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Comparative Study of Three Different Techniques to Increase Active and Passive Hamstring Flexibility Using a Randomized Controlled Trial.

Tabassum Khan[1], Mayank Shukla[2]*, Gautam Gupta[3]
[1,2] Amity Institute of Physiotherapy, Amity University, Noida, 201313, Uttar Pradesh, India
[3]A+ Orthopedic and Sports Medicine Center, New Delhi, 110016, India
[2]*Corresponding Author: mshukla@amity.edu, mailmayankshukla@gmail.com

ABSTRACT

The present study was aimed at comparing the self-myo-fascial release technique (SMFR), cupping therapy (CTh), & static stretching (SS) on the hamstring flexibility (HF) using active knee extension test (AKE), for active flexibility; sit & reach test (SRT) and the passive straight leg raise (PSLR) test, for passive flexibility. N = 45 individuals were evaluated for hamstring flexibility. Interventions were given using foam roller (4mins for 3days), cupping therapy (7 minsfor3days) and passive stretching (3 times with 30 seconds hold for 5 days). One-way ANOVA in the follow-up analysis of three groups has shown variation for AKE (p value = 0.013*), for PSLR (p value = 0.019*). In parallel analysis using unpaired t test - post intervention analysis, SRT has shown better result for SMFR versus SS (p= 0.018), AKE has shown better result for SS versus CTh (p=0.043), and PSLR has shown better result for CTh versus SMFR (p=0.02); follow-up analysis , SRT has shown better result for SMFR versus SS (p=0.04), and SMFR versus CTh (p=0.012), AKE has shown better results for SMFR versus SS (p= 0.045), and SMFR versus CTh (p=0.0035), PSLR has shown better results for CTh versus SMFR (p= 0.004), and SS versus SMFR (p= 0.025)

Keywords:
Hamstring flexibility, Self -Myofascial release, Cupping therapy, Static stretching, Sit and reach test, Active knee extension test, Passive straight leg raise.

1.Introduction

Human movements are not possible without a certain amount of fitness component commonly called flexibility – meaning cellular and structural pliability. Loss of flexibility (tightness) is defined as lesser elongation capacity of tendons, fascia or skeletal muscle groups (Bandy et al 1997). To date hamstring muscle tightness is present in all most all the population of the world. The tight hamstring muscle (H-Tt) is means < 20 degree of full knee extension (Deguzman et al 2018). Many techniques are used for active and passive hamstring flexibility, but their relative superiority is unknown. The effect of Static stretching (SS), cupping therapy (CTh) and self MFR (SMFR) have been well demonstrated in the literature as seen in Table 1. However, no study compared SS, CTh and SMFR in for increasing active and passive hamstring flexibility post intervention and in one-week follow-up and hence this study was undertaken.

SS is performed passively & gradually within the pain tolerance range of the individual to decrease H-Tt, and is better than range of motion (ROM) exercises (Bandy 1998). Evidence supports that SS for duration of 30 sec , thrice in a session can decreases H-Tt (Medeiros et al 2015 & Bandy 1998).

Other alternative intervention that can be used is CTh – which is complementary to other therapies for facilitating movement. It stimulates fascial distortion active compression and rolling, thus easing the restriction caused by adhesions, and enhancing lubrication leading to decreased friction (Kim et al 2017 & Markowshi et al 2014). Evidence suggests 7 minute of cupping treatment should be given (Williams et al 2019).

MFR is a passive soft-tissue manipulation. Passive force (which is maintained for a minimum of 90 seconds and aimed at free fascial gliding (Le-Bauer et al 2008).

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On the contrary, Self MFR is actively applied using a foam roller and the individual himself perceives the loosening of restriction in his limb and flow to fluids. It is more convenient and less expensive as compared to MFR. The most commonly used tool for MFR is the foam rollers (MacDonald et al 2013), Mohr et al 2014, Beardsley & Škarabot 2015 & Peacock et al 2015). Cylindrical rollers of soft-foam are used for multipurpose tool, it can be used to improve inter-fascial "sliding and gliding" of active muscles alternate session for three days with a rest day in between (Jung et al 2017).

Aim and Objective: to compare Static stretching, Cupping therapy and Self Myofascial release, for hamstring group's active and passive range of motion (H-Tt), using AKE, PSLR and SRT.

Table 1– Studies for hamstring flexibility using Cupping therapy (CTh), Static stretching (SS), and myofascial release (MFR), showing varying outcomes. ROM=range of motion, SR=Systematic review, MA=meta-analysis, H-Tt = hamstring tightness, SMFR=Self-myo-fascial release, CTh= Cupping therapy, SS=Static stretching, SLR=straight leg raise.

Author & Year	Study Design	Conclusion
Shah 2012	Experimental comparative study	MFR there was significant improvements of passive SLR if end position is held for 30-60 seconds
Healey et al 2014	Randomized crossover design	No significant increase in the athletic performance but it is seen that there is significant decrease in the post exercise fatigue, soreness and exertion.
Couture et al 2015	Repeated measures	No effect of foam rolling.
Junker et al 2015	RCT (pretest/posttest)	The Foam roller based myo fascial release effectively decreased H-Tt.
Medeiros et al 2016	Systematic review (SR) and Meta-Analysis (MA)	Static stretching effective for hamstring flexibility
Beardsley & Škarabot 2015	Systematic review (SR) and Meta-Analysis (MA)	Foam roller SMFR increases flexibility.
Behara et al 2017	Randomized crossover design	There is significant increase in the flexibility of the hip joint but there is no significant change in the muscular strength or power
Jung et al 2017	Cross-sectional study.	Self MFR effective for both and active and passive hamstring flexibility
Deguzman et al 2018	3 group pre post design.	No clear superiority was seen, all interventions – PNF, SMFR and warm up were effective.
Monteiro et al 2018	A single-blinded, randomized, crossover, within-subject design	It is seen that there post treatment reading of combined effect is better than the individual treatment. It is seen that there is acute significant increase in range of motion and flexibility.
Williams et al 2019	Cohort Design	No significant change for Cupping therapy (t = -.961, p = .35)
Skinner et al 2020	SR & MA	Foam rolling increases ROM significantly.
Wilke et al	and multilevel meta-	Foam rolling an effective method for acute

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2020	analysis	improvements in joint ROM.

2. Materials and Methods

2.1. Sample size estimation: Using the G*power version - 3.1.9.6, at an $\alpha = 0.01$ and $1- \beta = .95$ using effect size of 1.5 (Junker et al 2015) for three group comparison of one - way ANOVA of three group comparison. A total of 15 was derived as a sample. 15x 3= 45 were considered for final analysis of the data out of total N= 60 participants.

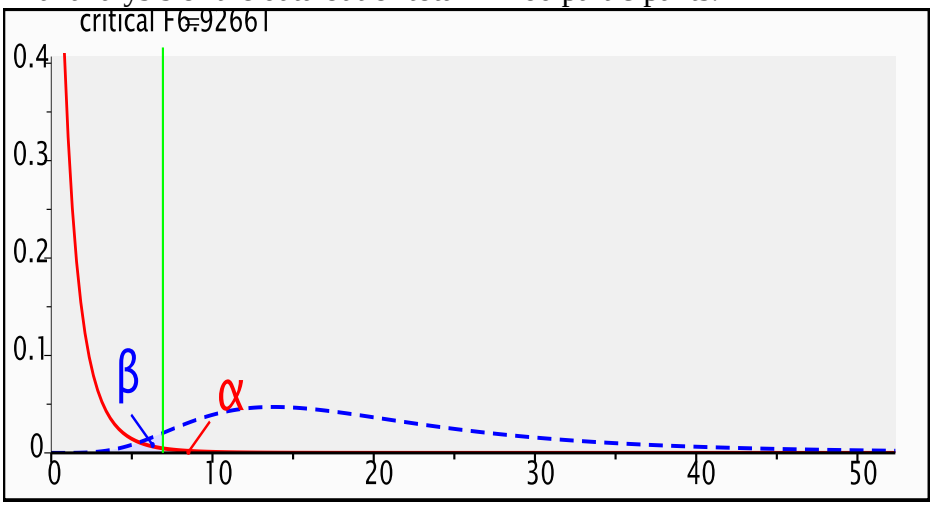

Fig 1– Power and sample size calculation. Critical F is seen as 6.92.

2.2. Participants:
Out of N=60 selected, and finally eligible N= 48 individuals were randomly allocated into 3 groups (15 in each). They were evaluated for hamstring flexibility. Study was conducted at A+ Orthopaedic and Sports Med Centre. Inclusion criteria Age between 18-30 with BMI between 18.5-24.9, hamstring are tight and passive SLR range between 30-70, < 20 degree of full knee extension in bow string test, participants with less than 12 inches in Sit and reach test and Stretch end feel during complete range of motion. Exclusion criteria past history of hamstring injury within 2 years, hypermobility, , known bone disease, non -union of fracture, lumbar and lower limb neurological compromise, limb length discrepancy, acute joint pain with exercise, straight leg, hip flexion range of motion was greater than 70 degree.

2.3. Trial Registration & Institutional ethical approval
The trial has been registered with UMIN Clinical Trials Registry（UMIN-CTR）with the number - UMIN000042960.
Ethical approval for this randomized study was granted by, NTCC committee of AIPT, AUUP, A+ orthopaedic and sports Med Centre. Written informed consent was obtained from all participants and any relevant questions answered on data collection, all concerned were aware of the right to withdraw from the study at any time.

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2.4. Research design: Randomized controlled trial

2.4.1. Allocation Participants grouping were given randomly by a computer generated sequence, with group assignment maintained in sealed, sequentially, numbered, opaque envelope.

2.4.2. Procedure: Grouping

The procedure of interventions was explained to all participants. Appropriate clothing were worn by participants to allow the elongation of the hamstring group. Participants agreeing to participate signed the consent which was prescribed by A+ orthopaedic and Sports Med Centre. A standardized physical examination was performed on all participants which included age (should be between 18-30), weight, height and BMI, Hamstring flexibility and range of motion was assessed by sit & reach (SRT) test, passive SLR, & active knee extension (AKE) test.

Group 1 - Static Stretching (SS)

Participants were in supine lying position with tested leg in active knee extension test position, therapist passively extend the knee until the participant feels the intolerable stretch as seen in Fig-7. This procedure was repeated for 5 days, 3 times per day with 30 sec hold and 10 seconds interval in between each stretch, after a week follow-up was taken. (Bandy et al 1997).

Group 2 - Self Myofascial Release (SMFR)

A foam roller was placed under the thigh and rolled actively by the participant while maintaining the long sitting position with bodyweight passing through the roller. The rolling was from knee to hip and it was to and fro as seen in Fig-3. This intervention was given daily for 3 days. Every intervention was of 2 minutes duration for each thigh. (Jung et al 2017).

Group 3 - Cupping Therapy (CTh)

It was performed by the Physical therapist specialized in cupping technique in individual sessions. The cupping technique involved the static cupping application for 7 minutes. JINKANG B242 Cupping set was used. The participant lie down in prone position, scanty coating was done with a lotion to the hamstring and cups were placed on the trigger points as seen in Fig-4(Williams et al 2019).

The assigned intervention was applied bilaterally to all participants and they were asked to continue their normal weekly exercise or activity routine. Follow up measurement was taken after 1 week of intervention. On last day of intervention, re-evaluation of subjects using AKE, PSLR and SRT was done.

2.4.3. Clinical outcome:

Measurements were taken pre, & post intervention and at follow up after one week. Hamstring flexibility and range of motion was re-assessed using the outcome measure (AKE, PSLR & SRT)

Position of the subject for PSLR test- the participant positioned in supine lying SLR was performed there was no pillow used anywhere, knee extension, hip medial rotation and adduction were executed slowly till available range. The participant's leg was lifted-up by the posterior ankle while keeping the knee in a fully extended position as seen in Fig -6. The limb was then passively flexed at hip until firm resistance was experienced (Magee 2008).

Position of the subject for Active knee extension test- Participant was in supine lying as in Fig-5. The hip was passively flexed until the thigh is vertical - used the goniometer to measure the position of the thigh. The opposite leg was placed in a fully extended position (Koli & Anap 2018).

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Position for Sit and reach test- Participant's position was long sitting as seen in Fig-2, soles were in supported and neutral position against the box, arms were taken in extension over the scale. The reading was then recorded (Kothawale & Rao 2018).

Data analysis: Data was compiled and exported to Microsoft excel, 2010, for analysis. The data collected was arranged for comparison of these three techniques and analyzed using descriptive and inferential statistics. Descriptive statistics was checked using mean and SD. The results were analysed inferentially using ANOVA, paired and unpaired t - test. The $p < 0.05$ was taken for checking the hypothesis i.e. t-differences in means.

A total of 45 subjects were taken. Each group consists of 15 subjects. The participants were randomized into 3 groups by envelope method. Statistical analysis was done on the post treatment reading of the active knee extension, passive leg raise and sit and reach test.

Fig.2. Sitandreachtest.

Fig.3. Self-myofascialreleaseusingfoamroller.

Fig.4. Cuppingtherapy

Fig.5.AKEtest

Fig.6.PSLRtest

Fig.7. StaticStretching

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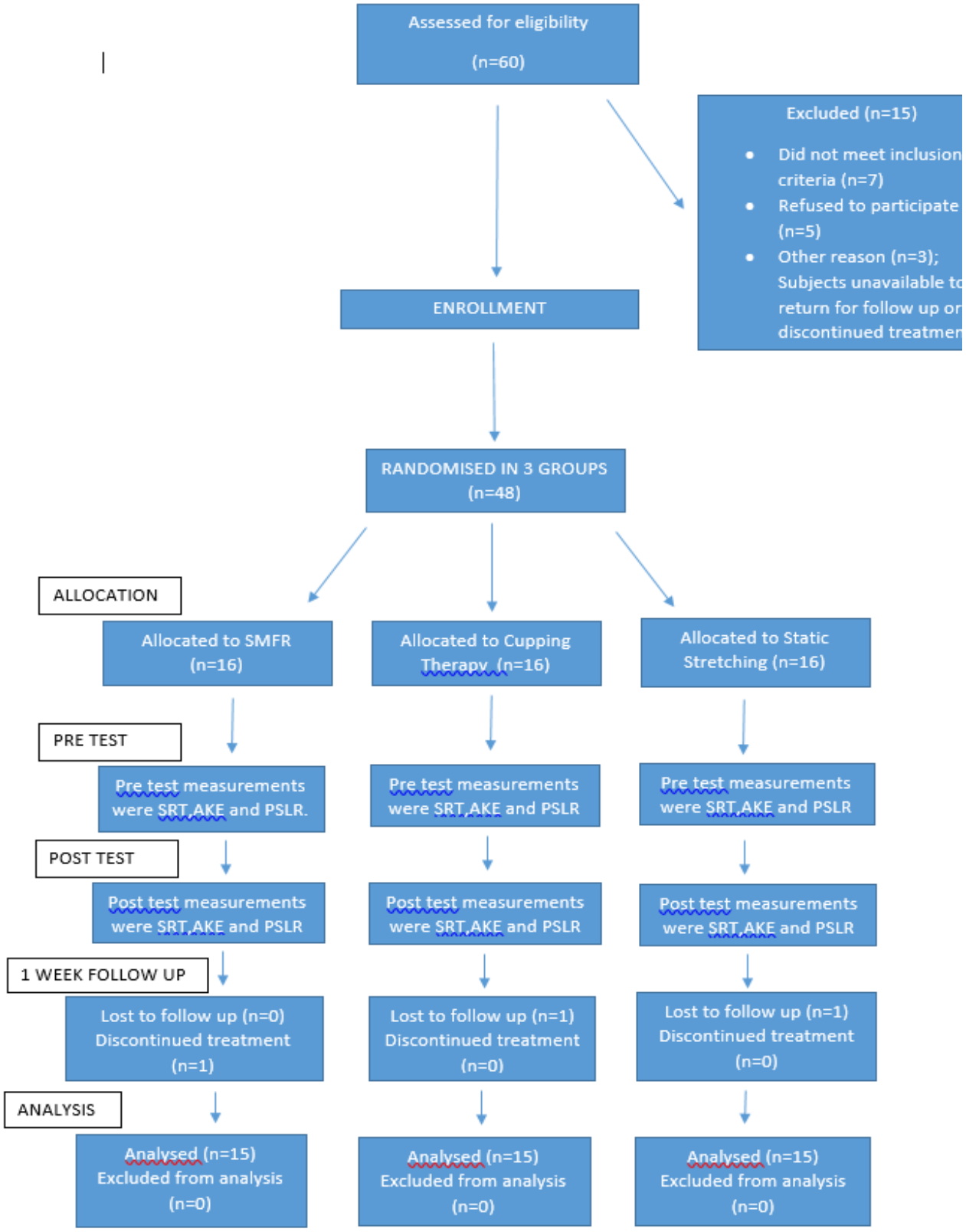

Fig 8- Flow diagram showing the progress of study with participants at each stage of randomized clinical trial.

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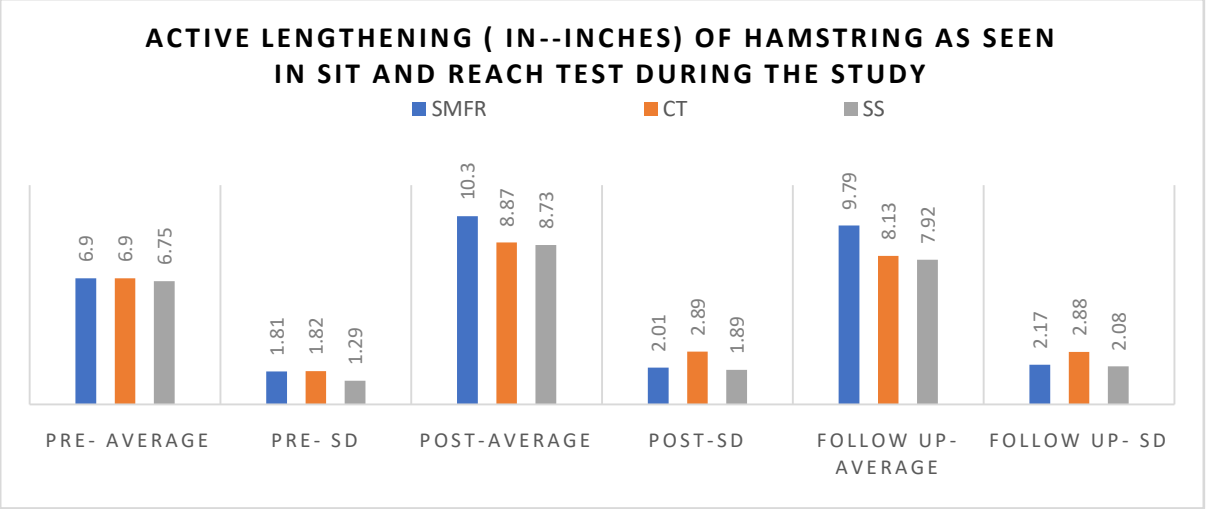

Figure 9 : Active lengthening of the three groups seen with SRT. SMFR has shown better result.

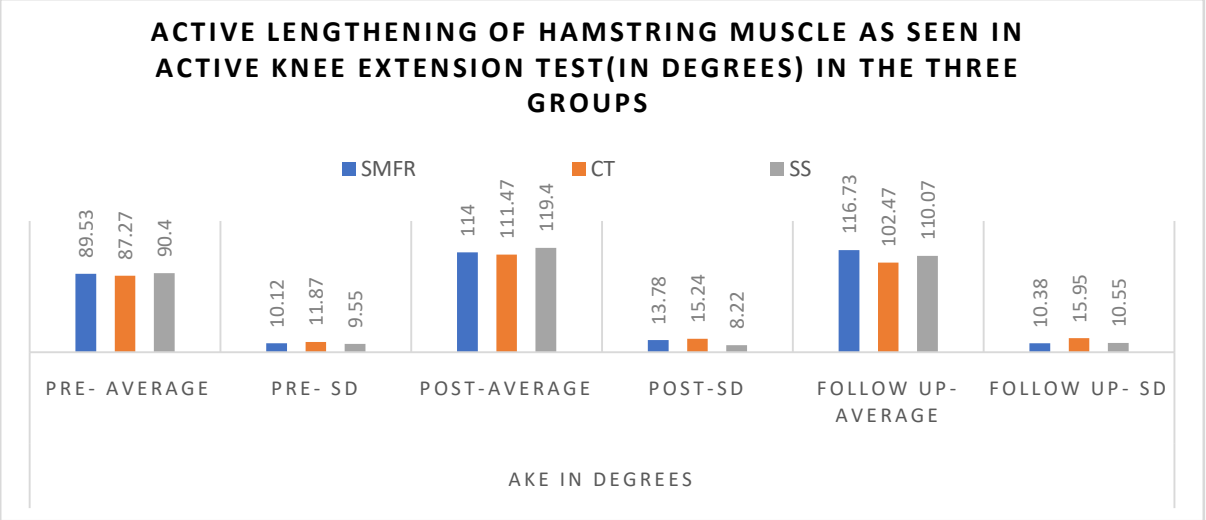

Figure 10 : Active lengthening of the three groups seen with AKE. SMFR has shown better result.

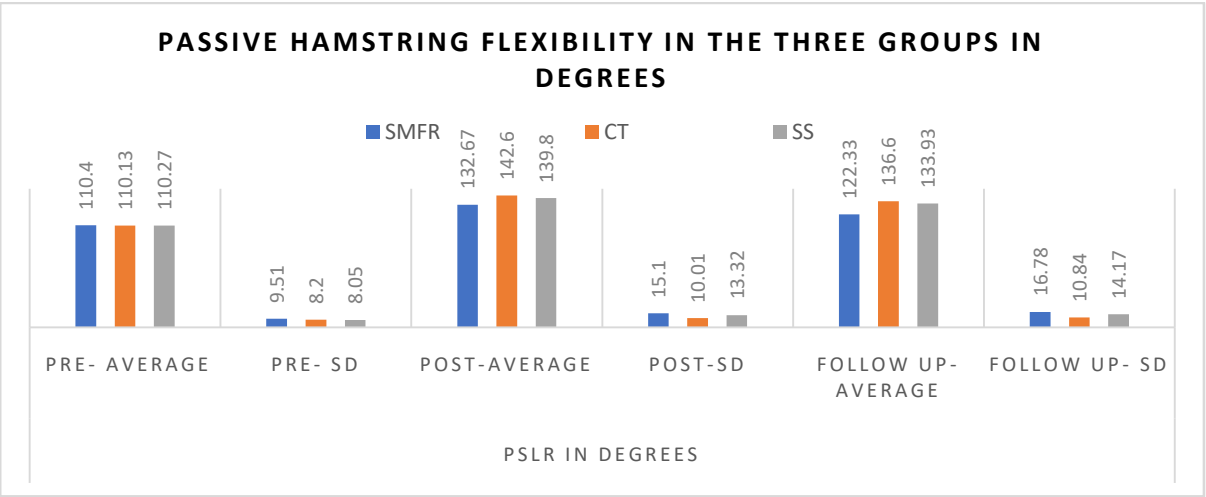

Figure 11 : Passive lengthening of the three groups seen with PSLR. CT has shown better result.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 334 – 346
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3.Results

The descriptive data can be seen in table -2 and table -3 shows the one-way ANOVA results. Unpaired t test results for different group comparisons are seen in tables 4 & 5. Figures 9,10 & 11 show the differential effect of various interventions graphically.

Parameter	Groups	Mean+SD
AGE	1	25.13 ± 3.13
	2	24.8± 3.48
	3	21.66± 1.17
HEIGHT	1	169.77± 8.24
	2	170.17± 8.20
	3	161.37± 5.50
WEIGHT	1	66.83± 11.68
	2	66.3± 10.97
	3	56.46± 7.08
BMI	1	23.15± 2.84
	2	27.0± 2.61
	3	21.74± 2.12

Table 2 Showing mean and standard deviation of different groups with descriptive parameters.To summarize, this table shows mean and standard deviation of various parameters like, age, height, weight and BMI of GROUP-1, GROUP-2 and GROUP-3.

SN	InterventionOutcome	SMFR(Mean±SD)	CTh(Mean±SD)	SS(Mean±SD)	F-value	p-value
1	Pre SRT	6.9±1.81	6.9±1.82	6.6±1.29	0.04	0.96
2	Post SRT	10.3±2.0	8.87±2.89	8.73±1.89	2.13	0.13
3	Follow up SRT	9.78±2.17	8.13±2.88	7.92±2.08	2.7	0.078
4	Pre AKE	89.53±10.12	87.27±11.87	90.4±9.55	0.35	0.71
5	Post AKE	114±13.78	111.46±15.24	119.4±8.22	1.51	0.23
6	Follow up AKE	116.73±10.38	102.47±15.95	110.07±10.55	4.84	0.013*
7	Pre PSLR	110.4±9.5	110.13±8.19	110.26±8.05	0.004	0.99
8	Post PSLR	132.67±15.1	142.6±10.01	139.8±13.32	2.33	0.11
9	Follow up PSLR	122.33±16.78	136.6±10.84	133.94±14.17	4.31	0.019*

Table 3: Showing One-way ANOVA of different groups with F value and p value for all parameters.

Outcome measure	Group [Mean±SD]	Group [Mean±SD]	t- VALUE	P-VALUE
SRT	Post SMFR **[10.3±2.0]**	Post CTh **[8.87±2.89]**	1.58	0.062
	Post SMFR **[10.3±2.0]**	Post SS **[8.73±1.89]**	2.2	0.018*
	Post CTh **[8.87±2.89]**	Post SS **[8.73±1.89]**	0.15	0.441
AKE	Post SMFR	Post CTh	0.477	0.318

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	[114±13.78]	**[111.46±15.24]**		
	Post SMFR **[114±13.78]**	Post SS **[119.4±8.22]**	-1.3	0.1
	Post CTh **[111.46±15.24]**	Post SS **[119.4±8.22]**	-1.77	0.043*
PSLR	Post SMFR **[132.67±15.1]**	Post CTh **[142.6±10.01]**	-2.12	0.02*
	Post SMFR **[132.67±15.1]**	Post SS **[139.8±13.32]**	-1.37	0.09
	Post CTh **[142.6±10.01]**	Post SS **[139.8±13.32]**	0.651	0.266

Table 4 Unpaired t test in the post intervention data of different groups.

Outcome measure	**Group [Mean±SD]**	**Group [Mean±SD]**	**t- VALUE**	**p-VALUE**
SRT	Follow up SMFR **[9.78±2.17]**	Follow up CTh **[8.13±2.88]**	1.77	0.04*
	Follow up SMFR **[9.78±2.17]**	Follow up SS **[7.92±2.08]**	2.4	0.012*
	Follow up CTh **[8.13±2.88]**	Follow up SS **[7.92±2.08]**	0.23	0.408
AKE	Follow up SMFR **[116.73±10.38]**	Follow up CTh **[102.47±15.95]**	2.9	0.0035*
	Follow up SMFR **[116.73±10.38]**	Follow up SS **[110.07±10.55]**	1.74	0.045*
	Follow up CTh [102.47±15.95]	Follow up SS [110.07±10.55]	-1.54	0.067
PSLR	Follow up SMFR **[122.33±16.78]**	Follow up CTh **[136.6±10.84]**	-2.76	0.004*
	Follow up SMFR **[122.33±16.78]**	Follow up SS **[133.94±14.17]**	-2.04	0.025*
	Follow up CTh **[136.6±10.84]**	Follow up SS **[133.94±14.17]**	0.57	0.28

Table 5 Unpaired t test in the post intervention data of different groups.

4. Discussion

Hamstring is made of fascia, muscles and myotendinous junctions. This produces different cellular and tissue properties. Collectively studied as *hamstring flexibility* - a desirable function for all. The active and passive components are reflective of different cellular types as a main site for tightness. Presently different interventions are popular and different outcomes for various interventions are reported as seen in table -1. Sufficient power to differentiate them is a desired fact. In the present study with a high power (Fig-1)1-β = >96% - SMFR, SS and CTh (Figs- 2-7) were studied for *active and passive* hamstring flexibility. Total N=60 were considered but after the exclusion, dropout and withdrawal N= 45 were randomized and completed the trial as seen in

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 334 – 346
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the Fig-8. The three groups remained comparable as seen in the table -2, there is more age in group1 and more BMI in group 2 though.

All interventions were effective a seen in the paired analysis. In one way ANOVA analysis – comparison of active and passive flexibility among the groups show significant variations at the follow-up only. The follow-up AKE (p=0.013), and follow-up PSLR (p=0.019) show variations for active and passive flexibility respectively as seen in table-3. Unpaired t test has shown significant differences in the post (table-4) and follow-up (tabe-5) analysis showing differential outcome for three interventions on active and passive flexibility. Active and passive flexibility has different postural and functional roles.

SMFR influences the *active muscle bulk and its fascia* with direct pressure while muscle is active. SMFR has shown to increase the active lengthening of hamstring muscle more as compared to the SS and CTh (table 4 and 5 and Fig 9 & 10). The fascia and other connective tissues around the hamstring muscle are known to cause hamstring symptoms (Pérez-Bellmunt et al 2015). SMFR releases these tissues and causes the active lengthening. How these tissues allow active lengthening is not understood. Relaxed posture of hip and knee is flexion causes "hamstring", tightness, but which of the structures are causing the active or passive tightness is not known. However, during SMFR the hamstring muscle is working and th effect is getting transmitted to the active structures. It may be effective for prevention of injuries during the activation of hamstrings in open kinematic work as it is a prime mover for knee flexion during movement full active excursion of hamstring allows two joint action like running at fast speed. Tendons are contracted by three large muscles (semimembranosus, semitendinosus, and biceps femoris) leading to two joint motion or flexion of knee or as a accessory hip extensor. They lengthen during eccentric contraction of the muscles and are prone for injury.Dynamic kinesiologic hamstring muscle work is required for balanced lower limb functions.

The hamstring play an important role in our many activities of daily living, like, running, jumping, walking and controlling some of the trunk movements. The three 'true' hamstrings cross and acting on two- the coxa and the genu, and thus have involvement in ambulation forward propulsion and running.

SS influences *the different medial and lateral muscles of hamstring* with the rotational component. CTh also affects the *distal and proximal tendinousattachments* of the muscle.

SS and CTh improve the passive lengthening of hamstring as seen in Tables 4 & 5 and Fig 11. During these manuvers the hamstring muscle is not working but is relaxed and muscle work is not there thus the effect may be getting transmitted to the passive structures like ligaments and popliteal structure. Popliteal structures are functionally useful for knee (Satoh et al 2016). It may also be effectively working for the posture maintenance and resultant low back pain.H-Tt influences the posture and may predispose to postural pains as well as my take part in lower crossed syndrome.

In a static bipedal posture, the tone of the hamstring helps in hip extension and pelvic stabilization, where sufficient passive lengthening allows for healthy bipedal stance with balanced pelvis. During SS the popliteal region and its boundaries are stretched, popliteal region is known to have implications for lower limb function (Hyland et al 2020)

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Clinical Relevance:

Different techniques affect active/passive lengthening of hamstring differently. It is dependent upon the tissue producing the tightness (Pérez-Bellmunt et al 2015).

SMFR is efficacious for active lengthening of hamstring as compared to CTh and SS.CTh and SS are efficacious for passive lengthening of hamstring as compared to SMFR.

Such findings of our study and of others for differential movement (Bueno-Gracia et al 2017) are having clinical relevance.

Limitations:
EMG or US diagnostic studies can give insight in to force generation capacity changes with techniques to increase flexibility.
Inter-rater and intra-rater reliability studies may also be undertaken simultaneously.

5. Conclusion

Active and passive flexibility of the hamstring (AKE, SRT and PSLR) are affected distinctly by the studied interventions (SMFR, SS and CTh). They have implications on the various clinical and functional conditions of the proximal and distal hamstring tendons and medial and lateral muscles.

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