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INVESTIGATION INTO THE EFFECTS OF 6 WEEKS OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION AND DYNAMIC STRETCHING TECHNIQUES ON SELECT FITNESS MEASURES OF POWER ATHLETES

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ABSTRACT

This study investigated the effect of 6 weeks of proprioceptive neuromuscular facilitation and dynamic stretching techniques on select fitness measures of power athletes. To obtain data, the investigators had selected sixty (N=60) female power athletes of 18-23 years of age to act as subjects All the subjects were purposively assigned to Proprioceptive Neuromuscular Facilitation (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 informed content and 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 on the variable agility among power athletes of three groups. Significant differences were observed among power athletes of three groups on the balance, flexibility and muscular endurance ($p \leq 0.05$). Thus, when LSD Post-Hoc test was applied to study the direction and significance of differences between the paired adjusted final means for balance, 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 balance, flexibility and muscular endurance whereas PNF stretching group had demonstrated better on balance than control group though not significantly. However, PNF stretching group has demonstrated significantly better on flexibility than control. This study concludes that significant differences are observed in balance, flexibility and muscular endurance whereas insignificant differences are observed in agility with regard to power athletes.

INTRODUCTION

Stretching is a therapeutic technique designed to improve elasticity of soft tissues and achieve comfortable muscle tone by lengthening the tight structures. Athletes routinely perform stretching as part of a warm up before any exercise or competition to increase joint range of motion, decrease risk of injury and improve athletic performance by decreasing muscle stiffness (Knudson *et al*., 2004). Static tension placed on the muscle-tendon unit during stretching produces autogenic inhibition of the stretched muscle by activating the GTO (Bandy and Sanders, 2001).

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Traditionally, static stretching was the most frequently used technique by athletes and coaches. However many studies have shown its detrimental effects on performance resulting in use of other stretching techniques nowadays. Proprioceptive Neuromuscular Facilitation (PNF) is a stretching technique which is used to improve flexibility of muscle and has been shown to have a positive effect on active and passive range of motions (Funk *et al*., 2003; Lucas and Koslow, 1984; Wallin *et al*., 1985). It has demonstrated larger ROM gains which occurs at faster rates than static stretching as this technique utilizes muscle inhibition before stretch to increase effectiveness of the stretch (Marek *et al*., 2005; Kisner and Colby, 2002; Young and Elliott , 2001). Two techniques: contract-relax method (CR) and the contract-relax-antagonist-contract method (CRAC) of PNF stretching are more frequently used than other methods.

In CR method, the target muscle is lengthened and held in that position while the subject isometrically contracts the target muscle to its maximum for an allotted time period. This is followed by a shorter relaxation of the target muscle by passively stretching the muscle (Etnyre and Abraham, 1986). The CRAC method also follows the same procedure as the CR method, but it is continued further. Instead of just passively stretching the target muscle, the subject contracts the antagonist muscle to the target muscle for another allotted time period (Etnyre and Abraham, 1986). PNF stretching has shown to enhance muscular strength and improve performance of athlete (Nelson *et al*., 1986). However, its effect on muscular function is unclear, as many studies have shown that it improves muscular function when performed after exercise and decreases it when performed before any athletic event (Marek *et al*., 2005; Nelson *et al*., 1986; Bradley *et al*., 2007; Mikolajec *et al*., 2012).

Currently, dynamic stretching method is replacing static stretching in modern warm-up as it has proven to prepare the athlete for sports event in a better way (Fletcher, 2010). It involves controlled, sport-specific movements through the active range of motion for each joint to prepare the body for activity. It uses momentum and active muscle contractions to produce a stretch. The dynamic stretches consist of repetitive movements that are identical to those performed during an athletic event or exercise session (Mann and Jones, 1999). According to Gesztesi, a dynamic warm-up before the explosive activity reduces the likelihood of injury (Gesztesi, 1999). Incorporating dynamic stretching warm into the daily training session can produce sustained power, strength, muscular endurance, anaerobic capacity, and agility performance enhancements (Herman and and Smith, 2008). However, dynamic warm-ups can also lead to fatigue, which could negatively affect performance (Sargeant, 1987; Edwards *et al*., 1972). Thus, the purpose of present study is to investigate the effect of 6-weeks of PNF and dynamic stretching intervention on select fitness measures in power athletes.

MATERIALS AND METHODS

Subjects

To obtain data, the investigators had selected sixty (N=60) female power athletes (wrestlers, power lifters and judo players) between the age group of 18-23 years of age to act as subjects. Power athletes 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.

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

PNF stretching: Contract Relax Antagonist Contract (CRAC) PNF stretching technique was used. 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. PNF stretching and dynamic stretching group were given six weeks of stretching, four times a week. 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:

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 insignificant (P>0.05). Since "F" ratio 2.966 was found statistically insignificant, therefore, there is no need to apply post hoc test.
It is evident from Table 3 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 6.355 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 balance (left). The results of post-hoc test have been presented in Table 4 below.

A glance at Table 4 showed that the mean value of PNF stretching group was 8.286 whereas dynamic stretching group had mean value as 9.292 and the mean difference between both the groups was found 1.005. The p-value sig .006 shows that the dynamic stretching group had demonstrated significantly better on balance (left foot) than their counterpart's PNF stretching group. The mean difference between PNF and control group was found 0.119. The p-value sig .741 shows that the PNF stretching group had demonstrated better on balance (left foot) than their counterpart's control group though not significantly.

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

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

Table 1. Subject's Demographics

Variables	Power Athletes (n_1=60)		
	Dynamic stretching	PNF stretching	Control
Age	19.95±1.31	20.05±1.09	19.90±1.07
Body Height	164.96±6.92	164.13±7.27	161.55±6.91
Body Mass	64.75±5.29	60.90±4.08	60.75±5.89

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	2.509	2	1.255	2.966	.060
Within Groups	23.689	56	.423		

F .05 (2, 56)

Table 3. 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	15.128	2	7.564	6.355	.003
Within Groups	66.649	56	1.190		

F .05 (2, 56)

Table 4. Analysis of Least Significant Difference (LSD) post hoc test among experimental groups and control group on the variable of Balance (left foot)

Group (A)	Group (B)	Mean Difference (A-B)	Sig.
PNF Stretching Group	Dynamic stretching group	-1.005*	.006
(Mean=8.286)	Control group	.119	.741
Dynamic Stretching Group	PNF Stretching group	1.005*	.006
(Mean=9.292)	Control group	1.124*	.002
Control	Dynamic stretching group	-1.124*	.002
(Mean=8.168)	PNF Stretching group	-.119	.741

*Significant at .05 level

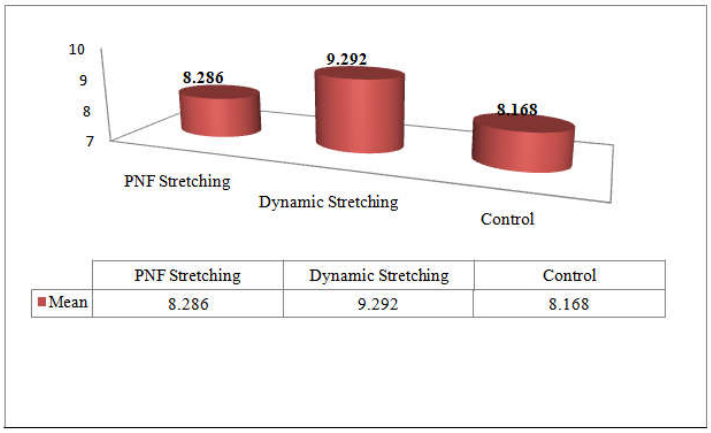

Figure 1. Mean comparison with regard to PNF, dynamic stretching and control on the sub-variable balance (left foot)

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	28.145	2	14.072	4.608	.014
Within Groups	171.025	56	3.054		

F .05 (2, 56)

Table 6. Analysis of Least Significant Difference (LSD) post hoc test among experimental groups and control group on the variable of Balance (Right Foot)

Group (A)	Group (B)	Mean Difference (A-B)	Sig.
PNF Stretching Group	Dynamic stretching group	-1.252*	.028
(Mean=7.399)	Control group	.363	.516
Dynamic Stretching Group	PNF Stretching Group	1.252*	.028
(Mean=8.651)	Control	1.615*	.006
Control	PNF Stretching Group	-.363	.516
(Mean=7.035)	Dynamic Stretching Group	-1.615*	.006

*Significant at .05 level

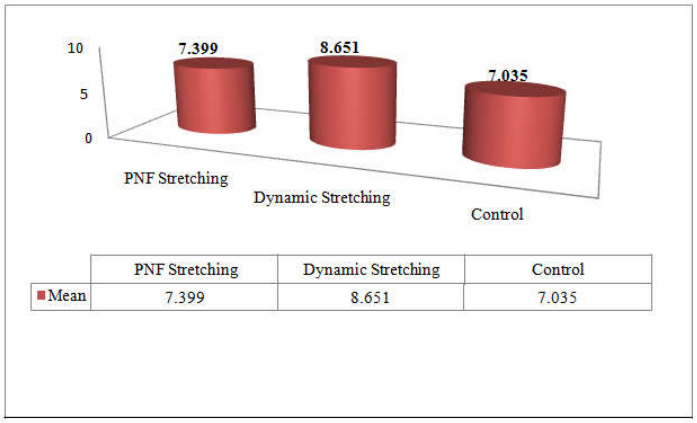

Figure 2. Mean comparison with regard to PNF, dynamic stretching and control on the sub-variable balance (right foot)

Table 7. 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	82.993	2	41.497	21.924	.000
Within Groups	105.996	56	1.893		

F .05 (2, 56)

Table 8. Analysis of Least Significant Difference (LSD) post hoc test among 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	-.925*	.040
(Mean=9.163)	Control	1.934*	.000
Dynamic Stretching Group	PNF Stretching Group	.925*	.040
(Mean=10.088)	Control	2.859*	.000
Control	PNF Stretching Group	-1.934*	.000
(Mean=7.229)	Dynamic Stretching Group	-2.859*	.000

*Significant at .05 level

The mean difference between dynamic stretching and control group was found 1.124. The p-value sig .002 showed that the dynamic stretching group had demonstrated significantly better on balance (left foot) than their counterpart's control group. The graphical representation of responses has been exhibited in Figure1. 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 significant (P<0.05).

Since the obtained "F" ratio 4.608 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 balance (right). The results of post-hoc test have been presented in Table 6 below. A glance at Table 6 showed that the mean value of PNF stretching group was 7.399 whereas dynamic stretching group had mean value as 8.651 and the mean difference between both the groups was found 1.252.

The p-value sig .028 shows that the dynamic stretching group had demonstrated significantly better on balance (right foot) than their counterpart's PNF stretching group. The mean difference between PNF stretching and control group was found 0.363. The p-value sig .516 shows that the PNF stretching group had demonstrated better on balance (right foot) than their counterpart's control group though insignificantly. The mean difference between dynamic stretching and control group was found 1.615.

The p-value sig .006 showed that the dynamic stretching group had demonstrated significantly better on balance (right foot) than their counterpart's control group. The graphical representation of responses has been exhibited in Figure 2. It is evident from Table 7 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 21.924 was found statistically significant, therefore, Post Hoc test (LSD) was applied to

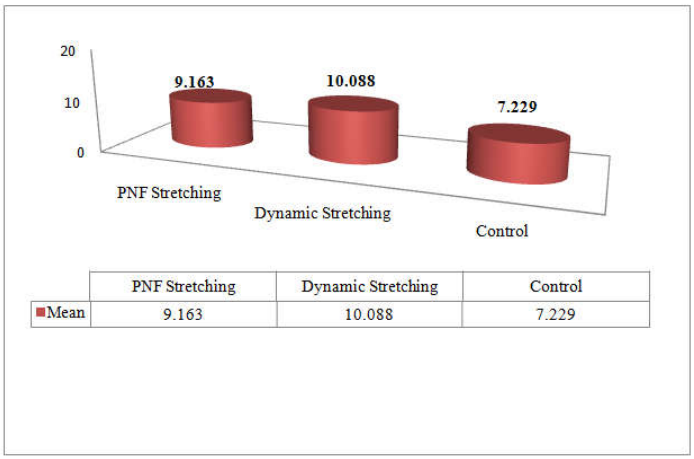

Figure 3. Mean comparison with regard to PNF, dynamic stretching and control on the sub-variable flexibility

Table 9. 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	31.061	2	15.530	7.456	.001
Within Groups	116.643	56	2.083		

F .05 (2, 56)

Table 10. Analysis of Least Significant Difference (LSD) post hoc test among 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	-1.848*	.000
(Mean=33.760)	Control	-.872	.136
Dynamic Stretching Group	PNF Stretching Group	1.848*	.000
(Mean=35.608)	Control	.976*	.050
Control	PNF Stretching Group	.872	.136
(Mean=34.632)	Dynamic Stretching Group	-.976*	.050

*Significant at .05 level

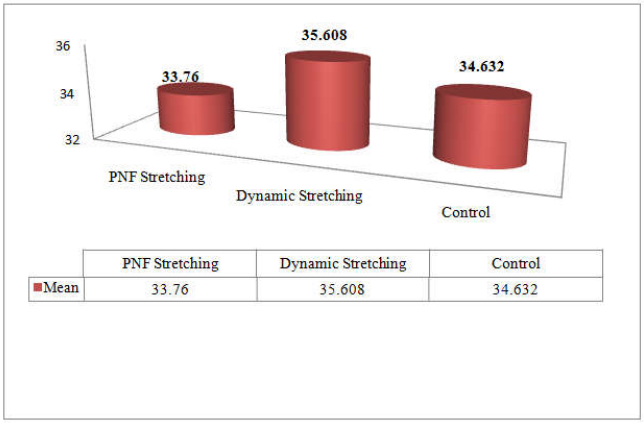

Figure 4. Mean comparison with regard to PNF, dynamic stretching and control on the sub-variable muscular endurance

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 8 below. A glance at Table 8 showed that the mean value of PNF stretching group was 9.163 whereas dynamic stretching group had mean value as 10.088 and the mean difference between both the groups was found 0.925. The p-value sig .040 shows that the dynamic stretching group had demonstrated significantly better on flexibility than their counterpart's PNF stretching group. The mean difference between PNF stretching and control group was found 1.934. The p-value sig .000 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 2.859. The p-value sig .000 showed 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 3.

It is evident from Table 9 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 7.456 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 10 below. A glance at Table 10 showed that the mean value of PNF stretching group was 33.760 whereas dynamic stretching group had mean value as 35.608 and the mean difference between both the groups was found 1.848. The p-value sig .000 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 0.872. The p-value sig .136 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 0.976. The p-value sig .050 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 4.

DISCUSSION

It has been observed from the above Analysis of Variance (ANOVA) table 2 with regard to agility that no significant difference on agility in all the groups of power athletes. Wallmann *et al*. (2008) showed the same results as of present study, that there was no significant difference among the agility of the three different stretching techniques (static, contract-relax, no stretch) in twelve healthy, female, collegiate soccer players (Wallmann *et al*., 2008). Another study by Chaouachi (2009) investigated the effects of static and dynamic stretching alone and in combination on subsequent agility and results revealed no significant differences for agility (Chaouachi *et al*., 2010). Also, Radice and Marissa (2012) did not find significant difference in agility after 10 weeks of Static stretching, PNF stretching and self-myofascial release (Radice, 2012). Analysis of Variance (ANOVA) table 3-6 with regard to balance revealed significant differences among power athletes 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 balance, all the three experimental groups were found to be significantly different when compared with the control group. Thus, flexibility training leads to significant improvement in balance of power athletes. Dynamic stretching group has demonstrated better among all the three groups. The study which is in accordance to the results of our study is of Wang (2013) who in his study showed significant improvement in anterior, posterior- lateral and posterior- medial balance in both static and dynamic stretching intervention. However, there was also no significant interaction between two stretching interventions (Wang , 2013). The enhanced ability to maintain balance after an increased flexibility might be due to a desensitized stretch reflex. A less responsive stretch reflex could suppress the postural deviations, enhance the proprioceptive input, and thus make it easier to establish equilibrium. Another contributor might be elevated muscle and body temperature after dynamic stretching, which enhance nerve conduction velocity. The sensory systems might play a dominant role in regulating the static postural control. However in the present study, the PNF stretching group has demonstrated better on Balance than their counterpart's control group though not significantly.

A study by Ryan *et al*. (2010) revealed that contract-relax-antagonist-contract (CRAC) form of proprioceptive neuromuscular facilitation (PNF) stretching of the hamstrings, plantar flexors, and hip flexors with or without warm-up improved Medial/Lateral stability (Ryan *et al*., 2010). In the present study, significant differences are seen on the variable flexibility from table 7-8 among all the three groups. Both PNF and dynamic stretching groups have demonstrated better on control group. However, dynamic stretching group has demonstrated significantly better on flexibility than their counterpart's PNF stretching group.The result of this study is consistent with the results of Marek *et al*. (2005) who suggested that proprioceptive neuromuscular facilitation stretching protocols increased active range of motion and passive range of motion (Marek , 2005). 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 (Nagarwal *et al*., 2010). The increase in flexibility may be due to decrease in stiffness of muscles and more slack connective tissue around the joints following stretching. 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 (Fasen *et al*., 2009). Herman and Smith (2008) 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 (Herman and Smith, 2008). A persual at Analysis of Variance (ANOVA) table 9-10 with regard to muscular endurance revealed significant differences among power athletes 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 power athletes 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 (Herman and Smith, 2008). 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) (Gomes *et al*., 2011).

Conclusion

Based on the findings of this study, it is concluded that significant differences were observed in balance, flexibility and muscular endurance whereas insignificant difference was observed in agility among three groups with regard to power athletes. The results from our study can be beneficial to the athletes for improving balance and flexibility by incorporating dynamic stretching in their daily warm up routine and can hence decreasing the incidence of injury by fall in sports event. Coaches and athletic trainers may utilize the findings of the present study by preparing or modifying the existing training schedules for power athletes. Improvement in muscular endurance can help athletes who indulge in power activities.

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