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RESEARCH ARTICLE

EFFECTS OF CONTRACT RELAX ANTAGONIST CONTRACT PNF AND DYNAMIC STRETCHING TECHNIQUES ON PERFORMANCE MEASURES OF LONG DISTANCE RUNNERS

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ABSTRACT

This study investigated the effect of 6-weeks of dynamic and contract- relax antagonist contract PNF stretching intervention on performance measures of long distance runners. To obtain data, the investigators had selected sixty (N=60) female long distance runners of 18-23 years of age to act as subjects The purposive sampling technique was used to select the subjects. All the subjects were purposively allotted to Contract Relax Antagonist Contract PNF (CRAC-PNF) stretching group (n_1 =20); Dynamic stretching group (n_2=20) & control Group (n_3=20). All the subjects, after having been informed about the objective and protocol of the study, gave their consent and they volunteered to participate in this study. An Analysis of Covariance was employed to determine the intra group differences among the three groups. When a significant difference among the groups was observed, a pair-wise comparison of the groups was done by using the LSD post-hoc test to identify direction and significant differences between the groups. To test the hypothesis, the level of significance was set at 0.05. The results revealed insignificant differences among long distance runners of three groups on the balance. Significant differences were observed on the variable of agility, flexibility and muscular endurance among the three groups of long distance runners ($p \leq 0.05$). Thus, when LSD Post-Hoc test was applied to study the direction and significance of differences between the paired adjusted final means for flexibility and muscular endurance, the experimental groups were found to be significantly different when compared with the control group. It has been observed that dynamic stretching group had demonstrated significantly better on agility, flexibility and muscular endurance whereas CRAC-PNF stretching group had demonstrated better on agility than control group though not significantly. However, CRAC- PNF stretching group has demonstrated significantly better on flexibility than control. This study concludes that significant differences are observed in agility, flexibility and muscular endurance whereas insignificant differences are observed in balance with regard to long distance runners of three groups.

INTRODUCTION

Stretching is a therapeutic maneuver used for increasing the flexibility of a muscle-tendon unit promotes better performance and decreases the number of injuries. Stretching increases range of motion by its viscoelastic and neural effects. With respect to neural effects of stretching, it is apparent that when slow passive stretches are applied to skeletal muscle of healthy individuals, there is minimal active contractile activity in response to the stretch (Magnusson *et al*., 1995, 1996; McHugh *et al*., 1998; Ryan *et al*., 2008) and indices of motor neuron excitability are decreased (Guissard *et al*., 1988, 2001; Avela *et al*., 1999). While the viscoelastic effects of stretching have shown that increases in joint range of motion are associated with decreases in passive resistance to stretch such that after several stretches of a given duration, resistance to stretch at the same range of motion will be decreased (Magnusson *et al*., 1995, 1996; McHugh *et al*., 1998; Ryan *et al*., 2008). This decrease in resistance can be referred to as a decrease in muscle stiffness or an increase in muscle compliance. Several authors have suggested that stretching has a beneficial effect on injury prevention (Ekstrand *et al*., 1983; Bixler and Jones, 1992; Amako *et al*., 2003; Hadala & Barrios, 2009) by making MTU more compliant (Toft *et al*., 1989; Magnusson *et al*., 1996; McHugh and Nesse, 2008) and enhanced ability to resist excessive muscle elongation may decrease the susceptibility to a muscle strain injury. In contrast, clinical evidence suggesting that stretching before exercise does not prevent injuries has also been reported (Pope *et al*., 1998). PNF stretching is defined as a combination of passive stretch and isometric contractions of the target muscle, is often utilized to increase the joint range of motion, muscular strength, and neuromuscular control by a therapist in clinical and rehabilitation environment (Marek *et al*., 2005). It has demonstrated larger ROM gains which occurs at faster rates

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than static stretching (Marek *et al*., 2005) as this technique uses muscle inhibition before stretch to enhance effectiveness of the stretch (Kisner C & L.A. Colby, 2002; Young and Elliott, 2001). Two techniques are seen in the literature more frequently than others, the contract-relax method (CR) and the contract-relax-antagonist-contract method (CRAC) of PNF. The CR method includes the concentric contraction of the shortened muscle and then relaxation phase of the target muscle that usually included a passive stretch (Etnyre and Abraham, 1986). The CRAC method followed the exact same procedure as the CR method, but is continued further. Instead of just passively stretching the target muscle, the participant contracts the antagonist muscle to the target muscle (Etnyre and Abraham, 1986). Contract-relax-antagonist-contract form of proprioceptive neuromuscular facilitation stretching improves medial - lateral postural stability (Ryan *et al*., 2010). PNF also helps to develop muscular strength and improve performance (Nelson *et al*., 1986). However, acute PNF stretching has also been shown to have even more detrimental effects on strength, power output, as well as maximum vertical jump height when compared to static stretching (Bradley *et al*., 2007; Church J.B *et al*., 2001).

Dynamic stretches are designed in a manner that replicates repetitive movements identical to those performed during an athletic event or exercise session (Mann & Jones, 1999). Dynamic stretching is often included as part of the warm-up or preparation for a sports event. Studies have shown improved muscular performance following dynamic stretching in the areas of shuttle run time, medicine ball throw distance, jump and sprint performance, and leg extension power (Fletcher, 2010; Fletcher & Anness, 2007; Little & Williams, 2006; McMillian *et al*., 2006; Yamaguchi & Ishii, 2005; Yamaguchi *et al*., 2007). Several possible mechanisms by which dynamic stretching improved muscular performance could be elevated muscle and body temperature (Fletcher & Jones, 2004), post-activation potentiation in the stretched muscle (Torres *et al*., 2008), and stimulation of the nervous system (Yamaguchi & Ishii, 2005). According to Gesztesi (1999), a dynamic warm-up before the explosive activity reduces the likelihood of injury. Thus incorporating dynamic stretching warm into the daily preseason training regimen can produce sustained power, strength, muscular endurance, anaerobic capacity, and agility performance enhancements (Herman & smith (2008). However, dynamic warm-ups can also lead to fatigue, which could negatively affect performance (Sargeant, 1987; Edward *et al*., 1972).

MATERIALS AND METHODS

Subjects

To obtain data, the investigators had selected sixty (N=60) female long distance runners between the age group of 18-23 years of age (Mean ± SD: age 20.23± 1.48 years, height 161.32 ± 6.96 cm, body mass 52.05 ± 3.47 kg) to act as subjects. Long distance runners were purposively assigned into three groups: Group-A: PNF stretching (n_1=20); Group-B: Dynamic stretching (n_2=20); Group-C: control (n_1=20). The purposive sampling technique was used to select the subjects. All the subjects, after having been informed about the objective and protocol of the study, gave informed content and volunteered to participate in this study. Data was collected from Guru Nanak Dev University and DAV sports complex, Amritsar, Punjab, India. The graphical representation of subject's demographics is presented in Table 1.

Table 1. Subject's Demographics

Variables	Long distance runners (n_l=60)		
	Dynamic stretching	PNF stretching	Control
Age	20.35±1.56	20.10±1.41	20.25±1.55
Body Height	159.56±6.87	160.47±7.28	163.95±6.23
Body Mass	51.30±3.06	51.85±3.49	53.00±3.78

Variables

Agility was measured by using Illinois Agility Test by recording the minimum time taken to complete the test. Balance was assessed using Stork Balance Test and the time for which the athlete was able to balance on the ball of foot was recorded. Flexibility of hamsting was measured using Sit and Reach Test. Muscular Endurance was determined using Squat Test and the maximum number of squats performed in a minute was recorded.

Stretching Intervention

Contract Relax Antagonist Contract (CRAC) PNF stretching

The muscle was stretched until the subject first reported a mild stretch sensation; this position was held for 10 seconds. Next, the subject then isometrically contracted the stretched muscle for 7 seconds. Following this, the subject was asked to relax the stretched muscle and concentrically contract the opposing muscle for 7 seconds. Then, muscle was stretched for 5 seconds to the new range. This sequence was repeated 5 times with each sequence separated from each by a 20 second interval. General warm up i.e., jogging at normal pace for 5 minutes followed by PNF stretching of: Hip flexors, Hamstring, Quadriceps, Abductors, Adductors, Gastrocnemius.

Dynamic stretching

General warm up i.e., jogging at normal pace for 5 minutes followed by dynamic stretching consisting of following exercise repeated 5 times with 20 seconds rest interval:

Dynamic Stretching Description	Intended muscle group to be stretched	Duration
Frontal plane leg swings	Hip adductors and Abductors	30 s each leg
Saggital plane leg Swings	Hip flexors and extensors	30 s for each leg
Straight leg march	Hamstrings	performed at a walking pace for 30 s
Butt kickers	Quadriceps	performed at a walking pace for 30 s
Drop lunges	Gluteals	30 s for each leg
Lateral lunges	Adductors	30 s for each leg
Ankle bounces	Gastrocnemius	30 s for each leg
High knee carioca	Abductors	performed for 30s at walking pace

CRAC- PNF stretching and dynamic stretching group were given six weeks of stretching, four times a week.

Control Group: General warm up i.e. jogging at normal pace for 5 minutes.

Statistical Technique

An Analysis of Covariance (ANCOVA) was used to determine significant differences for dependent variables within the three groups. When a significant difference among the groups was observed, a pair-wise comparison of the groups was done by using the LSD post-hoc test to identify direction and significant differences between the groups. For testing the hypothesis, the level of significance was set at 0.05.

RESULTS

It is evident from Table 2 that the results of Analysis of Covariance (ANCOVA) among three groups with regard to the variable agility were found to be statistically significant (P<0.05). Since "F" ratio 5.960 was found statistically significant, therefore, Post Hoc test (LSD) was applied to determine the degree and direction of difference between the paired means among the groups with regard to agility. The results of post-hoc test have been presented in Table 3. A glance at Table 3 showed that the mean value of PNF stretching group was 21.481 whereas dynamic stretching group had mean value as 20.895 and the mean difference between both the groups was found 0.585. The p-value sig .041 shows that the dynamic stretching group had demonstrated significantly better on reduced agility time than their counterpart's PNF stretching group. The mean difference between PNF stretching and control group was found 0.355.

Table 2. Analysis of Covariance (ANCOVA) of Experimental Groups and Control Group on the variable of Agility

Source of variance	Sum of Squares	Df	Mean Square	F-ratio	Sig.
Between Groups	8.327	2	4.164	5.960	.005
Within Groups	39.122	56	.699		

F .05 (2, 56)

Table 3. Significance of difference of paired means of Experimental Groups and Control Group on the variable of Agility

Group (A)	Group (B)	Mean Difference (A-B)	Sig.
PNF Stretching Group (Mean=21.481)	Dynamic stretching group	.585*	.041
	Control group	-.355	.187
Dynamic Stretching Group (Mean=20.895)	PNF Stretching group	-.585*	.041
	Control group	-.940*	.001
Control (Mean=21.835)	Dynamic stretching group	.940*	.001
	PNF Stretching group	.355	.187

*Significant at .05 level

The p-value sig .187 shows that the PNF stretching group had demonstrated better on than their counterpart's control group though not significantly. The mean difference between dynamic stretching and control group was found 0.940. The p-value sig .001 showed that the dynamic stretching group had demonstrated significantly better on reduced agility time than their counterpart's control group. The graphical representation of responses has been exhibited in Figure 1.

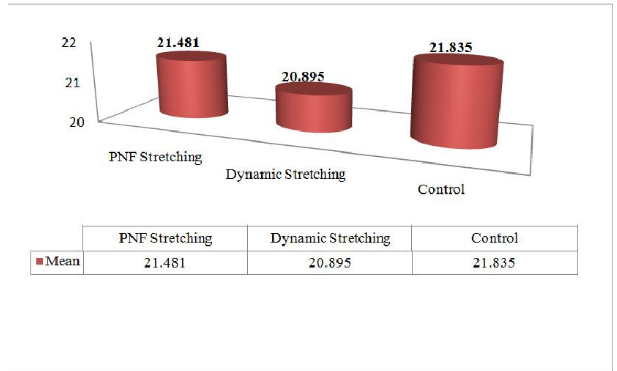

Figure 1. Mean comparison with regard to PNF stretching, dynamic stretching and control on the sub-variable agility

Table 4. Analysis of Covariance of Experimental Groups and Control Group on the variable of Balance (Left Foot)

Source of variance	Sum of Squares	df	Mean Square	F-ratio	Sig.
Between Groups	10.308	2	5.154	2.569	.086
Within Groups	112.353	56	2.006		

F .05 (2, 56)

It is evident from Table 4 that the results of Analysis of Covariance (ANCOVA) among three groups with regard to the variable balance (left foot) were found to be statistically significant (P>0.05). Since the obtained "F" ratio 2.569 was found statistically insignificant, therefore, no need to apply Post Hoc test. It is evident from Table 5 that the results of Analysis of Covariance (ANCOVA) among three groups with regard to the variable balance (right foot) were found to be statistically insignificant (P>0.05).

Table 5. Analysis of Covariance of Experimental Groups and Control Group on the variable of Balance (Right Foot)

Source of variance	Sum of Squares	df	Mean Square	F-ratio	Sig.
Between Groups	12.706	2	6.353	1.922	.156
Within Groups	185.126	56	3.306		

F .05 (2, 56)

Table 6. Analysis of Covariance of Experimental Groups and Control Group on the variable of Flexibility

Source of variance	Sum of Squares	Df	Mean Square	F-ratio	Sig.
Between Groups	18.146	2	9.073	3.640	.033
Within Groups	139.569	56	2.492		

F .05 (2, 56)

Since the obtained "F" ratio 1.922 was found statistically insignificant, therefore, no need to apply Post Hoc test. It is evident from Table 6 that the results of Analysis of Covariance (ANCOVA) among three groups with regard to the variable flexibility were found to be statistically significant

(P<0.05). Since the obtained "F" ratio 3.640 was found statistically significant, therefore, Post Hoc test (LSD) was applied to determine the degree and direction of difference between the paired means among the groups with regard to flexibility. The results of post-hoc test have been presented in Table 7 below.

Table 7. Significance of difference of paired means of Experimental Groups and Control Group on the variable of Flexibility

Group (A)	Group (B)	Mean Difference (A-B)	Sig.
PNF Stretching Group	Dynamic Stretching Group	-.063	.901
(Mean=9.865)	Control	1.195*	.023
Dynamic Stretching Group	PNF Stretching Group	.063	.901
(Mean=9.929)	Control	1.258*	.021
Control	PNF Stretching Group	-1.195*	.023
(Mean=8.671)	Dynamic Stretching Group	-1.258*	.021

*Significant at .05 level

A glance at Table 7 showed that the mean value of PNF stretching group was 9.865 whereas dynamic stretching group had mean value as 9.929 and the mean difference between both the groups was found 0.063. The p-value sig .901 shows that the dynamic stretching group had demonstrated better on flexibility than their counterpart's PNF stretching group though not significantly. The mean difference between PNF stretching and control group was found 1.195. The p-value sig .023 shows that the PNF stretching group had demonstrated significantly better on flexibility than their counterpart's control group. The mean difference between dynamic stretching and control group was found 1.258. The p-value sig .021 shows that the dynamic stretching group had demonstrated significantly better on flexibility than their counterpart's control group. The graphical representation of responses has been exhibited in Figure 2.

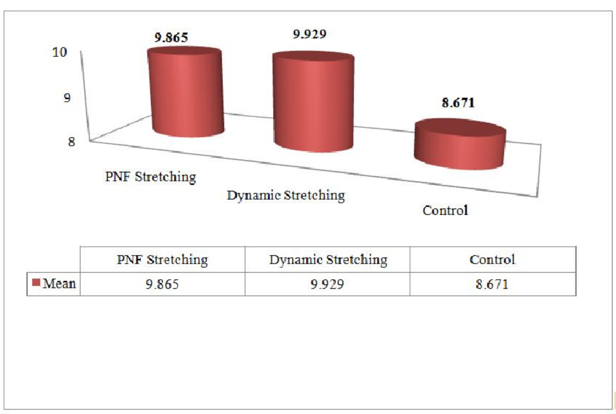

Figure 2. Mean comparison with regard to PNF stretching, dynamic stretching and control on the sub-variable flexibility

It is evident from Table 8 that the results of Analysis of Covariance (ANCOVA) among three groups with regard to the variable muscular endurance were found to be statistically significant (P<0.05). Since the obtained "F" ratio 4.986 was found statistically significant, therefore, Post Hoc test (LSD) was applied to determine the degree and direction of difference between the paired means among the groups with regard to muscular endurance. The results of post-hoc test have been presented in Table 9.

Table 8. Analysis of Covariance of Experimental Groups and Control Group on the variable of Muscular Endurance

Source of variance	Sum of Squares	Df	Mean Square	F-ratio	Sig.
Between Groups	31.904	2	15.952	4.986	.010
Within Groups	179.167	56	3.199		

F .05 (2, 56)

Table 9. Significance of difference of paired means of Experimental Groups and Control Group on the variable of Muscular Endurance

Group (A)	Group (B)	Mean Difference (A-B)	Sig.
PNF Stretching Group	Dynamic Stretching Group	-2.672*	.003
(Mean=25.419)	Control	-.973	.093
Dynamic Stretching Group	PNF Stretching Group	2.672*	.003
(Mean=28.090)	Control	1.699*	.040
Control	PNF Stretching Group	.973	.093
(Mean=26.391)	Dynamic Stretching Group	-1.699*	.040

*Significant at .05 level

A glance at Table 9 showed that the mean value of PNF stretching group was 25.419 whereas dynamic stretching group had mean value as 28.090 and the mean difference between both the groups was found 2.672. The p-value sig .003 shows that the dynamic stretching group had demonstrated significantly better on muscular endurance than their counterpart's PNF stretching group. The mean difference between PNF stretching and control group was found 0.973. The p-value sig .093 shows that the control group had demonstrated better on muscular endurance than their counterpart's PNF group though not significantly. The mean difference between dynamic stretching and control group was found 1.699. The p-value sig .040 showed that the dynamic stretching group had demonstrated significantly better on muscular endurance than their counterpart's control group. The graphical representation of responses has been exhibited in Figure 3.

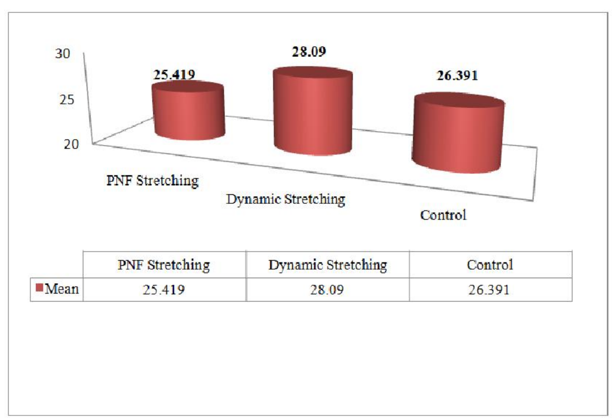

Figure 3. Mean comparison with regard to PNF stretching, dynamic stretching and control on the sub-variable muscular endurance

DISCUSSION

It has been observed from the above Analysis of Covariance (ANCOVA) Table 2 & 3 with regard to agility that significant difference on agility in all the groups of long distance runners. Thus, when LSD Post-Hoc test was applied to study the direction and significance of differences between the paired adjusted final means for agility, all the three experimental groups were found to be significantly different when compared with the control group. Both PNF and dynamic stretching groups have demonstrated better on control group. However, dynamic stretching group has demonstrated significantly better on agility than their counterpart's PNF stretching group.The result of this study is consistent with the results of Amiri-Khorasani *et al*. (2010), reported significant decrease in agility time following dynamic stretching vs. static stretching in soccer players. Herman and Smith (2008) also reported that dynamic-stretching warm-up (DWU) intervention performed daily over 4 weeks positively improved agility in twenty-four male collegiate wrestlers when compared to a static-stretching warm-up (SWU) intervention. A persual at Analysis of Covariance (ANOVA) Table 4 & 5 with regard to balance revealed insignificant differences among long distance runners of three groups. The study which is in accordance to the results of our study is of Wang (2013) who in his study showed that there were no significant differences among the three groups (dynamic stretching, static stretching and control group). In the present study, significant differences are seen on the variable flexibility from Table 6-7 among all the three groups. Both PNF and dynamic stretching groups have demonstrated better on agility than control group. However, dynamic stretching group has demonstrated better on flexibility than their counterpart's PNF stretching group though insignificantly. The result of this study is consistent with the results of Herman and Smith (2008) who found that dynamic-stretching warm-up (DWU) intervention performed daily over 4 weeks positively improved flexibility measures in twenty-four male collegiate wrestlers when compared to a static-stretching warm-up (SWU) intervention. Nagarwal (2010) compared the effectiveness of 3 weeks of two PNF stretching techniques--Hold Relax (HR) and Contract Relax- Antagonist Contract (CRAC) for improving hamstring flexibility. The results demonstrated significant improvement in hamstring flexibility for subjects of CRAC when compared with those of HR at the end of three weeks, with improvement ranging from 0.50 to 15.66 degrees of active knee extension ROM. The results of Fasen *et al*. (2009) also suggested that there was a statistically significant improvement in hamstring length ($p < 0.05$) using active stretches as compared with passive stretches after 4 weeks of stretching. Marek *et al*. (2005) suggested that proprioceptive neuromuscular facilitation stretching protocols increased active range of motion and passive range of motion. The increase in flexibility may be due to decrease in stiffness of muscles and more slack connective tissue around the joints following stretching.

A persual at Analysis of Covariance (ANOVA) Table 8-9 with regard to muscular endurance revealed significant differences among long distance runners of three groups. Thus, when LSD Post-Hoc test was applied to study the direction and significance of differences between the paired adjusted final means for muscular endurance, all the three experimental groups were found to be significantly different when compared with the control group. Dynamic stretching group has demostrated better among all groups. A study which is in accordance to the results of long distance runners is by Herman and Smith (2008) who found that dynamic-stretching warm-up (DWU) intervention performed daily over 4 weeks improved strength-endurance by increasing broad jump (4%), underhand medicine ball throw (4%), sit-ups (11%), and push-ups (3%) in twenty-four male collegiate wrestlers when compared to a static-stretching warm-up (SWU) intervention. However in the present study, control group has demostrated better than PNF stretching group though not significantly. Similarly, Gomes *et al*. (2011) suggested PNF stretching decreased muscle endurance when they compared the effects of static and proprioceptive neuromuscular facilitation (PNF) stretching.

Conclusion

Based on the findings of this study, it is concluded that significant differences were observed in agility, flexibility and muscular endurance whereas insignificant difference was observed in balance among three groups with regard to long distance runners. The results from our study can be beneficial to the athletes for improving agility and flexibility by incorporating dynamic stretching in their daily warm up routine. The results of this study will be of immense support to the sports scientists, physician, teachers and coaches to frame or modify the existing schedules of training. Improvement in agility and flexibility can prevent the long distance runners from falls and injuries and better muscular endurance of legs can allow them to continue running for long period of time.

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