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Research Article

Effect of Dynamic Stretching versus Proprioceptive Neuromuscular Facilitation Stretching of Antagonist Muscle on Knee Extensor Torque and Dynamic Balance in Young Male Collegiate

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I N F O

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A B S T R A C T

Introduction: Many athletes perform stretching exercises as part of a warm-up prior to physical activity in order to prevent injuries and enhance their performance by an increase in flexibility. The significance of this study was that it may provide information about the better stretching method between dynamic and PNF stretching immediately before the sports events which may help to enhance the strength of knee extensor, thereby helping in improving performance and injury prevention.

Method: An experimental design was used in the study. 51 subjects were randomly divided and statistically analysed for results. Group 1 had to under go dynamic stretching, Group 2 had to undergo PNF stretching for a period of four, and Group 3 (control group) did not undergo any kind of stretching.

Results: It was observed that there was no significant difference in peak torque and average torque at 60°/s and 180°/s and SEBT scores after 4 weeks of dynamic vs PNF stretching. No significant difference was found in dynamic balance after 4 weeks of dynamic vs PNF stretching.

Conclusion: We may infer that dynamic stretching and proprioceptive neuromuscular facilitation stretching of antagonist muscle have the same effect on knee extensor torque and dynamic balance in young collegiate males.

Keywords: Dynamic Stretching, PNF Stretching, Isokinetic Peak, Average Torque, Dynamic Balance

Introduction

Stretching is classically used as a part of a warm-up to either increase flexibility or pain-free range of motion (ROM) about a joint in an attempt to ensure better performance and abate the risk of injury.[1] Many athletes perform stretching exercises as a part of warm-up prior to any

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physical activity in order to prevent injuries and amplify their performance by building up flexibility.[2] Rehearsal of the skill about to be performed is incorporated into the warm-up at increasing intensities so that the specific muscle fibres and neural pathways are activated and recruited for optimum performance.[3] It has been well-established that stretching improves neuromuscular performance, including stimulation of muscle temperature and core body temperature, improves muscle strength, and creates better balance and coordination. It also improves the joint ROM Muscular flexibility is quintessential to normal human function. Restricted flexibility may be an underlying cause of many musculoskeletal injuries and may adversely impact one's quality of life. Musculo skeletal repetitive motion injuries resulting from lower-extremity flexibility encompass all injuries from stress fractures and shin splints to PFPS and muscle strains. This "stretching-induced force deficit" has been reported to affect isometric force, power, concentric isometric peak torque, dynamic constant external resistance (DCER) force, vertical jumping performance and balance.[4] There are two principal hypotheses that describe stretching-induced force deficit: (a) the first hypothesis proposes that mechanical factors are responsible for an immediate decrease in musculotendinous stiffness that may be having an adverse impact on the muscle length-tension association and sarcomere shortening speed, and (b) the second hypothesis proposes neural factors as the underlying cause because motor neuron pool excitability diminishes which may decrease peripheral muscle activation, diminish firing frequency, and alter reflex sensitivity. The decrease in neural drive induced by stretching could be for a percentage of the force deficit, and thus neural as well as mechanical factors may reinforce stretching-induced force deficit.[5]

Dynamic stretching (DS) is explained as a controlled active range of motion while in motion but not moving more than the limits of an individual's extensibility.[6] According to a study, the main aim of DS is to enhance the dynamic flexibility of the target muscle by contracting the antagonist muscle without bouncing. A number of studies have found its encouraging impact on high-intensity performance in various activities such as joint ROM, jumping, sprinting, leg power output, as well as agility.

PNF stretching involves passive stretch as well as isometric contractions of the targeted muscle. It is primarily used to improve the strength of muscles, neuromuscular control and joint ROM.[6] Various methods of PNF stretching based on Kabat's concept are Hold Relax, Contract Relax, and Contract Relax Antagonist Contract (CRAC). The Hold Relax (HR) technique involves an isometric contraction of the target muscle against maximum resistance which is followed by a relaxation phase.

An example of dynamic balance is when a person does a deliberate activity on a base of support without yielding the base of support. Various techniques of dynamic balance measurements are used such as Star Excursion Balance test or wobble board.

To the author's knowledge, there has been no published research investigating the effect of dynamic versus PNF stretching for antagonist muscle of knee extensor torque and dynamic balance.

The antagonist muscles create an inhibitory force against the movement of their opposing muscles, which can be reduced by stretching the antagonist muscle. Strength, as well as power, can be improved by this technique after antagonist stretching. A gain in strength may be attained by enhancing the neural activity of the agonist and neurological inhibition of the antagonist.[7] Therefore, the significance of this study was that it will be helpful for sports person and coaches as it may provide information about the better stretching method between dynamic and PNF stretching immediately before the sports events which may help to enhance the strength of knee extensor thus improving performance in explosive sports like soccer, basketball, sprint, etc. and the improvement in dynamic balance may further help in improving performance and injury prevention.

Methodology

It is a pre-test- post-test experimental study design; a randomised controlled trial done on 60 subjects from Jamia Hamdard University, New Delhi who were shortlisted based on the inclusion and exclusion criteria after signing the Informed Consent Form. Inclusion criteria included subjects who were healthy males, aged between 18 and 28 years, and with a BMI between 18.5 and 24.0 kg/m^2. They should have full passive knee flexion, with hamstring muscle tightness. Exclusion criteria were a recent history of any musculoskeletal or neurological impairment, current or recent hip knee and ankle-related injuries within the last six months, systemic disease, or a major surgery within the last six months. 9 subjects dropped out of the study as they completed their course and shifted to their native place. The remaining 51 subjects were randomly divided equally into three groups, which showed the following characteristics: mean age of 21.94 ± 2.98 years, 25 ± 2.29 years, and 23.11 ± 2.73 years, mean BMI of 21.56 ± 5.81, 22.54 ± 1.50, and 22.61 ± 1.86 kg/m^2, mean hamstring flexibility (HF) of 40.35 ± 5.81, 42.11 ± 5.79 and 40.35 ± 5.06, and a mean limb length (LL) of 90.38 ± 2.75 cm, 91.73 ± 5.12 cm, and 90.17 ± 5.21 cm respectively. Approval for the procedure was obtained from the research committee of Jamia Hamdard University prior to data collection.

The subjects of one group had to undergo dynamic stretching, those of the other had to undergo PNF (hold-relax) and those of the control group did not have to undergo any kind of stretching. The values were statistically analysed for results.

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Screening of every subject was done. The subjects were assessed for hamstring tightness using the AKE test (ICC of 0.761).

Procedure for AKE Test

The subject was asked to lie in a supine position with hips at 90 degrees, flexed along with flexed knees. For the correct position of both hip and thigh, a steel crossbar was utilised. The site of testing was the dominant side of the lower extremity following the opposite lower extremity. The pelvis was strapped down to the table for checking unnecessary movements and to keep the pelvis stable. A permanent marker was used to mark greater trochanter, lateral condyle of femur, and lateral malleolus which were utilised as landmarks to measure the range of motion of hip and knee. The fulcrum of the goniometer was kept over the lateral condyle of the femur with the stationary arm along the shaft of femur while the greater trochanter was utilised as a reference point. The hip and knee under testing were kept in 90 degree flexion while contact of the anterior aspect thigh was maintained with the horizontal bar continuously to keep the hip in 90 degrees of flexion. The participant was then asked to extend the lower extremity to the maximum till there was a mild stretch sensation. The angle of knee flexion was measured with a goniometer. The final reading for hamstring tightness was taken as the average of three repetitions.[8]

Maximal concentric isokinetic peak torque and average power for knee extension of the dominant leg (based on kicking preference) were measured at 60°/s and 180°/s on a Biodex Isokinetic dynamometer (System 4) (ICC OS 0.05). Calibration was performed prior to testing. A pre-speed warm-up session as a familiarisation period preceded each action of the isokinetic test. Before the warm-up session, descriptive data (height, weight, age, dominant leg) of participants were tabulated in a computer programme. The warm-up session comprised 3or 4 sub-maximal, with half the effort, followed by 3 maximal (100% effort) repetitions at both velocities.

Procedure for Isokinetic Dynamometer

The participants were tested in a seated position. Thigh, pelvis, and torso straps were utilised to check body movements and keep them stable. Upper body movement and muscular substitution were kept in check by means of diagonal shoulder straps across the chest. A dynamometer was connected to knee attachment with their red dots completely aligned with each other. The subject was then asked to move the knee into flexion and extension in a sitting position. The bony landmark for the axis of rotation of the knee joint with the axis of rotation of the dynamometer shaft red dot was the lateral femoral epicondyle. The calf pads werekept approximately 2 inches proximal to the lateral malleolus and securedusing the padded shin strap.[8]

In two consecutive sessions, a t test was conducted with or without preceding antagonist stretching. There was a 10 min rest between maximal tests with each testing velocity done in a randomised order. The number of maximal attempts was five and the maximum value was considered to analyse the data.[9]

Dynamic Stretching Procedure

In dynamic stretching protocol, the participants were kept in a lying position and their knees were completely extended with maximum flexion of the hip joint. A 5 sec rest was allowed after each movement and repetition of the exercise was done for 4 minutes a day for the right leg. During the next 4 weeks, exercise was done once a day for five days every week.[10]

PNF Stretching Protocol

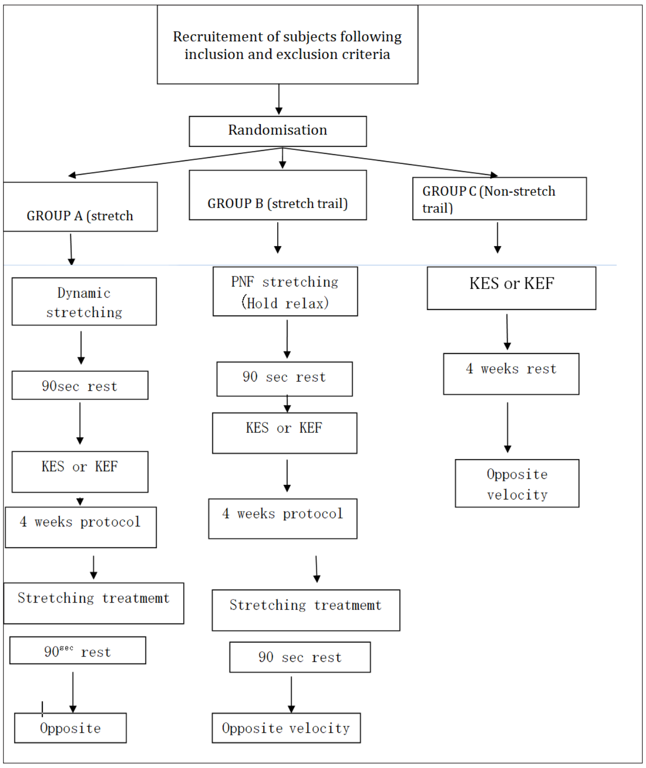

Figure 1.Protocol

The position of the participants was supine with straps on their left lower extremity. The method was standardised using pre-determined time periods for stretching, contracting and relaxing using a stopwatch. The hamstring muscles were stretched by passively flexing the hip with the knee fully extended. These muscles were stretched until the subjects felt a mild stretch sensation; this position was maintained for the next 7 sec. Then, the subjects isometrically contracted the hamstring muscle for 3 sec by attempting to push his leg down towards the table against

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the resistance of the investigator. A relaxation of 5 sec was provided after this. Repetition of stretches was done 5 times with each sequence after a gap of 20 seconds.[11]

Protocol

Figure 1 shows the various steps followed.

Data Analysis

Statistical analysis was done using SPSS Version 21 software system. Independent t-test was used to compare the changes in peak torque at 60°/s and 180°/s and average torque at 60°/s between the groups. For pre and post-test, the significance of differences in dependent variables within the group for dependent variables was tested using the paired t-test, while the significance of differences in dependent variables across the groups for dependent variables was tested using the independent t-test. A statistically significant difference was defined as p value less than 0.05.

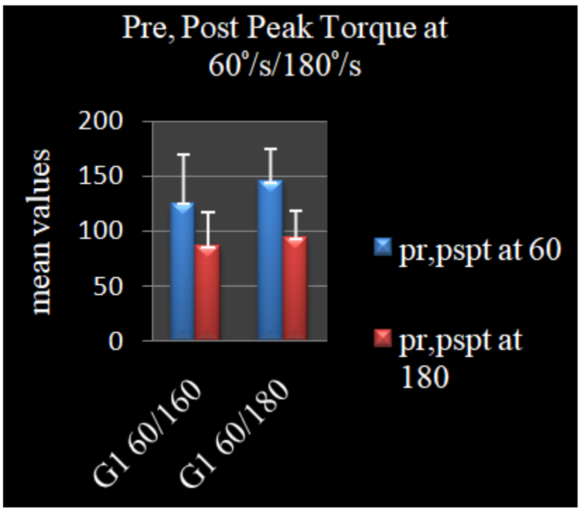
Results

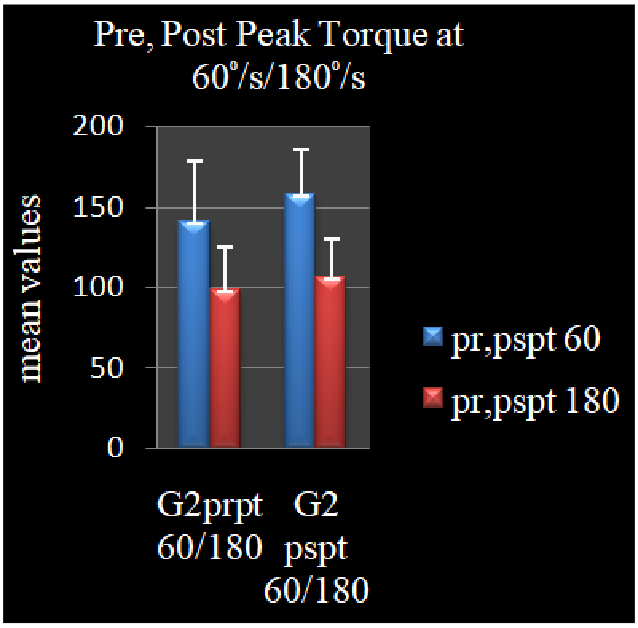
Analysis within the Groups-Peak Torque at 60°/s and 180°/s

The comparison for peak torque at 60°/s and 180°/s within the three groups was carried out using t-test (Figure 2).

In group 1 (G1), statistically significant results were observed for pre-QPT at 60°/s (125.37 ± 44.31) vs post-QPT at 60°/s (145.18 ± 28.96) with a p value of 0.02, while, the results for pre-QPT at 180°/s (86.86 ± 30.02) vs post-QPT at 180°/s (86.86 ± 30.02) showed no statistically significant difference with a p value of 0.18.

Statistically significant results were observed for pre-QPT at 60°/s (141.08 ± 36.97) vs post-QPT at 60°/s (157.61 ± 27.60) with a p value of 0.01 in group 2 (G2). However, the results for pre-QPT at 180°/s (98.73 ± 26.40) vs post-QPT at 180°/s (106.18 ± 23.97) showed no statistically significant difference with a p value of 0.12.





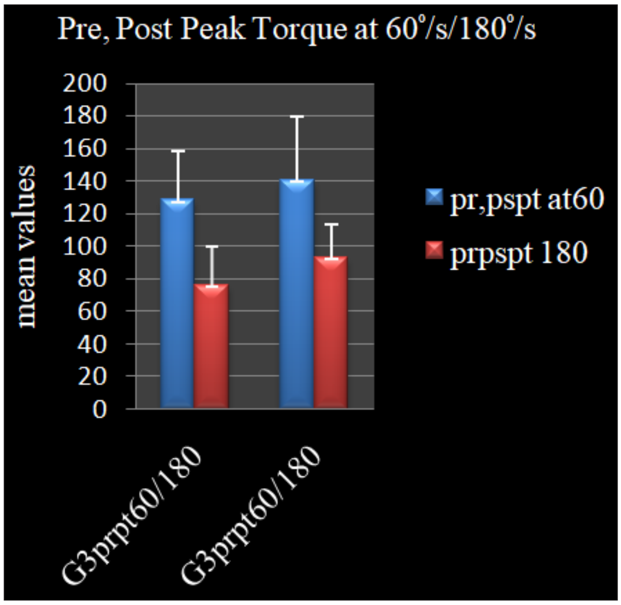


Figure 2.Comparison within the Groups for Peak Torque at 60°/s and180°/s

Statistically significant results were observed in group 3 (G3) for pre-QPT at 180°/s (76.28 ± 23.58) vs post-QPT at 180°/s (93.32 ± 20.00) with p = 0.00. However, for pre-QPT at 60°/s (128.44 ± 29.83) vs post-QPT at 60°/s (140.48 ± 39.01), the results showed no statistically significant difference with a p value of 0.18.

Analysis within the Groups - Average Torque at 60°/s and 180°/s

The in-group comparison for average torque at 60°/s and 180°/s for the three groups was carried out using t-test (Figure 3).

Statistically significant results were observed in G1 for

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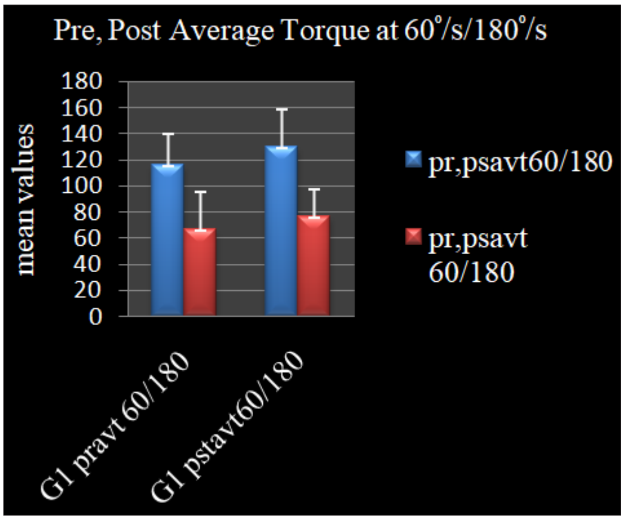
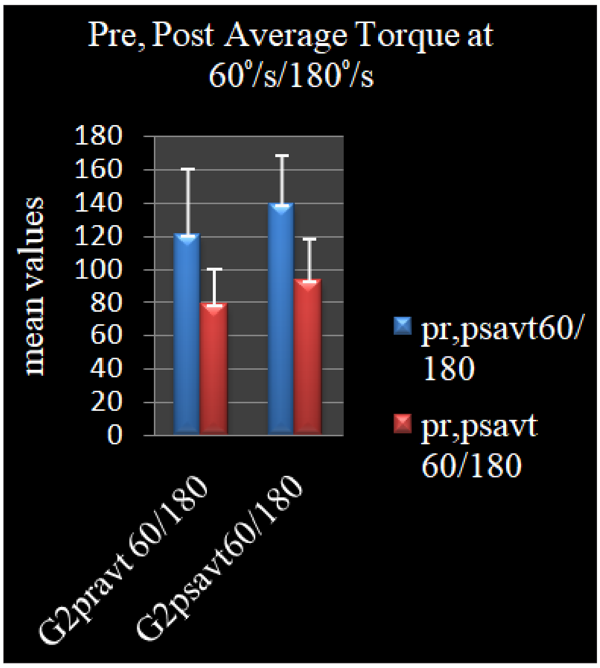
pre-QAVT at 60°/s (116.74 ± 23.37) vspost-QAVT at 60°/s (130.14 ± 28.47) with a p value of 0.00. However, the results for pre-Q AVT at 180°/s (66.87 ± 28.78) vs post-QAVT at 180°/s (76.37 ± 21.04) showed no statistically significant differences (p = 0.08).

Statistically significant results were observed for pre-QAVT at 60°/s (120.62 ± 39.04) vs post-QAVT at 60°/s (139.39 ± 28.47) with a p value of 0.01, while the results for pre-QAVT at 180°/s (78.74 ± 20.73) vs post-QAVT at 180°/s (93.64 ± 24.60) showed statistically significant differences (p = 0.00).

In G3, statistically significant results were observed pre-QAVT at 180°/s (59.60 ± 17.70) vs post-QAVT at 180°/s (80.67 ± 18.09) with a p value of 0.00. On the other hand, the results for pre-QAVT at 60°/s (107.85 ± 27.89) vs post-QAVT at 60°/s (120.44 ± 29.23) showed no statistically significant difference (p = 0.07).





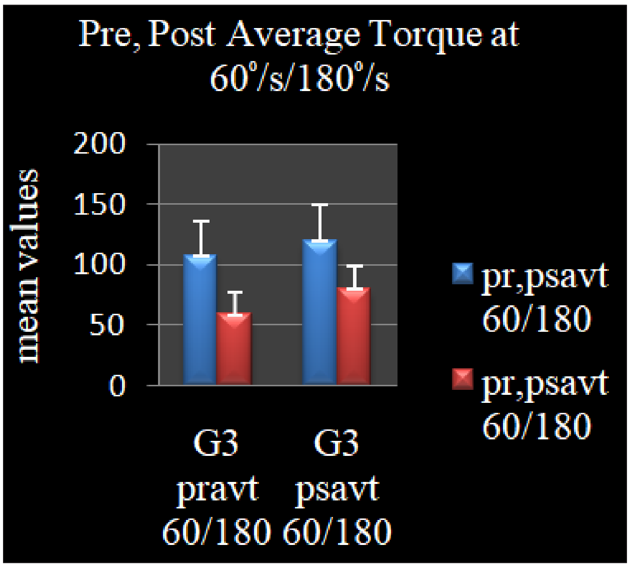


Figure 3.Comparison within the Groups for Average Torque at 60°/s and 180°/s

Analysis within the Groups - SEBT (Dynamic Balance Test) for Right Leg

The in-group comparison for dynamic balance via SEBT for the three groups was carried out using t-test.

Statistically significant results were observed for dynamic balance (DB) in G1 (pre-test value = 7.10 ± 0.84, post-test value = 7.65 ± 0.97, p value = 0.00), G2 (pre-test value = 7.10 ± 1.00, post-test value = 7.95 ± 1.15, p value = 0.00), and G3 (pre-test value = 6.30 ± 0.98, post-test value = 7.02 ± 1.19, p value = 0.00) (Figure 4).

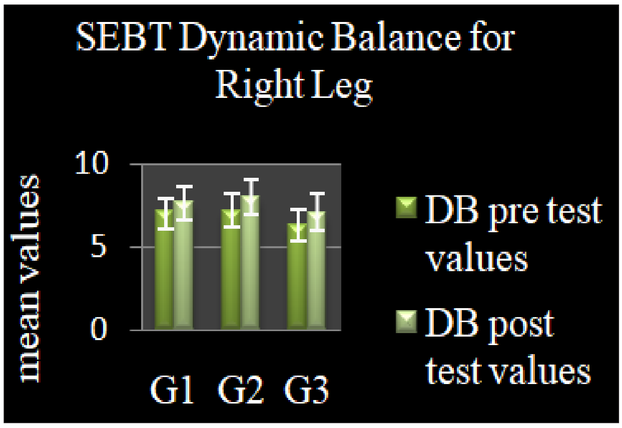


Figure 4.SEBT (Dynamic Balance Test) for Right Leg

Analysis within the Groups - SEBT (Dynamic Balance Test) for Left Leg

Statistically significant results were observed for dynamic balance (DB) in G1 (pre-test value = 7.34 ± 0.91, post-test value = 7.83 ± 1.14, p value = 0.00), G2 (pre-test value = 7.66 ± 0.92, post-test value = 8.06 ± 0.98, p value = 0.03), and G3 (pre-test value = 6.55 ± 1.16, post-test value = 7.28 ± 1.32, p value = 0.00) (Figure 5).

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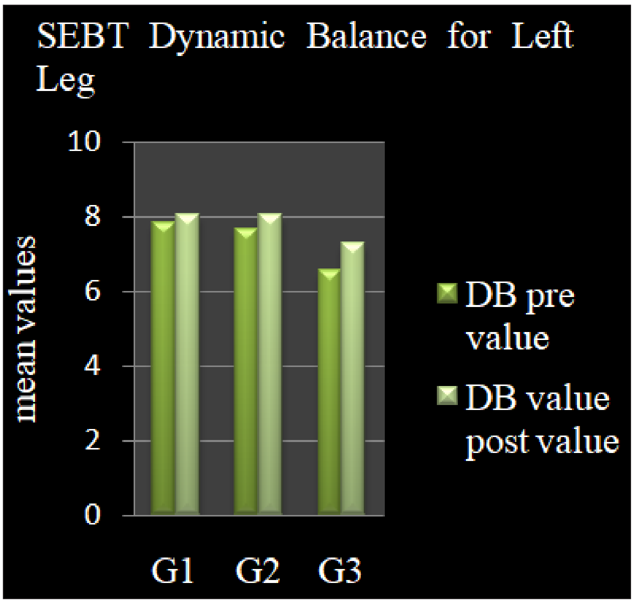

Figure 5.SEBT (Dynamic Balance Test) for Left Leg

Analysis among the Groups using ANOVA followed by Post Hoc Test

ANOVA test was used followed by Post Hoc test (Bonferroni Alfa) to do multiple comparisons among the three groups.

Differences in Quadriceps - Peak Torque at 60˚/s

The analysis revealed that the mean baseline measurements of quadriceps pre-peak torque at 60˚/s of G1, G2, and G3 were 125.37 ± 44.31, 141.08 ± 36.97, and 128.44 ± 29.83 respectively. The result showed no statistically significant difference in quadriceps pre-peak torque in G1 vs G2 with p value of 0.68, G1 vs G3 with p value of 1, and G2 vs G3 with p value of 0.99 with mean difference of 15.71, -3.06, and 0.99 respectively (Figure 6).

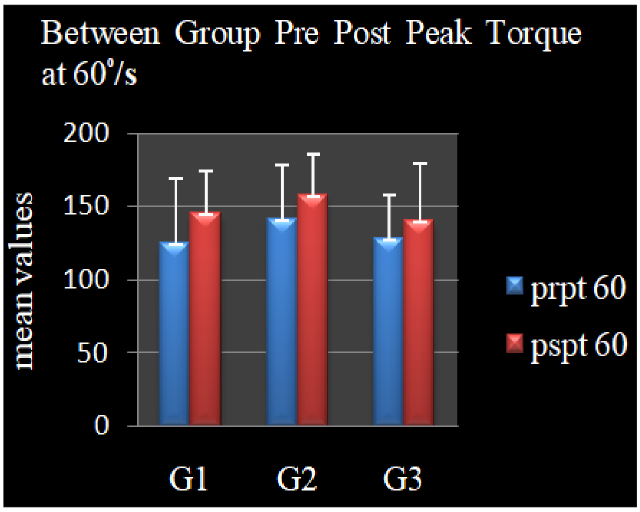

Figure 6.Difference in Quadriceps among the 3 Groups(Peak Torque at 60˚/s)

After 4 weeks of intervention, the analysis of quadriceps post-peak torque at 60˚/s revealed that mean values of G1, G2 and G3 were 145.18 ± 28.96, 145.18 ± 28.96, and 140.48 ± 39.01 respectively. The result showed no statistically significant difference inquadriceps post-peak torque in G1vs G2 (p = 0.99), G1 vs G3 (p = 1), and G2 vs G3 (p = 0.27) with mean difference of 12.42, -9.30, and 21.72 respectively.

Difference in Quadriceps - Peak Torque at 180˚/s

The analysis revealed that the mean baseline measurements of quadriceps pre-peak torque at 180˚/s of G1, G2 and G3 were 86.86 ± 30.02, 98.73 ± 26.40, and 98.73 ± 26.40 respectively. The result showed a statistically significant difference in quadriceps pre-peak torque in G2 vs G3 (p = 0.05) and a mean difference of 22.45. No significance was observed in G1 vs G2 (p = 0.60) and G1 vs G3 (p = 0.76) with mean difference of -11.87 and 10.58 respectively (Figure 7).

After 4 weeks of intervention, the analysis revealed that mean values of quadriceps post-peak torque at 180˚/s for G1, G2, and G3 were 94.30 ± 24.04, 106.18 ± 23.93, and 93.32 ± 20.00 respectively. The result showed no statistically significant difference in quadriceps post-peak torque in G1 vs G2 with p value of 0.40, G1 vs G3 with p value of 1.0, and G2 vs G3 with p value of 0.31, and mean difference of 11.88, 0.98, and 12.86 respectively.

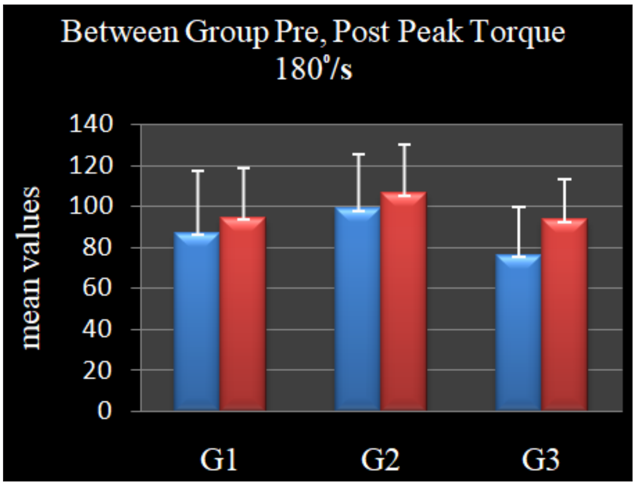

Figure 7.Difference in Quadriceps among the 3 Groups (Peak Torque at 180˚/s)

Difference in Quadriceps - Average Torque at 60˚/s

The analysis revealed that the mean baseline measurements of quadriceps pre-average torque at 60˚/s of G1, G2, and G3 were 116.74 ± 2 3.37, 120.62 ± 39.04, and 107.85 ± 27.89 respectively. The result showed no statistically significant difference in quadriceps pre-average torque in G1 vs G2

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with p value of 1.0, G1 vs G3 with p value of 1.0, and G2 vs G3 with p value of 0.69, and a mean difference of 3.88, 8.88, and 12.77 respectively (Figure 8).

The analysis of the results of quadriceps post-average torque at 60˚/s after 4 weeks of intervention revealed that the mean values for G1, G2, and G3 were 130.14 ± 28.47, 139.39 ± 28.47 and 120.44 ± 29.23 respectively. The result showed no statistically significant difference of quadriceps post-average torque in G1 vs G2 (p = 1.0), G1 vs G3 (p = 0.99), and G2 vs G3 (p = 0.18), and mean difference of 9.25, 9.69, and 18.94 respectively.

Analysis between the Groups (Average Torque at 60˚/s)

Difference in Quadriceps (Average Torque at 180˚/s)

The analysis revealed that the mean baseline measurements of quadriceps pre-average torque at 180˚/s of G1, G2, and G3 were 66.87 ± 28.78, 78.74 ± 20.73, and 59.60 ± 17.70 respectively. The result showed a statistically significant difference in quadriceps pre-average torque in G2 vs G3 (p = 0.05) and a mean difference of 19.14. No significance was observed in G1 vs G2 (p = 0.41) and G1 vs G3 (p = 0.1) with mean difference of -11.87 and 7.27 respectively (Figure 9).

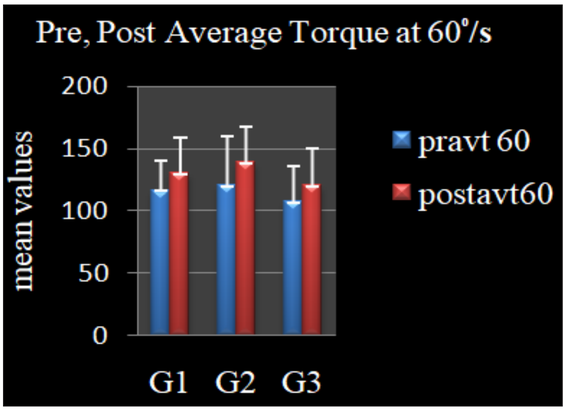

Figure 8.Difference in Quadriceps among the 3 Groups(Average Torque at 60˚/s)

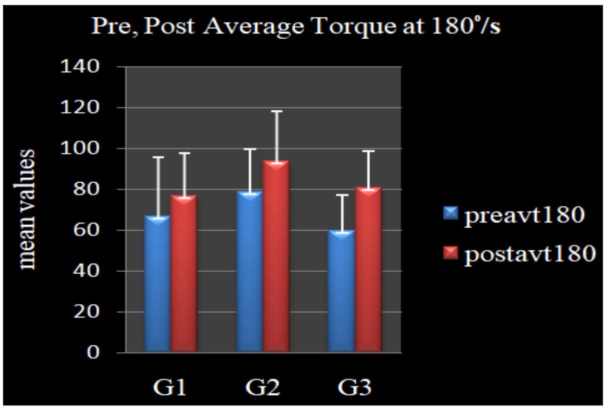

Figure 9.Difference in Quadriceps among the 3 Groups (Average Torque at 180˚/s)

After 4 weeks of intervention, the analysis of quadriceps post-average torque at 180˚/s revealed the mean values of G1, G2, and G3 to be 76.37 ± 21.09, 93.64 ± 24.60, and 80.67 ± 18.09 respectively. The result showed no statistically significant difference in quadriceps post-average torque in G1 vs G2 with p value of 0.06, G1 vs G3 with p value of 1.0, and G2 vs G3 with p value of 0.25, and a mean difference of -17.26, -4.30, and 12.96 respectively.

Differences in Dynamic Balance of Right Leg (SEBT) among the Groups

The analysis revealed that the mean baseline measurement of pre-test values of G1, G2 and G3 were 7.10 ± 0.84, 7.18 ± 1.00, and 6.30 ± 0.98 respectively. The result showed a statistically significant difference in the pre-test values of dynamic balance in G2 vs G3 (p = 0.02) and G1 vs G3 (p = 0.05)with a mean difference of -0.80 and 0.87 respectively. No significant difference was observed in G1 vs G2 (p = 1.0) with a mean difference of -0.07 (Figure 10).

The post-test values of dynamic balance after 4 weeks of intervention revealed that the mean values of G1, G2, and G3 were 7.65 ± 0.97, 7.65 ± 1.15 and 7.02 ± 1.19 respectively. The result showed statistically significant difference in the post-test values of dynamic balance in G2 vs G3 (p = 0.05), G1 vs G2 (p = 1.0), and G1 vs G3 (p = 0.31) and mean difference of -0.29, -0.63, and -0.92 respectively.

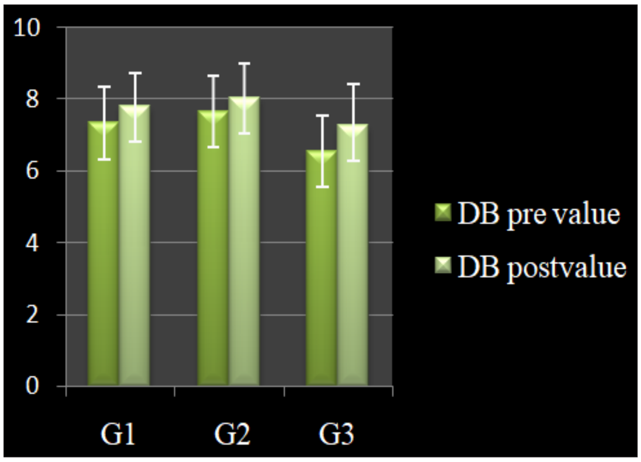

Figure 10.Comparison among Group Values for Right Leg (SEBT)

Differences in Dynamic Balance of Left Leg (SEBT) among the Groups

The analysis revealed that the mean baseline measurements of pre-test values of G1, G2, and G3 were 7.34 ± 0.91, 7.66 ± 0.92 and 6.55 ± 1.16 respectively. The result showed a statistically significant difference in the pre-test values of dynamic balance in G2 vs G3 (p = 0.00) with a mean difference of 1.10. No significant difference was observed in G1 vs G2 (p = 1.0) and G2 vs G3 (p = 0.08) with mean difference of -0.32 and -0.78 respectively (Figure 11).

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The analysis of the post-test values of dynamic balance after 4 weeks of intervention showed that the mean values of G1, G2, and G3 were 7.83 ± 1.14, 8.06 ± 0.98 and 7.28 ± 1.32 respectively. The result revealed no statistically significant difference in the post-test values of dynamic balance in G1 vs G2 with p value of 1.0, G1 vs G3 with p value of 0.53, and G2 vs G3 with p value of 0.17 and a mean difference of -0.23, -0.54, and -0.77 respectively.

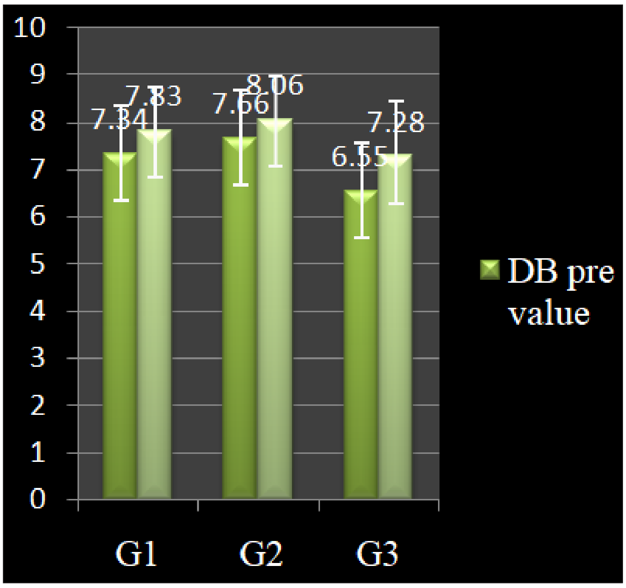

Figure 11.Comparison among Group Values for LeftLeg (SEBT)

Discussion

The purpose of this study was to investigate and compare the effect of dynamic stretching versus proprioceptive neuromuscular facilitation stretching of the antagonist muscles on knee extensor torque and dynamic balance.

In this study, the demographic data of the subjects revealed that homogeneity was not present across the three groups with respect to age as statistically significant differences were found while comparing group 1 and group 2 with a p value of 0.00. The subjects in the three groups were matched with respect to BMI, hamstring flexibility, and lower limb length.

Peak Torque

Dynamic stretching of the antagonist (hamstrings) muscles showed a significantly increased peak torque production for an isokinetic knee extension at 60°/s but a significant enhancement was not observed on these variables at 180°/s. These findings proved that the effect of antagonist stretching on peak torque production could be specific to velocity.

The results for PNF training also showed an increased peak torque production for an isokinetic knee extension at 60°/s but did not produce a significant enhancement on these variables at 180°/s.

The mechanism by which muscular performance was enhanced after dynamic stretching and PNF stretching may be due to two possibilities. Firstly, there may be certain positive impacts associated with temperature, for instance, dynamic short-duration performance is improved by an increase in muscle temperature. Increase in temperature occurs primarily as intra-muscular friction increases during exercises; more the temperature of the muscle, better the transmission rate of impulse, which shows a positive impact on the force-velocity relationship. The impact of skeletal muscle pumping would be a relatively large increase in the blood flow in muscle in comparison to static stretching protocol.

The second possibility is that neuromuscular phenomena elicited from a dynamic stretch or a PNF stretch may be contributing factors that lead to increased muscle force and power development.[12]

With further training in dynamic stretching, greater improvement in strength and power outcomes may be possible. The dynamic stretching process is not practised by recreational athletes worldwide; therefore, a difference in comfort level is observed among these athletes. As it is a new motor skill, a number of movements involved in dynamic stretching need an enhanced motor coordination and control of the increased level of exertion.[13]

The results of our study are not in line with a study carried out by Marek et al. where in a reduction in the peak torque, as well as mean power output in comparing static stretching with PNF during isokinetic leg extension, was reported when compared with no stretching. Large number of PNF stretching, when compared with other methods, has been explained by the theory of autogenic and reciprocal inhibition and it is also considered a possible cause of the reduction in endurance as it is directly related to the reduction in force.[14]

Nelson et al.[14] reported an opposite and negative effect for agonist stretching on peak knee extension torque. Three exercises were done to stretch the quadricep muscles before isokinetic knee extension tests.

Participants did exercises four times with 30 sec retention of each stretch. They tested five different velocities. Only the 2 slowest velocities showed a significant reduction ($p < 0.05$) in peak torque.

The present study found dissimilar results from this study and indicated that antagonist stretching of quadriceps had an opposite effect as compared to that of agonist stretching.

Our results support the results of the study by Manoel et al. who observed an enhanced knee extensor power at 60°/s and 180°/s with three repetitions of 30 sec dynamic stretches. The intensity of dynamic stretching is another factor to be considered.

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Average Torque

In a similar study, it was found that the electro myographic (EMG) response of the vastus lateralis for the fast knee extension stretch condition was 9.7% more than the fast knee extension non-stretch condition but a statistical difference was not seen.

This suggests that there was no relation between the difference in torque observed and increased activation of the prime movers. There was a 16% lower EMG response of the antagonist biceps femoris in the fast knee extension stretch versus the fast knee extension non-stretch, but a statistically significant difference was not found.[15]

Though biceps femoris EMG activity between fast knee extension stretch and fast knee extension non-stretch condition did not show a statistically significant difference, a moderate effect size (d = 0.55) for the decrease in biceps femoris EMG activity was observed by stretching the hamstring. This showed that stretching the hamstring before fast knee extension could decrease electrical activity in these muscles. Reduced electrical activity to the antagonist biceps femoris may also result in decreased braking forces and better production in the quadriceps.[16]

Young W and Elliott S, in their study, found that PNF and static stretching decrease the force as well as the power-producing capacity of the leg extensors accompanying voluntary maximal concentric isokinetic muscle actions at 60°/s and 300°/s. There are two factors that explain the stretching-induced reduction in the capacity to produce muscular force: (1) mechanical factors, such as changes in the viscoelastic qualities of the musculo tendinous unit, and (2) neurologic factors, such as decreased motor unit activation.[17] Rees et al. studied the impact of PNF stretching (three times per week for 4 weeks) on musculotendinous unit (MTU) stiffness of the ankle joint. An improvement in ankle ROM (7.8%), maximal isometric strength (26%), rate of force development (25%), and MTU stiffness (8.4%) was observed. Adaptations to maximal isometric muscle contractions applied in PNF stretching bouts may be the underlying cause of enhanced MTU stiffness following the training period.[18] Neither impairment nor facilitation was seen by dynamic stretching in the isokinetic force in the present study. Certain earlier researches have also reported no improvement in leg extensor and flexor concentric isokinetic peak torque. The procedure of improvement of subsequent performances by dynamic stretching may be associated with the betterment seen in central programming of muscle contraction/ coordination and reduced tiredness through enhanced warm up activity.[19] Our results are in concordance with the study of Ezzat H who studied the effect of passive stretching exercises as an optimal exercise programme to increase muscle length. The study found the maximum improvement in ROM immediately after stretching.[19]

Dynamic Balance - SEBT (Right and Left)

Mckeon et al. studied the impact of a 4-week balance training programme on both static and dynamic postural control in those with chronic ankle instability (CAI). The programme highlighted the dynamic stabilisation on single-leg stance. Reach distances improved significantly in the balance training group with the posteromedial (p = 0.01) and the posterolateral (p = 0.03) directions of the SEBT. Similarly, Hale et al. also observed differences in the posteromedial (p = 0.03), posterolateral (p = 0.01) reach directions of SEBT and a composite score of all 8 directions (p = 0.03) following a 4-week intervention of strength, ROM, and neuromuscular control exercises in those who had CAI.[20]

In a 6 weeks intervention training programme in healthy and physically active young adults, Kahle and Gribble observed scores higher by more than 4% (p = 0.001) in the anteromedial direction in the exercise group and 6% improvement from baseline as well as more than 6% improvement as compared to the control group in the medial direction with moderate to strong effect sizes.[21]

A study by Fitzgerald et al. reported improvements of 2.95% to 9.4% in the anterior, posteromedial, and posterolateral reach directions of SEBT after the 12 exercise sessions of a wobble board or postural stability training.[22]

Limitations

- There was no EMG investigation for activities to know about the mechanism of enhancement of performance for both types of stretching techniques
- The number of subjects was small
- The subjects were not matched as per age in dynamic vs PNF group

Future Research

- This study was conducted on healthy young adults. Future research should be done to assess the effect of stretching on older age groups, and to assess whether middle-aged or elderly adults show similar results
- Gender-specific studies should be designed to evaluate the difference in patterns between men and women
- Future research is required to find the best possible procedures based on mechanical, neural, or a combination of both in strength gain for both types of stretching techniques
- Future research is required to assess other types of muscle and movement patterns. The effect of the methods of antagonist stretching other than dynamic and PNF (e.g. static) should be investigated

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Conclusion

It was observed from the results that there was no significant difference in peak torque and average torque at 60°/s and 180°/s and SEBT scores after 4 weeks of dynamic vs PNF stretching. No significant difference was observed in dynamic balance after 4 weeks of dynamic vs PNF stretching.

To conclude, we may infer that dynamic stretching and proprioceptive neuromuscular facilitation stretching of antagonist muscles have the same effect on knee extensor torque and dynamic balance in young collegiate males.

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