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# A comparative study on the effects of autogenic mechanism and reciprocal mechanism on hamstring flexibility among AMU students

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## Abstract
**Title:** A comparative study on the effects of autogenic mechanism and reciprocal mechanism on hamstring flexibility among AMU students.
**Background:** There are less studies was done to investigate the effect on hamstring flexibility by using autogenic mechanism and reciprocal mechanism and all these studies have used combination of few mechanisms to identify the effect on muscle activity and range of motion which results in poor understanding on which mechanism causes improvement. There is also less awareness in clinical setting on mechanisms and stretching techniques: agonist contract relax stretch and contract relax since both mechanism and techniques can be used to improve muscle flexibility.
**Objective:** To compare the effectiveness of autogenic mechanism and reciprocal mechanism on Hamstring flexibility.
**Methods:** This study was conducted on 30 AMU students with hamstring tightness. Those 30 individuals were divided equally into 2 groups and contract relax and agonist contract relax was given respectively. Phase 1 and phase 2 were included in both techniques where angle of extension lag was recorded after each phase. Before each intervention, warm up period was given for 10 minutes in order to prevent muscle cramps and stretching techniques was excluded.
**Results:** There was a significant difference between contract relax and agonist contract relax techniques on phase 1($p \leq 0.05 = 0.018$) and phase 2($p \leq 0.05 = 0.02$). Comparison of mean between both techniques shows that agonist contract relax techniques shows more improvement than contract relax in phase 1(ACR=36.53, CR=45.90) and phase 2(ACR=28.90, CR=41.27).Thereby the alternative hypothesis is accepted which shows that there is significant difference between the mechanisms.
**Conclusion:** This has concluded that both mechanisms can be used in improving the hamstring flexibility but reciprocal mechanism (agonist contract relax) show greater gains in hamstring flexibility. In addition, application of both mechanisms for 20 seconds is more beneficial than 10 seconds due to duration of the contractions.

**Keywords:** Hamstring, Goniometry, agonist contract relax technique etc.

## Introduction
In human body, hamstring muscle tightness is found to be most prevalent and very common in general population. This muscle assists in knee flexion and hip extension and is innervated by sciatic nerve. Tightness of this muscle will cause decrease in range of motion and flexibility of the pelvis, hip and knee joints due to the location of this muscle which is originated from the infer medial impression on the upper part on ischial tuberosity and inserted on upper part of the posterior surface of tibia [1]. Stretching has become one of the interventions that play an important role in lengthening the muscle length, increase the extensibility of soft tissues surrounding the joint which eventually increases the range of motion and prevent hypo mobility. Static stretching, ballistic stretching, dynamic stretching and proprioceptive neuromuscular facilitation (PNF) are the examples of stretching techniques. Few studies have proven that Proprioceptive neuromuscular facilitation (PNF) technique has been providing better and improved range of motion when compared with other stretching techniques. For an example A study done by J. Brent Feland have reported that proprioceptive neuromuscular facilitation (PNF) stretching techniques promotes more flexibility on hamstring muscle compare with static stretching with median differences of 5 degree in PNF group and 4 degree

in static group [2]. Beside that, another study done by Ming-Cheng Weng also proved that proprioceptive neuromuscular facilitation (PNF) techniques are more beneficial for osteoarthritis patients in range of motion and muscle strength compare with static stretching [3]. Proprioceptive neuromuscular facilitation (PNF) involves in autogenic inhibition, reciprocal inhibition, stress relaxation and gate control theory mechanisms. In this study, autogenic mechanisms and reciprocal mechanisms was tested to identify which Proprioceptive neuromuscular facilitation (PNF) techniques will provide more significant increase in hamstring flexibility. Contract relax and agonist contract relax PNF techniques are used in this study because both are involved in autogenic inhibition mechanism and reciprocal inhibition mechanism respectively.

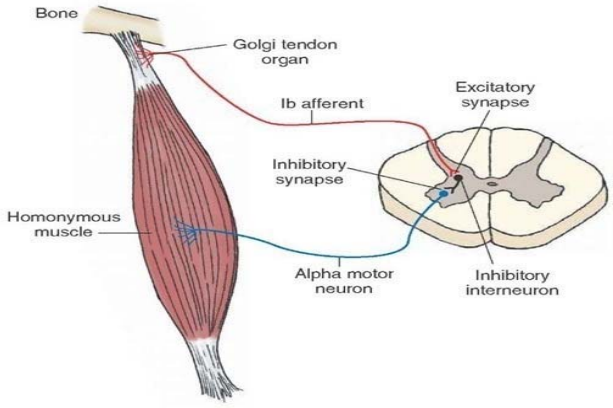



**Fig 1:** Mechanism of autogenic inhibition

Autogenic inhibition mechanism will take place in the target muscle when the same muscle is contracted or stretched by reducing the excitability because inhibitory signal is fired from the Golgi tendon organ (GTO). This tension will trigger activation of Ibafferent fiber within GTOs and send the signal to spinal cord. In the spinal cord, the signal will activate the inhibitory interneuron and fire inhibitory stimulus upon the alpha motor neuron which cause the nerve excitability and efferent motor drive to reduce. This feedback will lead the target muscle to relax and elongate the muscle fibers.

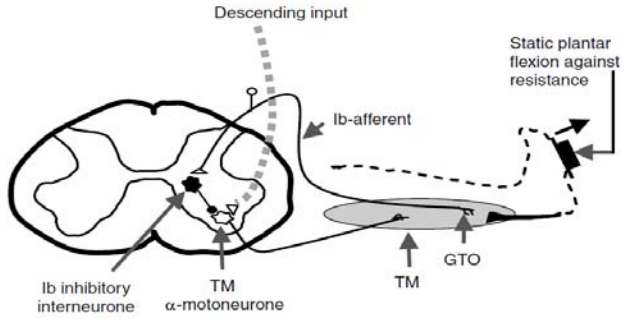



**Fig 1:** Mechanism of autogenic inhibition

But in reciprocal inhibition mechanism, voluntary contraction of opposing muscle because this mechanism to take place in the target muscle that will result in relaxation of target muscle. When an opposing muscle contracts, it will cause shortening of muscle spindle which will brings no sensory input to convey to central nervous system. Muscle spindle is a sensory receptor that will regulate the muscle length and velocity of length changes. Due to this, a descending input will act on alpha motor neuron of opposing muscle. In order to excite the opposing muscle; descending input and Ia afferent fiber enter the spinal cord and synapse with Ia inhibitory interneuron. This will cause inhibitory input on the target muscle's alpha motor neurons which result in decease of activation level and facilitate stretching on target muscle.

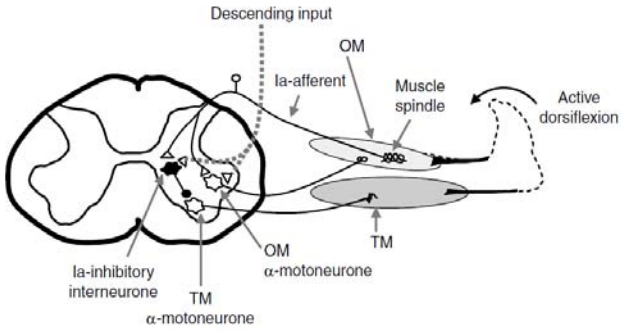



**Fig 3:** Mechanism of reciprocal inhibition

## Materials and Methods

**Study design:** A Quasi Experimental design
**Sampling method:** Purposive random sampling
**Study location:** Physiotherapy lab Asia Metropolitan University at Jalan Kemacahaya Batu 9, Cheras.
**Study duration:** 4 weeks

**Inclusion criteria**

- Age must be in between 18 to 28 years
- Only student population from AMU is allowed
- Both female and male subjects are included
- All the subjects must have normal BMI
- Having sedentary life style
- Hamstring tightness (AKE test is less than 160 ° of knee extension with hip at 90° of flexion) [52, 53]
- Absence of neurological, musculoskeletal, cardiovascular and respiratory problems

**Exclusion criteria**

- Active life style
- Overweight
- Contractures
- Injured lower limb
- Hip dislocation
- Multiple chronic disorder
- Any pathology and disorder of hip, knee and spine
- Hematoma
- Traumatic, neurological, musculoskel *et al*, cardiovascular and respiratory problems
- Unable to follow up the stretching procedures for 4 weeks

**Methodology**

Before conducting the study, the range of motion of knee extension was measured using goniometer to identify the hamstring tightness. All the subjects were randomly chosen and subjects were selected if the reading is below 160° of knee extension. After that, questions and answer session was conducted to all the subjects to make sure that all the subjects are in inclusion criteria. The questions and answers session was based on the prepared questionnaires. Then, all the subjects were informed to follow up the stretching procedure for 4 weeks which will be twice per week and a consent form was given. The weight and height of the subjects were taken.

All the underweight and overweight subjects were excluded according to BMI chart. The body mass index was calculated by the weight (kg) times with 10,000 and the answer will be by square of the height (cm). Before applying the PNF techniques, the measurement of angle of knee extension lag was taken for four times using the same active knee extension test and only average values were calculated and recorded. The angle of knee extension lag was measured for twice a week before and after during each interventions. To measure the angle of knee extension lag, the subject was positioned in supine lying with affected hip (right) is flexed in 90 degree supported with modified polystyrene pipe apparatus. Before that, a cloth strap was used across the left thigh and over the anterior superior spines of ilia for stabilization. A line was drawn at long axis of femur which will be pointing towards the greater trochanter and at long axis of fibula which will be pointing towards the lateral malleolus. The goniometer was placed where the stationary arm will be at the long axis of femur and moveable arm will be parallel to long axis of fibula. Then, the subject was asked to actively extend the knee until the terminal position is achieved. The terminal point of knee extension is the point when the subject complains discomfort, tightness and resistance when performing knee extension. Once the terminal point is achieved, the angle of knee extension lag was recorded

**Fig 4:** Positioning before AKE TEST

**Fig 5:** Placement of goniometer before measurement

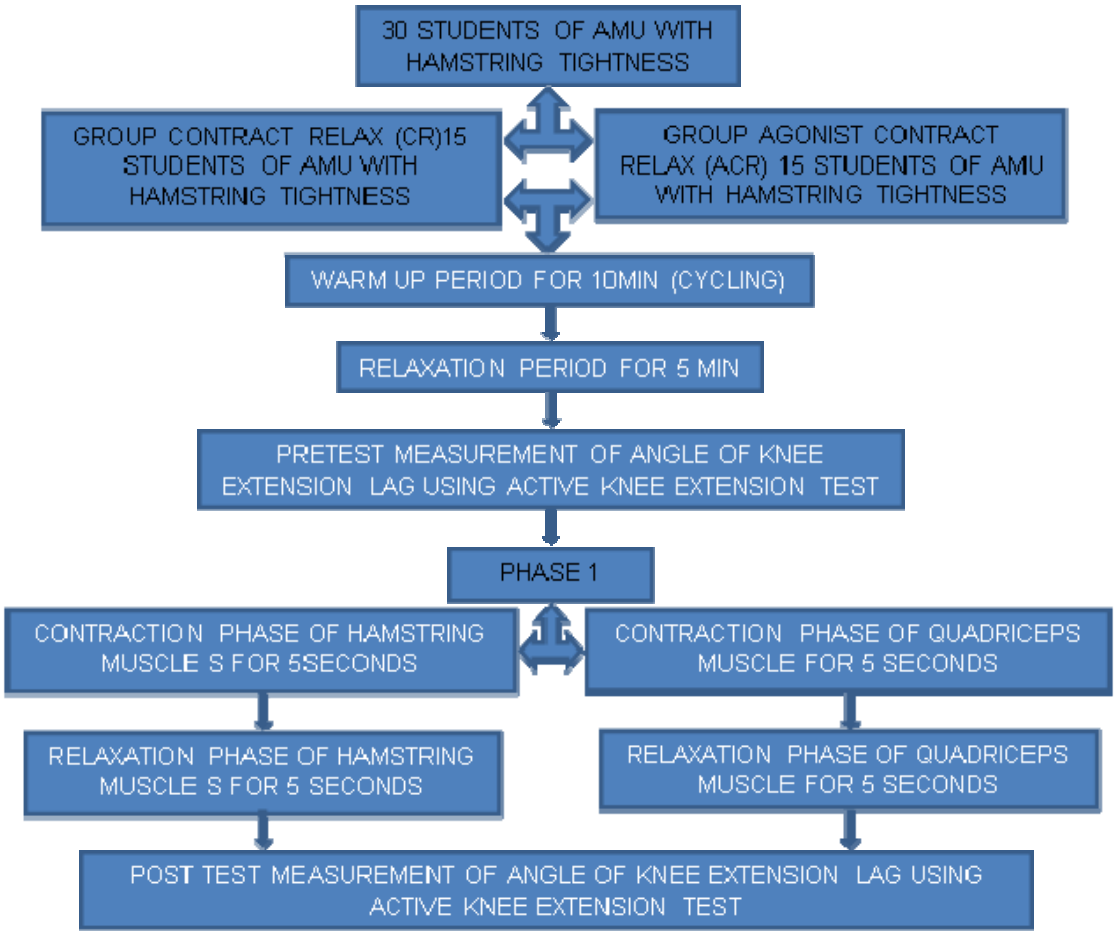
**Fig 6:** Placement of goniometer during the measurement

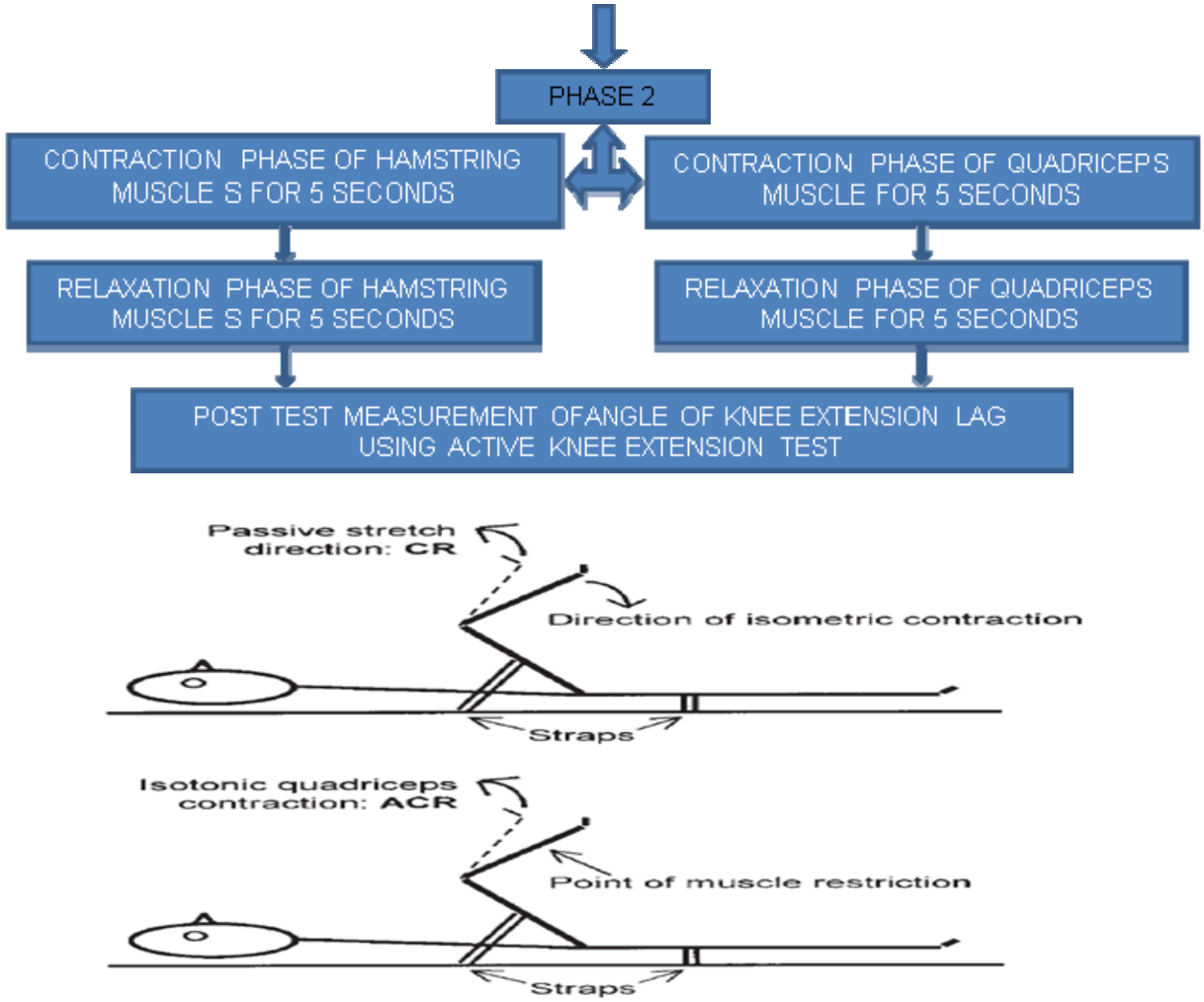
This study was conducted on 30 numbers of students AMU which will be selected based on inclusion and exclusion criteria for 4 weeks. The number of students was divided into 15 students per group and the group will be labeled as Group CR and Group ACR. All the pretest measurement was taken before the intervention is given. The right lower extremity was chosen for both stretching methods. Before the data collection, the subjects was instructed for 10 min of warm up but not including stretching as it is the component of warm up. Cycling was suggested as a warm up technique and 5 min resting period will be given to prevent fatigue. In group CR, the procedure was started with passive extension of knee joint to a point of muscle restriction and at the terminal point, the subjects was asked to flex the knee joint for maximum contraction against the resistance given for 5sec. Then, relaxation was given by asking the subjects to stop the contraction against the resistance whereas the examiner will continue the passive extension of knee joint for 5sec.The angle of knee flexion was measured and recorded under phase 1.The stretching procedure was again carried out immediately with contraction and relaxation. The new angle of knee flexion was measured and recorded under phase 2.The total duration for this procedure was 20 seconds which consists of 2 contraction periods and 2 relaxation periods.

**Fig 7:** Method of contract relax technique

For the group ACR, the procedure was started with passive extension of knee joint to the terminal point and the subject was instructed to actively extend the knee joint by giving concentric quadriceps contraction for 5sec while the examiner will manually assist the knee extension. After that, the subjects was instructed to relax the contracting muscle while the examiner will be maintaining the knee the stretched position for 5sec.The angle of knee flexion was measured and recorded and labeled as phase 1. Immediately, phase 2 was carried out where a same stretching procedure was repeated. The total duration for this procedure was 20 seconds which consist of 2 contraction periods and 2 relaxation periods.

**Fig 8:** Method of agonist contract relax technique






Placements of straps during the techniques

**Data Analysis**

A 30 samples of data were collected at Asia Metropolitan University (AMU) from Jun 2015 to July 2015 and were divided into two different groups, 15 samples in each group. Statistical package for social sciences (SPSS), version 20 software was used for analysis the data. Descriptive statistics and inferential statistics were used to analyze and interpret the data. Paired t-test was used to identify the significant difference between phase 1 and phase 2 for each week meanwhile independent t-test was used to find the significant difference between the two groups in week 4.Throughout the study, all the data collection was collected from 4 males and 26 females with age range from 18-28 years old with normal BMI. All the demographic information was collected using question and answer section and each sample was selected

Data analysis within the groups

a) Agonist contract relax technique

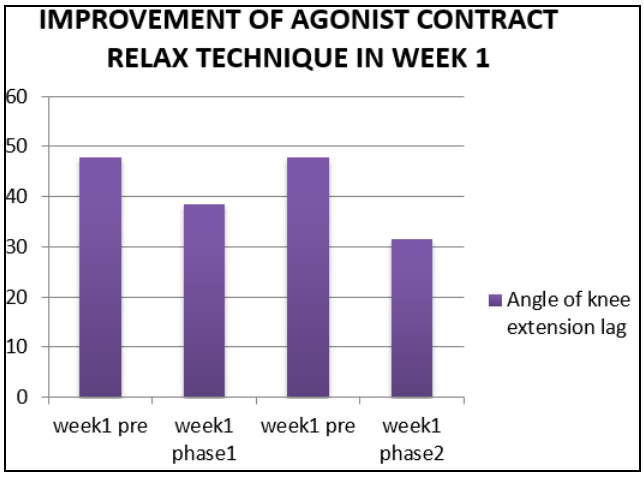
**(Week 1)**

Paired Samples Statistics

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | week1pre | 47.80 | 15 | 10.698 | 2.762 |
| | week1phase1 | 38.43 | 15 | 10.433 | 2.694 |
| Pair 2 | week1pre | 47.80 | 15 | 10.698 | 2.762 |
| | week1phase2 | 31.60 | 15 | 9.018 | 2.328 |

Pretest and post test results of ACR group (week 1)

Descriptive statistics and inferential statistics were used to analyze and interpret the data. The mean ± SD for week 1 pre and post for phase 1 are (47.80 ± 10.70) and (38.43 ± 10.43) respectively. Meanwhile, the mean ±SD for week 1 pre and post phase 2 are (47.80 ±10.70) and (31.60 ± 9.02).This shows that there is a greater improvement of hamstring flexibility in week 1 phase 2 compared with week 1 phase 1.




Mean values of pre and post of ACR group (Week 1)

Paired Samples Test

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | week1pre - week1phase1 | 9.367 | 2.888 | .746 | 7.768 | 10.966 | 12.563 | 14 | .000 |
| Pair 2 | week1pre - week1phase2 | 16.200 | 4.902 | 1.266 | 13.485 | 18.915 | 12.800 | 14 | .000 |

Paired difference between phases for ACR group (week 1)

In the paired sample T-test, at degree of freedom (14), the T-value for week 1 pre and post phase 1 is 12.563 which are significant at point 00 levels when P ≤ or equal to 0.05 is considered. For week 1 pre and post phase 2 the T-value is 12.80 at degree of freedom (14) which is significant at point 00 levels when P≤ or equal to 0.05 is considered. This shows a high significant difference between pretest -post test phase 1 and pretest-post test phase 2 in agonist contract relax technique group at week 1.

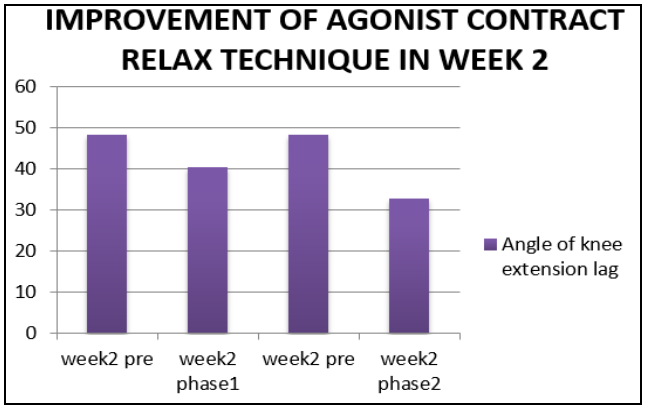
**(Week 2)**

Paired Samples Statistics

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | week2pre | 48.30 | 15 | 11.150 | 2.879 |
| | week2phase1 | 40.27 | 15 | 10.159 | 2.623 |
| Pair 2 | week2pre | 48.30 | 15 | 11.150 | 2.879 |
| | week2phase2 | 32.70 | 15 | 9.325 | 2.408 |

Pretest and post test results of ACR group (week 2)

Descriptive statistics and inferential statistics were used to analyze and interpret the data. The mean ± SD for week 2 pre and week 2 phase 1 are (48.30 ± 11.15) and (40.27 ± 10.16) respectively. Meanwhile, the mean ±SD for week 2 pre and week 2 phase 2 are (48.30 ±11.15) and (32.70 ± 9.33).This shows that there is a greater improvement of hamstring flexibility in week 2 phase 2 compared with week 2 phase 1.




Mean values of pre and post of ACR group (Week 2)

Paired Samples Test

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | week2pre - week2phase1 | 8.033 | 1.653 | .427 | 7.118 | 8.948 | 18.827 | 14 | .000 |
| Pair 2 | week2pre - week2phase2 | 15.600 | 2.551 | .659 | 14.187 | 17.013 | 23.685 | 14 | .000 |

Paired difference between phases for ACR group (week 2)

In the paired sample T-test, at degree of freedom (14), the T-value for week 2 pre and post phase 1 is 18.83 which are significant at point 00 levels when P ≤ or equal to 0.05 is considered. For week 2 pre and post phase 2, the T-value is 23.69 at degree of freedom (14) which is significant at point 00 levels when P≤ or equal to 0.05 is considered. This shows a high significant difference between pretest -post test phase 1 and pretest-post test phase 2 in agonist contract relax technique group at week 2.

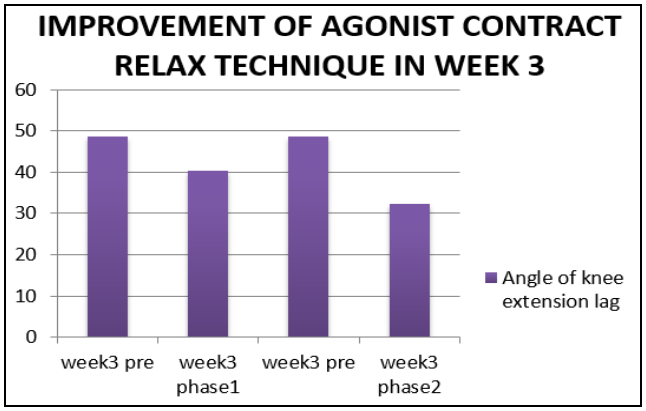
**(Week 3)**

Paired Samples Statistics

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | week3pre | 48.63 | 15 | 8.566 | 2.212 |
| | week3phase1 | 40.43 | 15 | 8.373 | 2.162 |
| Pair 2 | week3pre | 48.63 | 15 | 8.566 | 2.212 |
| | week3phase2 | 32.33 | 15 | 8.280 | 2.138 |

Pretest and post test results of ACR group (week 3)

Descriptive statistics and inferential statistics were used to analyze and interpret the data. The mean ± SD for week 3 pre and post phase 1 are (48.63 ± 8.57) and (40.43 ± 8.37) respectively. Meanwhile, the mean ±SD for week 3 pre and post phase 2 are (48.63 ±8.57) and (32.33 ± 8.28).This shows that there is a greater improvement of hamstring flexibility in week 3 phase 2 compared with week 3 phase 1.




Mean values of pre and post of ACR group (Week 3)

Paired Samples Test

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | week3pre - week3phase1 | 8.200 | 1.014 | .262 | 7.638 | 8.762 | 31.314 | 14 | .000 |
| Pair 2 | week3pre - week3phase2 | 16.300 | 1.971 | .509 | 15.208 | 17.392 | 32.026 | 14 | .000 |

Paired difference between phases for ACR group (week 3)

In the paired sample T-test, at degree of freedom (14), the T-value for week 3 pre and post phase 1 is 31.31 which are significant at point 00 levels when P ≤ or equal to 0.05 is considered. For week 3 pre and post phase 2, the T-value is 32.03 at degree of freedom (14) which is significant at point 00 levels when P≤ or equal to 0.05 is considered. This shows a high significant difference between pretest -post test phase 1 and pretest-post test phase 2 in agonist contract relax technique group at week 3.

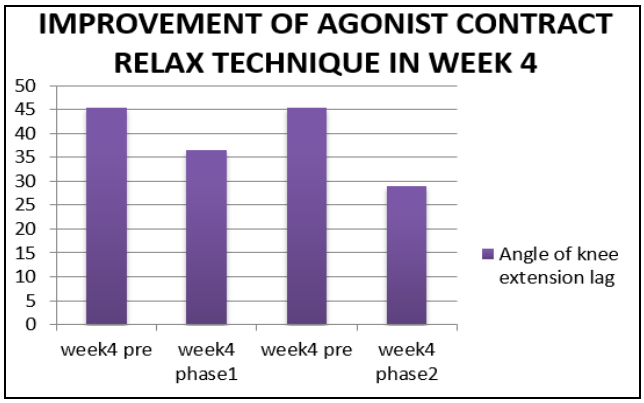
**(Week 4)**

Paired Samples Statistics

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | week4pre | 45.27 | 15 | 7.785 | 2.010 |
| | week4phase1 | 36.53 | 15 | 7.551 | 1.950 |
| Pair 2 | week4pre | 45.27 | 15 | 7.785 | 2.010 |
| | week4phase2 | 28.90 | 15 | 7.616 | 1.967 |

Pretest and post test results of ACR group (week 4)

Descriptive statistics and inferential statistics were used to analyze and interpret the data. The mean ± SD for week 4 pre and post phase 1 are (45.27 ± 7.79) and (36.53 ± 7.55) respectively. Meanwhile, the mean ±SD for week 4 pre and post phase 2 are (45.27 ± 7.79) and (28.90 ± 7.62).This shows that there is a greater improvement of hamstring flexibility in week 4 phase 2 compared with week 4 phase 1.




Mean values of pre and post of ACR group (Week 4)

Paired Samples Test

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | week4pre - week4phase1 | 8.733 | .904 | .233 | 8.233 | 9.234 | 37.429 | 14 | .000 |
| Pair 2 | week4pre - week4phase2 | 16.367 | 2.364 | .610 | 15.058 | 17.676 | 26.815 | 14 | .000 |

Paired difference between phases for ACR group (week 4)

In the paired sample T-test, at degree of freedom (14), the T-value for week 4 pre and post phase 1 is 37.43 which are significant at point 00 levels when P ≤ or equal to 0.05 is considered. For week 4 pre and post phase 2, the T-value is 26.82 at degree of freedom (14) which is significant at point 00 levels when P≤ or equal to 0.05 is considered. This shows a high significant difference between pretest -post test phase 1 and pretest-post test phase 2 in agonist contract relax technique group at week 4.

**b) Contract relax technique**

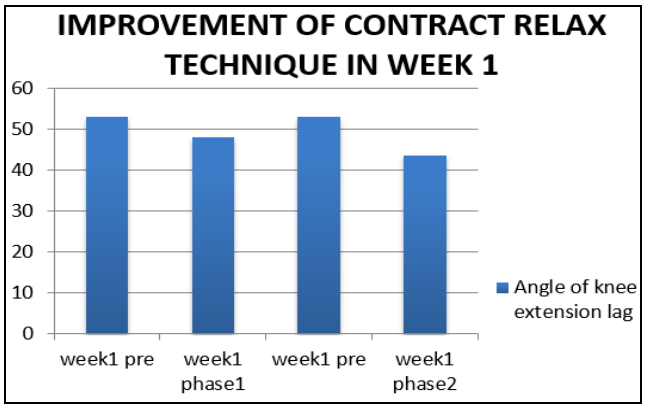
**(Week 1)**

Paired Samples Statistics

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | week1precr | 53.03 | 15 | 14.250 | 3.679 |
| | week1phase1cr | 47.87 | 15 | 14.560 | 3.759 |
| Pair 2 | week1precr | 53.03 | 15 | 14.250 | 3.679 |
| | week1phase2cr | 43.40 | 15 | 14.123 | 3.647 |

Pretest and post test results of CR group (week 1)

Descriptive statistics and inferential statistics were used to analyze and interpret the data. The mean ± SD for week 1 pre and week 1 phase 1 are (53.03 ± 14.25) and (47.87 ± 14.56) respectively. Meanwhile, the mean ±SD for week 1 pre and week 1 phase 2 are (53.03 ± 14.25) and (43.40 ± 14.12).This shows that there is a greater improvement of hamstring flexibility in week 1 phase 2 compared with week 1 phase 1.




Mean values of pre and post of CR group (Week 1)

Paired Samples Test

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | week1precr - week1phase1cr | 5.167 | 1.877 | .485 | 4.127 | 6.206 | 10.660 | 14 | .000 |
| Pair 2 | week1precr - week1phase2cr | 9.633 | 2.100 | .542 | 8.470 | 10.796 | 17.768 | 14 | .000 |

Paired difference between phases for CR group (week 1)

In the paired sample T-test, at degree of freedom (14), the T-value for week 1 pre and post phase 1 is 10.66 which are significant at point 00 levels when P ≤ or equal to 0.05 is considered. For week 1 pre and post phase 2, the T-value is 17.77 at degree of freedom (14) which is significant at point 00 levels when P≤ or equal to 0.05 is considered. This shows a high significant difference between pretest -post test phase 1 and pretest-post test phase 2 in contract relax technique group at week 1.

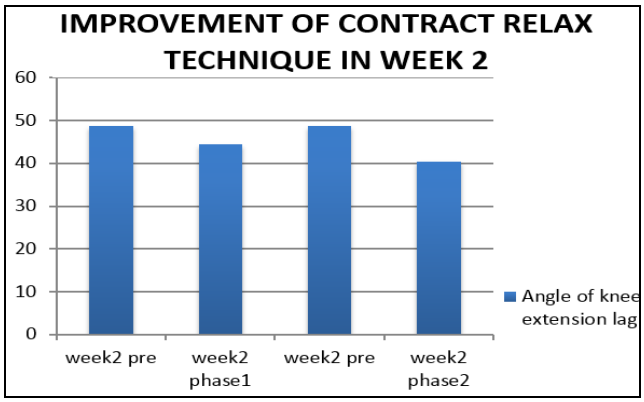
**(Week 2)**

Paired Samples Statistics

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | week2precr | 48.63 | 15 | 13.658 | 3.527 |
| | week2phase1cr | 44.40 | 15 | 13.088 | 3.379 |
| Pair 2 | week2precr | 48.63 | 15 | 13.658 | 3.527 |
| | week2phase2cr | 40.30 | 15 | 12.278 | 3.170 |

Pretest and post test results of CR group (week 2)

Descriptive statistics and inferential statistics were used to analyze and interpret the data. The mean ± SD for week 2 pre and post phase 1 are (48.63 ± 13.66) and (44.40 ± 13.09) respectively. Meanwhile, the mean ±SD for week 2 pre and post phase 2 are (48.63 ± 13.66) and (40.30 ± 12.28).This shows that there is a greater improvement of hamstring flexibility in week 2 phase 2 compared with week 2 phase 1.




Mean values of pre and post of CR group (Week 2)

Paired Samples Test

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | week2precr - week2phase1cr | 4.233 | 1.280 | .330 | 3.525 | 4.942 | 12.810 | 14 | .000 |
| Pair 2 | week2precr - week2phase2cr | 8.333 | 2.093 | .540 | 7.174 | 9.492 | 15.420 | 14 | .000 |

Paired difference between phases for CR group (week 2)

In the paired sample T-test, at degree of freedom (14), the T-value for week 2 pre and post phase 1 is 12.81 which is significant at point 00 levels when P ≤ or equal to 0.05 is considered. For week 2 pre and post phase 2, the T-value is 15.42 at degree of freedom (14) which is significant at point 00 levels when P≤ or equal to 0.05 is considered. This shows a high significant difference between pretest -post test phase 1 and pretest-post test phase 2 in contract relax technique group at week 2.

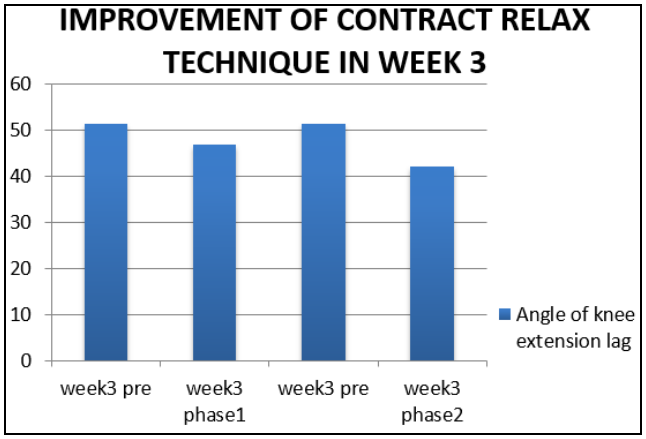
**(Week 3)**

Paired Samples Statistics

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | week3precr | 51.33 | 15 | 12.122 | 3.130 |
| | week3phase1cr | 46.73 | 15 | 11.995 | 3.097 |
| Pair 2 | week3precr | 51.33 | 15 | 12.122 | 3.130 |
| | week3phase2cr | 42.03 | 15 | 11.951 | 3.086 |

Pretest and post test results of CR group (week 3)

Descriptive statistics and inferential statistics were used to analyze and interpret the data. The mean ± SD for week 3 pre and post phase 1 are (51.33 ± 12.12) and (46.73 ± 12.00) respectively. Meanwhile, the mean ±SD for week 3 pre and post phase 2 are (51.33 ± 12.12) and (42.03 ± 11.95).This shows that there is a greater improvement of hamstring flexibility in week 3 phase 2 compared with week 3 phase 1.




Mean values of pre and post of CR group (Week 3)

Paired Samples Test

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | week3precr - week3phase1cr | 4.600 | .541 | .140 | 4.300 | 4.900 | 32.921 | 14 | .000 |
| Pair 2 | week3precr - week3phase2cr | 9.300 | 1.014 | .262 | 8.738 | 9.862 | 35.515 | 14 | .000 |

Paired difference between phases for CR group (week 3)

In the paired sample T-test, at degree of freedom (14), the T-value for week 3 pre and post phase 1 is 32.92 which is significant at point 00 levels when P ≤ or equal to 0.05 is considered. For week 3 pre and post phase 2, the T-value is 35.52 at degree of freedom (14) which is significant at point 00 levels when P≤ or equal to 0.05 is considered. This shows a high significant difference between pretest -post test phase 1 and pretest-post test phase 2 in contract relax technique group at week 3.

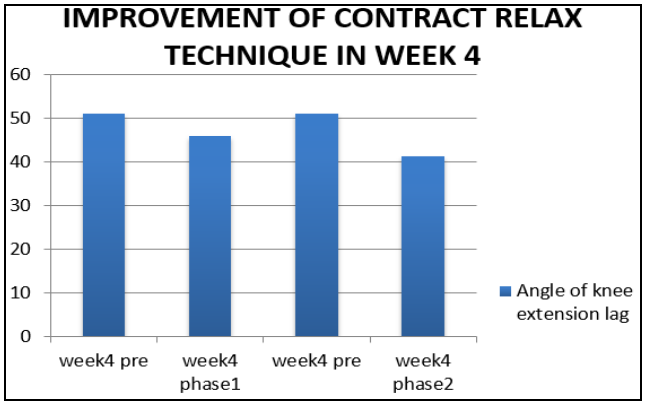
**(Week 4)**

Paired Samples Statistics

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | week4precr | 51.03 | 15 | 12.610 | 3.256 |
| | week4phase1cr | 45.90 | 15 | 12.300 | 3.176 |
| Pair 2 | week4precr | 51.03 | 15 | 12.610 | 3.256 |
| | week4phase2cr | 41.27 | 15 | 11.838 | 3.057 |

Pretest and post test results of CR group (week 4)

Descriptive statistics and inferential statistics were used to analyze and interpret the data. The mean ± SD for week 4 pre and post phase 1 are (51.03 ± 12.61) and (45.90 ± 12.30) respectively. Meanwhile, the mean ±SD for week 4 pre and post phase 2 are (51.03 ± 12.61) and (41.27 ± 11.84).This shows that there is a greater improvement of hamstring flexibility in week 3 phase 2 compared with week 3 phase 1.




Mean values of pre and post of CR group (Week 4)

Paired Samples Test

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | week4precr - week4phase1cr | 5.133 | 1.631 | .421 | 4.230 | 6.036 | 12.191 | 14 | .000 |
| Pair 2 | week4precr - week4phase2cr | 9.767 | 1.981 | .511 | 8.670 | 10.864 | 19.096 | 14 | .000 |

Paired difference between phases for CR group (week 4)

In the paired sample T-test, at degree of freedom (14), the T-value for week 4 pre and post phase 1 is 12.19 which is significant at point 00 levels when P ≤ or equal to 0.05 is considered. For week 4 pre and post phase 2, the T-value is 19.10 at degree of freedom (14) which is significant at point 00 levels when P≤ or equal to 0.05 is considered. This shows a high significant difference between pretest -post test phase 1 and pretest-post test phase 2 in contract relax technique group at week 4.

**Data analysis between groups**

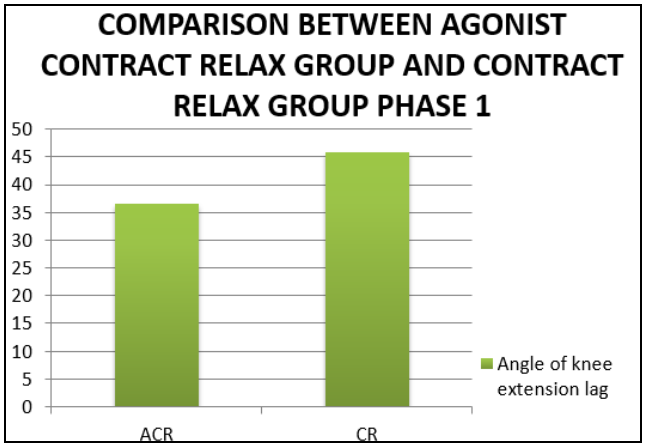
**a) At week 4 (phase 1)**

Group Statistics

| | analysisphase | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| comparison | acrphase1 | 15 | 36.5333 | 7.55094 | 1.94964 |
| | crphase1 | 15 | 45.9000 | 12.30012 | 3.17588 |

Means for both groups phase 1 (week 4)

Comparison between the groups for phase 1 was done by using independent t-test. The independent t-test value for agonist contract relax group shows mean of 36.53±7.55 while for group contract relax group shows mean of 45.90±12.30.




Mean values of pre and post for both groups phase 1 (Week 4)

Independent Samples Test

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| comparison | Equal variances assumed | 1.942 | .174 | -2.513 | 28 | .018 | -9.36667 | 3.72657 | -17.00019 | -1.73314 |
| | Equal variances not assumed | | | -2.513 | 23.240 | .019 | -9.36667 | 3.72657 | -17.07126 | -1.66208 |

Measurement of equality of variance

In independent t-test phase 1, the result for pooled t test at t (28) = 2.513; P<0.05(0.018), so here null hypothesis is rejected and alternate hypothesis is accepted. This shows evidence that there is a significant difference between both groups for phase 1.

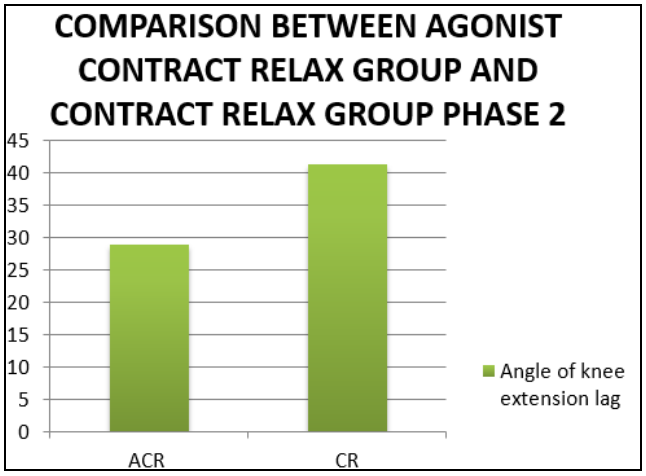
**At week 4 (phase 2)**

Group Statistics

| | Analysis phase | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| comparison | acrphase2 | 15 | 28.9000 | 7.61624 | 1.96651 |
| | crphase2 | 15 | 41.2667 | 11.83799 | 3.05656 |

Means for both groups phase 2 (week 4)

Comparison between the groups for phase 2 was done by using independent t-test. The independent t-test value for agonist contract relax group shows mean of 28.90±7.62 while for group contract relax group shows mean of 41.27±11.84.




Mean values of pre and post for both groups phase 2 (Week 4)

Independent Samples Test

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| comparison | Equal variances assumed | 1.962 | .172 | -3.403 | 28 | .002 | -12.36667 | 3.63451 | -19.81163 | -4.92170 |
| | Equal variances not assumed | | | -3.403 | 23.895 | .002 | -12.36667 | 3.63451 | -19.86968 | -4.86365 |

Mean values of pre and post for both groups phase 2 (Week 4)

In independent t-test phase 2, the result for pooled t test t (28) = 3.403; P< 0.05(0.002), so here null hypothesis is rejected and alternate hypothesis is accepted. This shows evidence that there is a significant difference between both groups phase 2.When comparison is made between phase 1 and phase 2 for both groups, group agonist contract relax phase 2 shows more effective results followed by agonist contract relax group phase 1, contract relax group phase 2 and contract relax group phase 1 because the mean for agonist contract relax phase 2 is 28.90 and agonist contract relax in phase 1 is 36.53 while the mean for contract relax phase 2 shows 41.27 and contract relax group phase 1 shows 45.90 which conclude that agonist contract relax phase 2 is the best technique can be used in reducing angle of knee extension lag in order to improve the hamstring flexibility.

**Discussions**

The purpose of this study was to investigate the effectiveness of autogenic mechanism and reciprocal mechanism in improving the hamstring flexibility. Based on the results, we can hypothesis that there is significant difference between autogenic mechanism and reciprocal mechanism. In the present study, both mechanisms were found to be beneficial in improving hamstring flexibility. However, agonist contract relax techniques shows more reduction in angle of knee extension lag which will eventually promote greater hamstring flexibility. We also can reveal that both phases of agonist contract relax group shows effective results compare with contract relax but agonist contract relax group phase 2 shows the most effective results because the mean was 28.90.Comparison between the results in each weeks indicate

that there was high significant level between phase 1 and phase 2 but phase 2 shows more productive results if means was used to compared for both groups. This finding was consistent with the previous study showing the agonist contract relax techniques denotes a 29%-34% higher range of motion and 65-119% greater EMG activity than contract relax and static stretching which has proven that agonist contract relax is more beneficial technique on knee joint[54]. Reed Ferber *et al* also done a same study using trained and untrained older adults and concluded that agonist contract relax promote better result by mentioning agonist contract relax demonstrate 4-6% more range of motion[55].A recent investigation also concluded that agonist contract relax technique is effective to be used in a single session because 6 second of this technique improve the hamstring flexibility.[56] This also explain why phase 2 demonstrated greater range of motion than phase 1. A study done by James W Youdas *et al* on healthy individual with bilateral hamstring tightness has concluded that one of modified proprioceptive neuromuscular techniques that used in the study promote 11° greater gain within a 10 second of single stretching session [57]. The greater mean difference between the two groups can be explained by underlying mechanisms. From the results, we can say that reciprocal mechanism generates more hamstrings flexibility than autogenic mechanism. This is due to activation of reciprocal reflex arc when an active quadriceps contraction takes place that leads to inhibition of hamstrings muscle. This shortening of quadriceps and relaxation of hamstrings muscle will cause muscle fiber in hamstring muscle to elongate even more and creating more stretching force and initiates more inhibitory network on hamstrings muscle which results in increase of hamstring flexibility. Meanwhile, in autogenic mechanism, the passive contraction of hamstring muscle will cause excitation of Golgi tendon organ to create inhibitory stimulus that makes nerve's excitability and efferent motor drive to reduce which leads to relaxation of same muscle. These same explained mechanisms have been well mentioned in a systemic review study done by Kayle B. Hindle *et al*. These authors used contract relax and contract-relax-antagonist-contract method to describe the same theory of mechanism and clarify the effect on range of motion, muscle strength and endurance[58]. In addition to that, Melanie J also described the same theory for both mechanisms and used few studies to prove that reciprocal inhibition can devotes greater improvement in range of motion. One of the discussed studies has concluded that greater gain is observed in range of motion and muscle activation if reciprocal mechanism is involved[59]. Besides that, the effectiveness of agonist contract relax technique can be results from active performance of subjects. Few articles have proven that active stretching is more effective than passive stretching. Example, a study on comparison between active stretching and passive stretching on hamstring flexibility has concluded that active stretching demonstrated greater results and the gains was almost maintained for 4 weeks [60]. Other investigation also reported that active stretching is effective in improving the flexibility of knee flexors, joint torque and functional mobility.

## Conclusion

The finding from this study has concluded that both mechanisms can be used in improving the hamstring flexibility but agonist contract relax techniques (reciprocal mechanism) show greater gains in hamstring flexibility. In addition, application of this mechanism behind the techniques for 20 seconds is more beneficial than 10 seconds due to longer duration of the muscle contraction.

## Limitations

- The point of musculature restriction was identified by subject's feedback
- The examiner was not blinded on the type of stretching which can cause bias
- The amount of muscle tension produced during the techniques was not measured
- More samples could have been recruited.

## Recommendations

- The comparison between the four theoretical mechanisms of PNF techniques could be done.
- Recruit more samples and the examiner can be blinded for future study
- Electrogonimeter can be used the measure the changes in range of motion
- The both mechanisms can be tested again on different group of muscles.

## References


1. Richard L, Drake A, Wayne Vogl, Adam W, Mitchell M. Gray anatomy for students, 2nd ed: Churchill Livingstone Elsevier.
2. Brent Feland J, Myrer JW, Merrill RM. Acute changes in hamstring flexibility: PNF versus static stretch in senior athletes. Physical Therapy in Sport 2001; 2(4):186-193.
3. Ming-Cheng Weng, Chia-Ling Leea, Chia-Hsin Chena, Jui-Jen Hsua, Wei-Der Leea, Mao-HsiungHuanga, *et al*. Effects of Different Stretching Techniques on the Outcomes of Isokinetic Exercise in Patients with Knee Osteoarthritis. The Kaohsiung Journal of Medical Sciences. 2009; 25(6):306-315.
4. Kayla Hindle B, Tyler Whitcomb J, Wyatt Briggs O, Junggi Hong. Proprioceptive Neuromuscular Facilitation (PNF): Its Mechanisms and Effects on Range of Motion and Muscular Function. Journal of Human Kinetics. 2012; 31:105-113.
5. Spernoga Timothy L, Uhl Brent L, Arnold Bruce M, Gansneder. Duration of Maintained Hamstring Flexibility after a One-Time, Modified Hold-Relax Stretching Protocol. Journal of Athletic Training. 2001; 36(1):44-48.
6. Feland JB, Marin HN. Effect of submaximal contraction intensity in contract-relax proprioceptive neuromuscular facilitation stretching. Br J Sports Med. 2004; 38(4).
7. Davis DS, Ashby PE, McCale KL, McQuain JA, Wine JM. The effectiveness of 3 stretching techniques on hamstring flexibility using consistent stretching parameters. J. Strength Cond. Res. 2005; 19(1):27-32.
8. Markos lpsilateral P. contralateral effects of proprioceptive neuromuscular facilitation techniques on hip motion and electromyography activity. Phys Ther 1979; 59(11):1366-73.
9. Ferber R, Osternig LR, Gravelle DC. Effect of PNF stretch techniques on knee flexor muscle EMG activity in older adults. Journal of Electromyography and Kinesiology. 2002; 12(5):391-7.
10. Osternig, Robertson, Troxel RK, Hansen P. Differential responses to proprioceptive neuromuscular facilitation stretch techniques. Med Sci Sports Exerc 1990; 22(1):106-11.
11. Reed Ferber, Denise Gravelle C, Louis Osternig R. Effect of Proprioceptive Neuromuscular Facilitation Stretch Techniques on Trained and Untrained Older Adults. Journal of Aging and Physical Activity. 2002; 10(2):132-142
12. Nicholson JR, Jack Lemons Deborah Turner Starring,

Marilyn Gossman R, Garvice G. Comparison Of Cyclic And Sustained Passive Stretching Using A Mechanical Device To Increase Resting Length Of Hamstring Muscles. Phys Ther 1988; 68(3):314-320.
13. Kendall FP, McCrear. Muscles. Testing and Function, 3 ed. Baltimore: Md: Williams& Wilkins; 1983.
14. Kapandji IA. The Physiology of the Joints. Edinburgh, Scotland: Churchill Livingstone 1985; 3:6471.
15. Toppenberg R, Bullock M. The interrelation of spinal curves, pelvic tilt and muscle length in the adolescent female. Australian Journal of Physiotherapy. 1986; 32(1):612.
16. Da Silva Díaz R, Gómez-Conesa. A Shortened hamstring syndrome. Fisioterapia 2005; 30:186-193.
17. López Miñarro PA, Rodríguez García PL, Yuste JL, Alacid F, Ferragut C, García Ibarra A. Validity of the lumbo-sacral position in bending as measure of hamstring muscle extensibility on young athletes. Archivos de Medicinadel Deporte 2008; 25:103-110.
18. Erkula G, Demirkan F, Kilic BA, Kiter E. Hamstring shortening in healthy adults. Journal of Back and Musculoskeletal Rehabilitation. 2002; 16(2):77-81.
19. Kevin Singer P, Dip PE, NZRP. A New Musculoskeletal Assessment in a Student Population. J Orthop Sports PhysTher. 1986; 8(1):34-41.
20. Moore, Marjorie A, Robert, Hutton S. Electromyographic investigation of muscle stretching techniques. Med. Sci. Sport Exercise 1980; 12(5):322-9.
21. Beltrão NB, Ritti-Dias RM, Pitangui ACR, De Araújo RC. Correlation between Acute and Short-Term Changes in Flexibility Using Two Stretching Techniques. Int J Sports Med. 2014; 35(14):1151-1154.
22. O'Hora J, Cartwright A, Wade CD, Hough AD, Shum GLK. Efficacy of static stretching and proprioceptive neuromuscular facilitation stretch on hamstrings length after a single session. Journal Strength Cond Res. 2011; 25(6):1586-1591.
23. Bekir Yuktasira, Fatih Kayab. Investigation into the long-term effects of static and PNF stretching exercises on range of motion and jump performance. Journal of Bodywork and Movement Therapies. 2007; 13(1):11-21.
24. Hanten WP, Chandler SD. Effects of myofascial release leg pull and sagittal plane isometric contract-relax techniques on passive straight-leg raise angle. J Orthop Sports Phys Ther. 1994; 20(3):138-44.
25. Dan Wallin RP, Björn Ekblom MD, Raymond Grahn, Thomas Nordenborg. Improvement of muscle flexibility, a comparison between two techniques. Am J Sports Med. 1985; 13(4):263-8.
26. Chen CH, Nosaka K, Chen HL, Lin MJ, Tseng KW, Chen TC. Effects of flexibility training on eccentric exercise-induced muscle damage. Med Sci Sports Exerc 2011; 43(3):491-500.
27. Rees Sven S, Murphy Aron J, Watsford Mark L, Mclachlan Ken A, Coutts Aaron J. Effects of proprioceptive neuromuscular facilitation stretching on stiffness and force-producing characteristics of the ankle in active women. Journal of Strength & Conditioning Research. 2007; 21(2):572-7.
28. Moore MA, Kukulka CG. Depression of Hoffmann reflexes following voluntary contraction and implications for proprioceptive neuromuscular facilitation therapy. Phys Ther 1991; 71(4):321-329.
29. Sady SP, Wortman M, Blanke D. Flexibility training: ballistic, static or proprioceptive neuromuscular facilitation. Arch Phys Med Rehabil 1982; 63(6):261-263.
30. Laurence E, Holt' Thomas M, Travisa Ted Okita. Comparative Study of Three Stretching Techniques. Perceptual and Motor Skills 1970; 31:611-616.
31. Sharman MJ, Cresswell AG, Riek S. Proprioceptive neuromuscular facilitation stretching: mechanisms and clinical implications. Sports Med 2006; 36(11):929-939.
32. Nick Kofotolis, Eleftherios Kellis. Effects of Two 4-Week Proprioceptive Neuromuscular Facilitation Programs on Muscle Endurance, Flexibility, and Functional Performance in Women with Chronic Low Back Pain. Phys Ther 2006; 86(7):1001-1012.
33. Rowlands AV, Marginson VF, Lee J. Chronic flexibility gains: effect of isometric contraction duration during proprioceptive neuromuscular facilitation stretching techniques. Res Q Exerc Sport 2003; 74(1):47-51.
34. Belinda Gabbe J, Kim Bennell L, Henry Wajswelner, Caroline Finch F. Reliability of common lower extremity musculoskeletal screening tests. Physical Therapy in Sport 2004; 5(2):90-97.
35. Richard Gajdosik, Gary Lusin, Hamstring Muscle Tightness. Reliability of an Active-Knee-Extension Test. Phys Ther, 63(7):1085-1088.
36. Denise Cameron, MPE PT, Richard Bohannon W, EdD PT, NCS. Relationship between Active Knee Extension and Active Straight Leg Raise Test Measurements. Journal of Orthopaedic & Sports Physical Therapy 1993; 17(5):257-260.
37. Brosseau L, Balmer S, Tousignant M, O'Sullivan JP, Goudreault C, Goudreault M, *et al*. Intra- and intertester reliability and criterion validity of the parallelogram and universal goniometers for measuring maximum active knee flexion and extension of patients with knee restrictions. Arch Phys Med Rehabil 2001; 82(3):396-402.
38. Richard Gajdosik L, Richard Bohannon W. Clinical Measurement of Range of Motion: Review of Goniometry Emphasizing Reliability and Validity. PhysTher 1987; 67:1867-1872.
39. Shanka Weerasekara, Iresha Kumari, Nilushika Weerarathna, Charith Withanage, Chamika Wanniarachchi, Yancy Mariyanayagam, *et al*. The Prevalence of Hamstring Tightness among the Male Athletes of University of Peradeniya in 2010, Sri Lanka. J Palliative Care Med. 2013; 1:108.
40. William Bandy D, Jean Irion M. The Effect of Time on Static Stretch on the Flexibility of the Hamstring Muscles. PHYS THER 1994; 74(9):845-850.
41. Youdas JW, Haeflinger KM, Kreun MK, Holloway AM, Kramer CM, Hollman JH. The efficacy of two modified proprioceptive neuromuscular facilitation stretching techniques in subjects with reduced hamstring muscle length. *Physiotherapy theory and practice* 2010; 26(4):240-250.
42. Meroni Roberto, Cesare Giuseppe Cerri, Carlo Lanzarini, Guido Barindelli, Giancesare Della Morte, Viviana Gessaga, *et al*. Comparison of active stretching technique and static stretching technique on hamstring flexibility. Clinical journal of sport medicine. 2010; 20(1):8-14.
43. Batista, Lucia Helena, Ana Carolina Vilar, José Jamacy de Almeida Ferreira, José Rubens Rebelatto, *et al*. Active stretching improves flexibility, joint torque, and functional mobility in older women. American Journal of Physical Medicine & Rehabilitation. 2009; 88(10):815-822.