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Short Term Effect of Knee-to-Chest Position Plus 90-90 Passive-Hamstring-Stretching Versus 90-90 Passive-Hamstring-Stretching in5-15 Years of Spastic Cerebral Palsy: Non-Randomized Controlled Study

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***Abstract*-Background:** In children with cerebral palsy(spastic diplegia/ quadriplegia), commonly has lower limb hamstring muscle tightness. Hamstrings tightness seen to various degree of tightness in these children. Hamstring tightness is determined by knee extension deficit(KED). The present study evaluated whether both proximal and distal ends of hamstrings stretching will prove better/more effective than alone stretching distal end of hamstring in full range. Hence, knee to chest position component addition to 90-90 hamstring stretch passively may enhances the hamstring flexibility.

Methods: Total 19 cerebral palsy children of 5-15 years of both gender with bilateral hamstring tightness(more than 20 degrees) were included. on every participant, application of 90-90 hamstrings passive stretch was applied (60 seconds) to the left leg, whereas knee towards chest position (30 seconds) plus passive 90-90 hamstring-stretching(30 seconds) was performed to the right lower limb. KED angle and angle of spasticity was recorded by using knee extension test(actively) and modified Tardieu scale(MTS) respectively before and after completion of stretching procedure on either side using universal goniometer.

Results: Statistically paired t-test was used. The mean hamstring angle of tightness before stretching was 38.95degrees on both sides, with KED to 18.42degrees on right side and on left side (control side) reduced to 11.06degrees. The mean change in spasticity angle on MTS on right side was 30degrees whereas on left side mean was 23.68degrees, suggestive of right side was more significant than left side.

Conclusion: The 90-90 passive-hamstring-stretching technique plus knee towards chest position found more effective in hamstring flexibility than passive 90-90 hamstring stretching alone in spastic cerebral palsy children.

Keywords—Cerebral palsy, Hamstring stretching, Knee extension deficit, Active knee extension test, spasticity, Modified Ashwarth's scale.

I. INTRODUCTION

Cerebral palsy describes an "umbrella term [1] covering a group of persisting[2] permanent disorders of posture and movement development[1,3,4] leads to activities limitation[2] that lead to static[5] or non-progressive disturbances,[1,4-6] but often changing, secondary to lesions that present in developing fetal or infant brain[3,4] usually at less than two years of age"[3,6]. As per World Health Organization (WHO) estimation, in India, it is 3.8% of the population[7,8] i.e. the incidence is 3 out of 1000 live births which is 15-20%, out of differently able children who suffer with condition of Cerebral Palsy (CP).[7] The worldwide incidence of CP being 2 to 2.5 per 1000 live births.[1,4] Although in CP, brain lesion is static, there are secondary musculoskeletal impairments such as muscle/tendon contractures, bony torsion, hip displacement, spinal deformity, knee contracture, torsion misalignment of the femur and tibia.[4] It often contribute to activity limitations[3] including effortful gait patterns, difficulty assuming and sustaining seated positioning, and difficulty performing self-care activities such as toileting, bathing, dressing, and self-feeding.[4] Factors that contribute to secondary impairment includes physical growth, muscle spasticity[3,9], dyskinesia, ataxia, hypotonia[9], weakness, and the cumulative effect of bio-mechanical forces through joints.[1] The most common muscle tonus problem which lead to loss of functions and reduction in muscle function capacity is, spasticity.[9]

The child with CP, typically with spastic diplegia or quadriplegia, commonly has tightness in the hip flexors (psoas), hamstrings[4,10,11],calf muscles[10], adductors, and internal rotators with resultant limitation in hip extension, abduction, and external rotation[4], leading to knee flexion/ crouch posture.[10] This standing posture has generally present in spastic CP children who have hamstrings and plantar flexor tightness.[11] Children with spastic diaplegic CP use excessive mechanical work of muscles and joints than typically developing children during standing, sit to stand, walking etc, with plausible reason of their poor sitting posture during the movement of

sit to stand caused by hamstring tightness and consequence of compensatory movement.[11] The progressive nature of hamstring contractures in CP children with moderate to severe deformity, during growth period, can lead to disabling low-back and knee pain with loss of walking ability.[12] Consistent monitoring of hamstring flexibility, weight, strength, and passive knee extension during this period of growth is necessary to prevent rapid worsening of crouch and subsequent impairments and functional limitations.[4]

Flexibility is major component for injury prevention, rehabilitation and it is a key measurement for fitness testing and training.[13] Stretching technique is an important component to reduce soft tissue injury and for keeping physical fitness.[13] Stretching exercises can be classified into static and dynamic stretching, ballistic stretching, neuro-muscular facilitation stretching technique and pre-contraction stretches.[14,15] In static stretching, a position of muscle stretch is held for some specific duration with point of stretch tension sensation and repeated.[14] This can be active or passive[14], but passive static stretches are used commonly in rehabilitation by physical therapists in treatment of spastic cerebral palsy condition.[16] Passive static stretching is currently used technique in the physical therapy management for spasticity[17] because of its unique lengthening effect on soft tissues (muscles), it's an important technique despite other available lengthening alternatives.[18] The modified Ashworth (MA) as well as modified Tardieu (MT) are the reliable tools to evaluate spasticity objectively in case of spastic cerebral palsy.[4] Stretching the fascicles and tendon have important lengthening effect in spastic CP.[16] Stretching also lead to a short-term decrease in spasticity, but changes are minor and not sustained.[3]

It was considered that the muscles, whose influence is exerted across two joints should be examined and elongated over both joints when measurements are taken for tightness[4] because muscles that cross two joints were particularly prone to development of more spasticity and contractures in spastic cerebral palsy.[19] Previous study explained that isolated knee flexion caused all three hamstring muscle tendon units (MTU's) to shorten but, because lever arms are larger at the hip than knee, isolated hip flexion (knee to chest position) caused all three MTU's to lengthen to a greater degree.[20] Hamstring tightness was evaluated by evaluating extension deficit (ED)angle of knee measured by half circle universal goniometer in healthy subjects of age 18-25 years.[20] It was found that hamstring stretching is more effective if both the ends of hamstring muscle are stretched at both the joints (hip and knee) i.e. knee to chest position causes the proximal part to get stretched and passive 90-90 hamstring stretch causes the distal end to get stretched and it was also concluded that 60 second was effective for static stretching.[20] Proximal hamstring tightness can be measured by knee to chest position.[21] Kay AD and colleagues found that acute increase in range of motion after single passive static muscle stretch session with reductions in muscle-tendineous unit which lead to stiffness, reduced neuromuscular reflex response, and increased stretch tolerance[22], which could build the hypothesis that, this method will help to reduce spasticity of muscles too.

In spastic CP, when hamstring tightness is excessive, the child show difficulty in ADL's, and the stride length may be limited during ambulation.[3,4] According to Deshmukh AA and colleagues, in hamstring flexibility the addition of knee bent towards chest position stretches the proximal part of hamstrings and showed significant increase in hamstrings flexibility in the subjects of age 18 to 25 years.[20] In clinical settings common method of hamstring stretch in spastic children with CP is 90-90 passive hamstring stretch[17] but there is scarcity of published literature available on comparison of knee to chest position plus passive 90-90 hamstring stretch i.e. stretching both ends of hamstring muscle versus 90-90 passive hamstring stretching in 5 -15 years spastic cerebral palsy.

II. RELATED WORK

In 2015 Nicola Theis, Thomas Korff, Amir A. Mohagheghi evaluated effect of long term passive stretch on muscle tendon unit mechanics in spastic cerebral palsy children. Total 13 children were included in this study of age group 8 to 14 years in which 7 children were diplegic and 6 were quadriplegic. There were two groups one was experimental and the other was a control group. The participants were distributed randomly into experimental group (n=7; diplegic CP=4, quadriplegic CP= 3) and in control group (n=6; diplegic CP=3, quadriplegic CP= 3).participants were of GMFCS(level 3 and 4). Treatment group consisted of 7 children and control group consist of 6 children. The treatment group followed additional 6 weeks of passive ankle dorsiflexion for 15 minutes to each leg for 60 sec repetition followed by 30 sec rest and control group continued normal routine. Both the groups were attending normal routines which consisted of dynamic activities and standing frame. The data analysis was done by mixed design ANOVAs. There was 3% improvement in ankle dorsiflexion along with 13% reduction in muscle stiffness of triceps surae. The study concluded that stretching can reduce muscle stiffness.[16]

In 2008, Thamar J Bovend'Eerdt published a systematic review on effect of stretching in spasticity. There were 10 Randomized control trials out of 11 clinical trials were included. The studies included adults with spasticity receiving different stretching methods and those using stretching modalities with splinting casting and orthotic applications were excluded because of sustained stretch effect .Stretching protocols were of inadequate description and poorly standardized. The study concluded positive evidence supporting the immediate effects of single stretching session, but remains unclear about how long these effects are and its long-term consequences.[17]

III. METHODOLOGY

A non-randomized controlled (experimental) study was conducted in 19 children with spastic cerebral palsy between the age group of 5-15 years. Institutional ethics committee approval was obtained to carry out research work. The purpose of study was explained and written consent was obtained from parents and participants. The participants were evaluated for hamstring tightness at bilateral lower limb and tightness was determined by extension deficit (ED) angle at knee (Fig.1). The participants having bilateral hamstring tightness of 20degrees or more were included.[20] Any participants with diagnosis of hemiplegic, hypotonic, monoplegia, ataxic, athetoid and/or choroid cerebral palsy, who were having contractures i.e. grade 4 of modified Ashworth scale, who had received Botulinum toxin injection in hamstrings in last four months, and who have undergone recent hamstrings surgery prior six months were excluded from the study.

Procedure

The study was conducted monitoring the short term effect of hamstring flexibility using knee towards chest position plus passive 90-90 hamstring stretching versus passive 90-90 hamstring stretching in 5-15 years spastic cerebral palsy. The hamstring muscle spasticity was assessed by modified Tardieu (MT) scale bilaterally. The participant was in supine position the head of the participant was maintained in neutral to avoid eliciting asymmetric tonic neck reflex.[9] Bony landmarks were determined for standardization of goniometric measurements. Pre stretch hamstring flexibility was measured by using universal goniometer (Fig.1), at the same time in same position angle of spasticity was recorded by using Modified Tardieu (MT) scale with Universal goniometer. On every individual participant, application of passive 90-90 hamstring stretch was applied for 60 seconds to the left leg, stabilizing right thigh using stabilization belt (Fig.2), whereas knee towards chest position (for 30 seconds) plus passive 90-90 hamstring stretch (for 30 seconds) was applied to right leg by stabilizing left leg, of the same participant (Fig.3: 3a,3b,and 3c) and there was no rest between procedures during right leg stretch.[20] For standardization of stretching speed passive movements were made in one second as recommended by Bohannon and Smith.[23] A stop watch was used to note the time of stretch. A two minutes rest was given between stretching on each side.

A 6-point rating, MT scale was used to assess spasticity.[9] The X and Y are two parameter along with two angles (R1 and R2) were determined in MT scale. The angle of muscle reaction (R1) is defined as the point in the joint range in which a velocity-dependent 'catch' or clonus was felt during a quick stretch of the muscle and measured the point of resistance to a rapid velocity stretch. The R1 angle was measured by moving the limb with the velocity V2 or V3.This gives an indication of muscle length at rest. The R2 angle was measured by moving the limb with the velocity V1.[9] Stabilization was done by using stabilizing belt. After 1 minute post intervention, hamstring flexibility and spasticity angle were measured and recorded. Data was collected and then analyzed statistically.

DATA ANALYSIS

The study participants' identity was kept confidential. The data entered into data sheet and was further utilized for analysis. Software EPI info version 07 was used for data analysis. The mean, standard deviation and percentage of age, hamstrings tightness angles and grade of spasticity of hamstrings was by MT scale was calculated on either side. The paired *t*-test was used to evaluate the effect of two different hamstring stretching techniques on either side.

IV. RESULTS AND DISCUSSION

RESULTS

Total 19 spastic diplegic cerebral palsy children of both genders were enrolled for study between the age of 5-15 years, divided into three sub-groups as 5-7 yrs, 8-12 yrs and 13-15 yrs. (Table 1)The percentage of boys (73.68%), girls (26.32%) as well as percentage of preterm children i.e. 73.68% (14 out of 19) i.e. distribution of preterm children (number and percentage) among participants was observed. Table 2 showed the mean and standard deviation of demographic data of children following age groups i.e. (5-15 years). It can be stated that as the age advances from 5 to 15 years, height and weight of children increases linearly which is indication of normal growth. In study, GMFCS level of cerebral palsy children in which Level I and level II shows the independent walker i.e. 47.36% (i.e. 9 out of 19) of total children and level III, IV, V showed the dependent children i.e. 52.63% (i.e. 10 /19).(Table 3)

The mean angle of pre hamstring stretching tightness was 38.95 degrees whereas post stretching tightness angle was 20.53 degrees (KED angle 18.42 degrees).(Fig.4) There was statistical difference present between pre and post hamstring stretching tightness angle ($p<0.01$). This indicated that knee bent towards chest plus passive 90-90 hamstring stretch technique is effective in gaining muscle length compared to pre stretch values in experimental side. (Fig.5) The mean value of pre hamstring stretching tightness angle was 38.95 degrees whereas post stretching tightness angle was reduced to 27.89 (KED angle 11.06 degrees) which was statistically significant ($p<0.01$). This indicated that passive 90-90 hamstring stretch technique alone is also effective in gaining muscle length compared to pre-stretch values in control side.(Fig.6)

From figure 7, in right side (experimental side) the mean hamstring angle of tightness before stretching was 38.95 degrees which reduced to 20.53 degrees (KED angle 18.42 degrees) and on left side (control side) the mean hamstring angle of tightness before stretching was 38.95 degrees which reduced to 27.89 degrees (KED angle 11.06 degrees). It was found that, at both sides the mean tightness angle decreased and was significant. This indicates that traditional stretching (90-90 stretching alone)

is also effective along with knee to chest plus passive 90-90 hamstring stretch but when compared to values of increased angle of hamstring tightness, the knee to chest plus passive 90-90 hamstring stretch is more effective compared to traditional 90-90 stretching technique alone ($p < 0.032$).

Descriptive statistics of experimental and control side among spastic diplegic cerebral palsy children (Table 4), indicated that both the techniques were significantly effective among both control and experimental side of limb as p value is less than 0.01. When compared between two techniques on either side, at same duration of 60 seconds, after a single session the experimental side has better results on muscle length i.e. mean difference in degrees of right side pre versus post hamstring tightness angle (38.95 minus 20.53) was 18.42 degrees (i.e. 47.24% improvement in angle of tightness) whereas on left side the mean difference of pre versus post hamstring tightness angle (38.95 minus 27.89) was 11.06 degrees (i.e. 28.39% improvement in angle of tightness). So it can be concluded that knee bent towards chest plus passive 90-90 hamstring stretch is more effective technique and proved to be better and faster way to achieve hamstring flexibility compared to traditional technique of hamstring stretching.

From figure 7 the difference in hamstring tightness angle according to Modified Tardieu scale [R2(b) minus R1(a)] in degrees among both experimental (right side) and control group (Left side) was noted. More the difference in angle between R2(b) minus R1(a), indicative of reduction in spasticity or angle of catch in MT scale. After stretching intervention, there was a significant reduction in spasticity on both right side and left side with p value 0.002. The mean change in angle on right side was 30 degrees whereas on left side mean was 23.68 degrees suggestive of right was more significant than left side. This implies that, a single session of 60 sec stretch by adding a knee towards chest component to the traditional passive 90-90 hamstring stretch showed better results on spasticity along with the increase in length of hamstring muscle.

DISCUSSION

The present study evaluate short term effect of 60 sec hamstring stretch using knee towards chest position plus passive 90-90 hamstring stretch versus passive 90-90 hamstring stretch alone among 5-15 years spastic cerebral palsy children. The objective was to determine the effect of each hamstring stretching technique on spasticity of hamstrings evaluated by Modified Tardieu scale. The current study revealed that there is significant effect of knee towards chest plus passive 90-90 stretching on right side (experimental side) after intervention compared to 90-90 stretching alone on controlled side (left side). The right side limb was held with knee towards chest position which stretching proximal end of hamstring at hip with a hold of 30 sec and then the distal end of hamstring muscle was stretched by extending the knee keeping the hip flexed at 90 degrees and was held for 30 sec compared to left side where only distal end of hamstring get stretched by 90-90 stretching alone. The similar results were found by Deshmukh AA [20] and colleagues in participants of age 18-to-25 years, stating that if hamstring muscles are stretched at both the ends i.e. proximal and distally in full range then it is more effective. In previous study[20] it was found that isolated hip flexion contributes to lengthened all three muscle tendon units at hip. In knee towards chest position hip is flexed fully which causes the proximal muscle fibers of hamstring to get lengthened. In present study the control side also showed significant improvement after traditional stretching technique i.e. the limb was taken into hip and knee in 90 degrees and then knee was extended and the position was maintained for 60 sec. It implies that traditional passive hamstring stretching has also been proven to be effective in reducing hamstring tightness. Hence in current study, it proved that, if both ends are being stretched i.e. proximal as well as distal ends, help to achieve better length compared to stretching distal end of hamstring alone.[20] Studies performed by Chumanov ES (2011)[24] and Fosang (2003)[25]quoted that, during the late swing phase of gait, there is hip flexion and knee extension and these both movements leads to hamstring stretch so it can be stated that hamstring length is important for normal ambulation function.[24,25]

The present study also found the effectiveness of hamstring stretching on spasticity and the spasticity was recorded by using MT Scale. The mean of dynamic component of MTS in intervention group (right side) was 30 degrees and in control group (left side) was 23.68 degrees. (The dynamic component here means the total available range in which the change was observed i.e R2(b) – R1(a) where R2 means the passive ROM and R1 means the first catch during a fast passive ROM [Figure 4]) This implies that as the hamstring muscle length increases there is reduction in spasticity as well. In support to this finding of present study, Bovend'Eerdt TJ [17] and colleagues also found that there is significant effect of stretching on reduction in muscle spasticity. It was also found that in spastic muscles, there is decrease in amplitude of EMG, decrease in motor unit potentials, decrease stiffness, increase in maximal voluntary contraction along with increase in ROM.[18]

In 2019 study by Shaikh Z[26] found that eccentric muscle work training on spasticity of hamstring has better effect on MTS than active stretching in the age group of 4-18 years children with spastic cerebral palsy. Previous studies[25,27] stated that MTS is reliable tool to measure grade of spasticity in cerebral palsy of age group 2-10 years, in hamstring, gastrocnemius and hip adductors.[26] The patients of neurological condition after receiving eccentric stretching intervention showed significant increase in Hoffman's reflex (H reflex) in healthy subjects and the mean of amplitude of H reflex, there was no change hence concluded that after stretching with eccentric contraction there is decrease in motor unit activation leading to reduction in spasticity.[27]

Static stretching increase muscle flexibility because of elastic properties of muscle fibers.[20] It was believed that static stretching promote the golgi tendon which leads to self inhibition of muscle that is being stretched.[20] Due to the prolonged stretching period in static stretching allows the muscle spindle to adapt over time and cease firing and physiologically this adaptation and relaxation phenomenon lead to muscle fibre lengthening.[20] The current study found that without complete change in the traditional technique, but adding a knee towards chest component can give better result in the same duration of stretch in hamstring muscle. This proved that knee bent towards chest plus passive 90-90 hamstring stretch technique can be use effectively in clinical settings to get a faster recovery for lengthening of muscle as well as to reduce spasticity in cerebral palsy children.

A. Table (1,2 and 3)

Table 1: The Distribution of spastic cerebral palsy children according to age sub-group, gender, number of preterm children and percentage of children distributed in each sub group.

Age sub group ⇨ / Category ⇩	5-7 Years	8-12 Years	13-15 Years	Total (%)
n (%)	2 (10.52%)	10 (52.63%)	7 (36.84%)	19 (100%)
Boys	1	8	5	14 (73.68%)
Girls	1	2	2	5 (26.31%)
Preterm	2/ 2 (100%)	7 /10 (70%)	5/ 7 (71.4%)	14 /19 (73.68%)

n = total number of children

Table 2: Mean and standard deviation of height, weight and BMI in children with cerebral palsy of age 5-15years.

Categories / Age Group	Height (cm) Mean ± SD	Weight (kg) Mean ± SD	BMI(kg/m^2) Mean ± SD
5-7 Yrs	106.75±5.02	16.35 ± 2.61	14.3 ± 0.98
8-12 Yrs	123.02±11.78	33.5 ± 11.77	21.53 ± 3.60
13-15 Yrs	148.98± 9.76	47.28±11.88	21.44 ± 5.77

Table 3. Distribution and percentage of spastic diplegic cerebral palsy children of 5-15 years according to GMFCS level into age sub group.

Age sub-group / GMFCS Levels	5-7 Yrs	8- 12 Yrs	13-15 Yrs	Total (%)
Level - I	0	2	3	5 (26.31%)
Level - II	0	3	1	4 (21.05%)
Level - III	0	1	0	1 (5.26%)
Level - IV	1	4	3	8 (42.10%)
Level - V	1	0	0	1 (5.26%)
Total (n)	2	10	7	19 (100%)

GMFCS- Gross Motor Function Classification System

Table 4:Descriptive statistics of experimental and control group of spastic diplegic cerebral palsy

Paired Samples Statistics						
Hamstring tightness angle (degrees)		n	Mean ± SD	Std. Error Mean	T value	*p* Value
Right	Pre	19	38.95 ± 9.51	2.18	21.43	<0.01
	Post	19	20.53 ±10.39	2.38		
Left	Pre	19	38.95 ± 9.36	2.14	15.28	<0.01
	Post	19	27.89 ± 9.90	2.27		

B. Figures (1,2,3,4,5,6,and 7)

Fig 1: Extension Deficit (ED) Angle at knee joint Measured By Using Universal Goniometer

Fig 2: Passive 90-90 hamstrings stretching on left side for 60 seconds.

(3a)

(3b) **(3c)**

Fig 3: (3a) Measurement of hamstring tightness angle. (3b) Knee bent towards chest position for 30 sec. (3c) Passive 90-90 hamstring stretch for 30 sec.

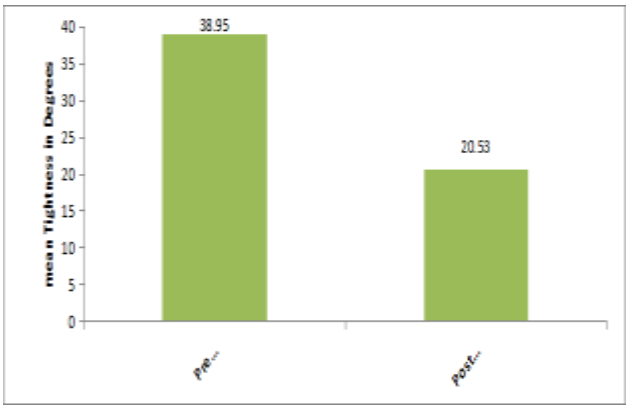

Fig 4: Comparison of pre and post hamstring tightness angles in degrees in right side (experimental side) i.e. knee towards chest plus passive 90-90 hamstring stretch.

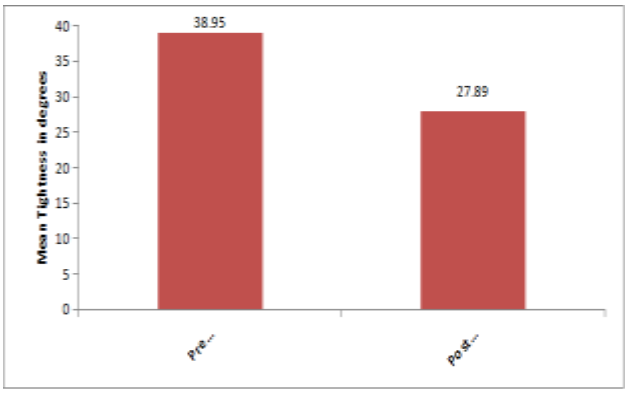

Fig5: Comparison of pre and post hamstring stretching tightness angles in left side (control side) i.e passive 90-90 stretching technique alone.

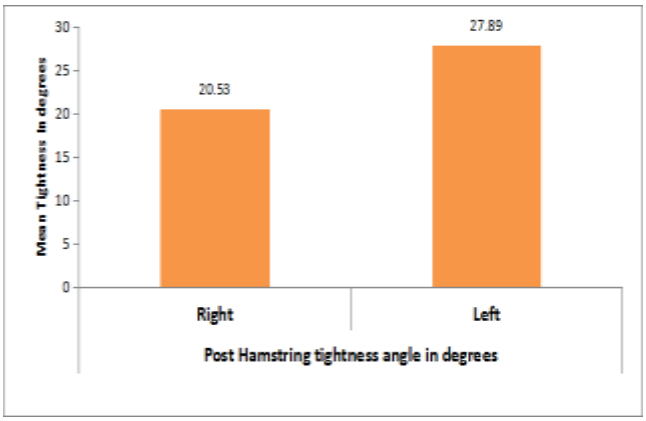

Fig 6: Comparisons between post hamstring stretching in right and left side (experimental and control side)

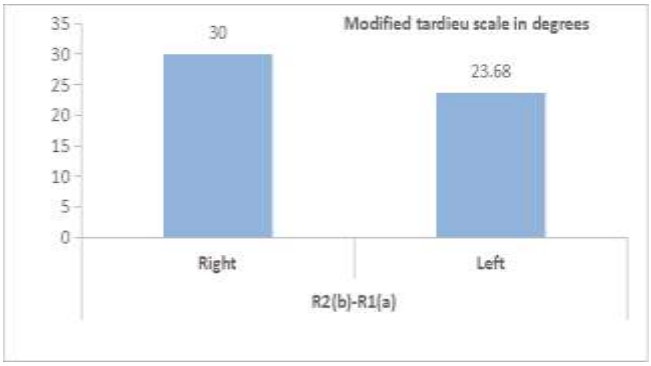

Fig 7: Difference in hamstring tightness angle according to MT scale [R2(b) minus R1(a)] in degrees among both experimental (right side) and control side (Left side)

C. Abbreviations and Acronyms

R2- Moving the limb slowly into a lengthened position or muscle length at rest i.e. passive range of motion

R1 -The point of resistance or "catch" to a rapid velocity stretch, the dynamic neural component of tone or the overactive stretch reflex

Modified Ashworth scale (MAS), Modified Tardieu scale (MTS), Muscle Tendon Units (MTU's), Knee Extension Deficit (KED).

D. Units

Angle-Degrees

V. Conclusion and Future Scope

The present, non randomized controlled study found that 60 seconds passive stretch of both proximal and distal ends of hamstring is significantly effective than stretching only distal end in neurological condition like spastic cerebral palsy in order to achieve better flexibility and also proved effective in reduction of hamstring muscle spasticity. The concept of stretching proximal as well as distal end of any other two joint muscles (like tendoachilis, rectus femoris, long head of biceps brachi etc) can also give better results than stretching at one end alone, which need to be evaluated in future studies.In future studies, the long term effect of knee to chest plus 90-90 passive hamstring stretching intervention can also be evaluated in condition like stroke and other neurological conditions with tightness and spasticity. It can be advised to determine the immediate effect of stretching intervention effectiveness in showing changes in immediate gait functions like crouching, step length, stride length and other components of gait among cerebral palsy children. So, it is advisable to use addition of knee to chest component to passive 90-90 hamstring stretching technique with 60 seconds stretch duration in neurological condition like spastic cerebral palsy of age 5 -15 years.

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