03 which was statistically significant. Increased hamstring flexibility in group A may be due to several factors. The most prominent are the viscoelastic, thixotropic, and neural

Properties of the musculotendinous unit. Musculotendinous units function in a viscoelastic manner, and, therefore, have the properties of creep and stress relaxation. Creep is characterized by the lengthening of muscle tissue due to an applied fixed load [25]. Stress relaxation is characterized by the decrease in force over time necessary to hold a tissue at a particular length. The musculotendinous unit deforms or lengthens as it is being stretched and goes through elastic and then plastic deformation before completely rupturing [26].

Studies of similar PNF stretching techniques suggested that autogenic inhibition of the stretched muscle provides increased ROM [27]. Autogenic inhibition was defined by

Knott and Voss as the inhibition of the homonymous muscle alpha motor neurons by the stimulation of the Golgi tendon organ. This inhibitory effect is thought to diminish muscle activity and, therefore, allow for relaxation so that the muscle can be stretched. Motor pool excitability has been measured by the Hoffman reflex during soleus muscle static stretching, contract-relax stretching, and contract-relax–agonist-contract stretching techniques. Motor pool excitability significantly diminished after the contract-relax and contract-relax–antagonist-contract methods of PNF stretching over static stretching of the soleus. This inhibitory effect has been suggested to increase muscle compliance, allowing for increased length during a stretch without stimulation of the stretch reflex [28].

However when comparing the mean VAS scores, group B was more effective in reducing the VAS score then group A. In group A the post mean VAS score was 5.13 with SD of 0.81 and in group B the post mean VAS score was 4.53 with SD of 0.62 which was statistically significant. This could be due to the fact that, coppieters and colleagues (2008) proposed that sliders are a less aggressive technique. Due to the reduction in nerve tension they limit the possibility of causing nerve irritation and inflammation. Furthermore the use of large amplitude movements, with minimal nerve aggravation, may help alter the ‘representation’ of pain and reduce the expectation of pain [29].

Hence the study concludes that group A (PNF hold-relax stretching) is more effective in increasing the flexibility of hamstring in collegiate students and group B is more effective in reducing the VAS.

4. Conclusion

Study concludes that PNF stretching is more effective than Neurodynamic sliding in increasing hamstring flexibility in collegiate students. Both the techniques are almost equal in their clinical effectiveness for improving hamstring flexibility and that either of the techniques may be used in clinical practice for improving hamstring flexibility.

5. References

1. Cross KM, Worrell TW. Effects of a Static Stretching Program on the Incidence of Lower Extremity Musculotendinous Strains: Journal of Athletic Training. 1999; 34(1):11-14.
2. Brotzman SB, Wilk KE. Clinical orthopaedic rehabilitation. 2nd ed. Mosby. 1996; 475-479.
3. Upton PA. Thermal pants may reduce the risk of hamstring injuries in rughby playes: Br Jr Sports Med. 1998; 30:57-60.
4. McLennan JG, McLennan JE. Injury patterns in Scotish heavy athletics: The American Journal of Sports Medicine. 1990; 18:529-32.

5. Gabbett TJ. Incidence of injury in semi-professional rugby league players: British Journal of Sports Medicine. 2003; 37(1):36-43.
6. Scott D, Ashby PE. The effects of 3 stretching techniques on hamstring flexibility using consistent stretching parameters: Journal of Strength and conditioning research. 2005; 19(1):27-32.
7. DePino GM, Webright WG. Duration of Maintained Hamstring Flexibility after Cessation of an Acute Static Stretching Protocol: Journal of Athletic Training. 2000; 35(1):56-59.
8. Williford HN, East JB, Smith FH, Burry LA. Evaluation of warmup for improvement in flexibility: Am J Sports Med. 1986; 14:316-9.
9. Cross KM, Worrell TW. Effects of a Static Stretching Program on the Incidence of Lower Extremity Musculotendinous Strains: Journal of Athletic Training. 1999; 34(1):11-14.
10. Yolanda Castellote-Caballero, Maríe Valenza C, Emilio Puentedura J, Cesar Fernandez-de-las-Peñas, Francisco Alburquerque-Sendin. Immediate Effects of Neurodynamic Sliding versus Muscle Stretching on Hamstring Flexibility in Subjects with Short Hamstring Syndrome: Journal of Sports Medicine. 2014; 4:1-8.
11. Villafane JH, Silva GB, Fernandez-Carnero J. Neurodynamic mobilization of the median nerve improves pressure pain threshold and pinch and grip strength in patients with secondary thumb carpometacarpal osteoarthritis: Journal of manipulative and physiological therapeutics. 2011; 34(7):449-56.
12. Oskay D, Meriç A, Kirdi N, Firat T, Ayhan C, Leblebicioğlu G. Effect of nerve mobilization techniques in the standard conservative management of cubital tunnel syndrome: Journal of manipulative and physiological therapeutics. 2010; 33(2):156-63.
13. Tanigawa MC. Comparison of the hold-relax procedure and passive mobilization on increasing muscle length. Physical Therapy, 1972; 52(7):725-735.
14. O'tlora, Cartwright A, Wade CD, Hough AD, Shum GL. Static stretching and PNF stretch on hamstrings length: journal of strength and conditioning research. 2011; 25(6):1586-91.
15. Surburg PR, Schrader JW. Proprioceptive Neuromuscular Facilitation Techniques in Sports Medicine: A Reassessment: Jr of Athletic Training. 1997; 32(1):34-39.
16. Nagarwal AK, Zutshi K, Ram CS, Zafar R. Improvement of Hamstring Flexibility: A Comparison between Two PNF Stretching Techniques: International Journal of Sports Science and Engineering. 2010; 4(1):25-33.
17. Halbertsma JP, Mulder I. Repeated passive stretching: Acute effects on passive muscle moment and extensibility of short hamstrings: Arch Phys Med Rehabil. 1999; 80:407-414.
18. Scott Spernoga G, Timothy L. Duration of maintained hamstring flexibility after one-time modified hold relax stretching protocol: Journal of Athletic Training. 2001; 36(1):44-48.
19. Knott M, Voss D. Stretching exercises. [Online] Available from:URL:http://www.stretching-exercises-guide.com/pnf-stretching.html
20. Marjorie Moore A, Carl Kukulka G. Depression of Hoffmann reflexes following voluntary contraction and implications for proprioceptive neuromuscular facilitation therapy: Physical Therapy. 1991; 321(9).
21. Bretischwerdt C, Rivas-Cano L, Palomeque-del-Cerro L, Fernández-de-las-Peñas C, Alburquerque-Sendín F. Immediate effects of hamstring muscle stretching on pressure pain sensitivity and active mouth opening in healthy subjects: Journal of Manipulative Physical Therapy. 2010; 33(1):42-7.
22. Weppler CH, Magnusson SP. Increasing muscle extensibility: a matter of increasing length or modifying sensation? Physical Therapy. 2010; 90(3):438-449.
23. Aparicio EQ, Quirante LB, Blanco CR, Send FA. Immediate effects of the suboccipital muscle inhibition technique in subjects with short hamstring syndrome: Journal of Manipulative and Physiological Therapeutics. 2009; 32(4):262-269.
24. Pain pathways. [Online] Available from: URL: http://neuroscience.uth.tmc.edu/s2/chapter08.html
25. Taylor DC, Dalton JD, Jr, Seaber AV, Garrett WE Jr. Viscoelastic properties of muscle-tendon units: the biochemical effects of stretching: Am J Sports Med. 1990; 18:300-309.
26. Nikolaou PK, Macdonald BL, Glisson RR, Seaber AV, Garrett WE. Jr. Biomechanical and histological evaluation of muscle after controlled strain injury: Am J Sports Med. 1987; 15:9-14.
27. Knott M, Voss DE. Proprioceptive Neuromuscular Facilitation: Patterns and Techniques. 2nd ed. Philadelphia. 1968.
28. Etnyre BR, Abraham LD. H-reflex changes during static stretching and two variations of proprioceptive neuromuscular facilitation techniques: Electroencephalogr Clin Neurophysiol. 1986; 63:174-179.
29. Coppieters, colleagues. Tensioners and sliders. [Online] Available from: URL: www.trackactive.co.