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RESEARCH ARTICLE

TO COMPARE THE LOWER EXTREMITY STATIC & DYNAMIC BALANCE AND CORE STABILITY PERFORMANCE IN DIFFERENT STRENGTH SPORTS

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ABSTRACT

Aim: The purpose of this study was to compare the lower extremity static & dynamic balance and core stability performance in three different types of strength athletes.
Material and Method: For the purpose of the present study, sixty (N=60) strength athletes, comprising of Wrestlers (n_1 =20); Weightlifters (n_2=20); Bodybuilders (n_3=20)] subjects between the age group of 18-25 years (Mean ± SD: Age 20.53 ± 1.57 years, height 165.98 ± 3.52 cm, body mass 57.60 ± 3.77 kg, leg length 87.51±2.03) were selected. Stork balance test, Y - balance test were used to assess static and dynamic balance of the dominant leg respectively. Modified beiring sorensen and prone plank test were used to measure core stability performance. Analysis of Variance (ANOVA) test was used to determine the intra group differences in the lower extremity static & dynamic balance and core stability performance among the three groups of strength athletes. 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. All the subjects, after having been informed about the objective and protocol of the study, gave informed consent and volunteered to participate in this study.
Results: Significant differences were observed in static balance, dynamic balance and core stability among strength athletes of three groups ($p \leq 0.05$). Thus, when LSD Post-Hoc test was applied to study the direction and significance of differences between the paired adjusted final means for static balance, dynamic balance and core stability, the wrestlers were found to be significantly different when compared with its counterparts. It has been observed that wrestlers had demonstrated significantly better dynamic balance whereas weightlifters and bodybuilders had demonstrated superior static balance and core stability than wrestlers. However, when different sub-variables of dynamic balance i.e. anterior, posteromedial and posterolateral balance were compared, the results revealed insignificant differences in the anterior balance among strength athletes of three groups. But, posteromedial and posterolateral balance was superior in wrestlers than the weightlifters and bodybuilders. This study concludes that the female wrestlers have lower static balance performance and core stability performance as compared to weightlifters and bodybuilders whereas they have superior dynamic balance among the three groups.

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INTRODUCTION

Postural stability is an important component for all sport activities as it prevents musculoskeletal injuries in athletes. Some sport events need more dynamic stability in which the players have to keep moving and changing the direction continuously like soccer, basketball and hockey whereas in archery, shooting and throwing events greater static balance is needed. By definition, balance is the ability of an individual of maintaining the center of gravity within the body's base of support (Guskiewicz and Perrin, 1996). Static balance is the ability to maintain posture while sitting or standing in one place when the body is not moving whereas dynamic balance refers to the ability to sustain postural control during movements. (Kalaja, 2012). Factors that in uence balance include sensory information obtained from the somatosensory, visual, and vestibular systems and motor responses that affect coordination, joint range of motion (ROM), and strength (Grigg, 1994; Nashner *et al*., 1982; Palmieri *et al*., 2003; Palmieri *et al*., 2002). Some evidence in the literature suggests that superior balance among experienced athletes is largely the result of repetitive training experiences that influence motor responses and not greater sensitivity of the vestibular system (Balter *et al*., 2004). Others argue that superior balance is the

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result of training experiences that influence a person's ability to attend to relevant proprioceptive and visual cues (Ashton-Miller *et al*., 2001). Literature has suggested that core musculature has an important role for the maintenance of stability when body is in motion as it controls the position and motion of the trunk over the pelvis to allow for the optimum production and transfer of energy throughout the kinetic chain of the body (Kibler *et al*.,2006). Therefore, decreased core stability has been suggested as one of the reason for lower extremity injuries, as well as weakness and poor endurance in the lumbar extensors. Hence strengthening of core muscles may be helpful to enhance athletic performance and to prevent sports specific injuries (Ekstrom *et al*., 2007). Some studies have compared balance and core stability performance in soccer, basketball, tennis and runners but very few studies have focused on athletes involved in strength events. So, the aim of our study is to compare the lower extremity static & dynamic balance and core stability performance in three different types of strength athletes.

MATERIALS AND METHODS

Subjects

The researcher collected the data on sixty (N=60) female athletes playing different types of strength sports between the age group of 18-25 years (Mean ± SD: age 20.53 ± 1.57 years, height 165.98 ± 3.52 cm, body mass 57.60 ± 3.77 kg, leg length 87.51±2.03). The subjects were purposively assigned into three groups: Group-A: Bodybuilders (n_1=20); Group-B: Weightlifters (n_2=20) & Group-C: Wrestlers (n_3=20). All the subjects, after having been informed about the objective and protocol of the study, gave informed consent and volunteered to participate in this study. Data was collected from St. Soldier College and D.A.V College, Jalandhar, Punjab, India. The graphical representation of subject's demographics is presented in Table 1:

Table 1. Subject's Demographics

Variables	Sample Size (N=60)			
	Total (N=60)	Group-A: Bodybuilders (n_1=20)	Group-B: Weightlifters (n_2=20)	Group-C: Wrestlers (n_3=20)
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Age (Years)	20.53±1.57	20.40± 1.60	20.30±1.38	20.90±1.74
Body Height(cm)	165.98±3.52	165.10±3.84	165.75±3.60	167.06±2.95
Body Weight (Kg)	57.60±3.77	56.05±4.16	59.20±3.73	57.55±2.79
Leg Length (cm)	87.51±2.03	88.11±1.92	87.92±2.16	86.51±1.68

Variables

A feasibility analysis as to which of the variables could be taken up for the present investigation, keeping in view the availability of tools, adequacy to the subjects and the legitimate time that could be devoted for tests and to keep the entire study unitary and integrated was made in consultation with experts. With the above criteria's in mind, the following tests were selected for the present study:

- **Static Balance:** Stork balance test was used to assess static balance of the dominant leg.
- **Dynamic Balance:** Y - balance test through which anterior, posteromedial & posterolateral balance of the dominant leg was assessed.
- **Core Stability:** Modified Beiring Sorensen and Prone Plank Tests were used.

Test Administration

i. **Stork Balance Test:** This is used to measure static balance performance. The subjects were required to assume a single leg standing position on the dominant leg and then commanded to raise her heel and maintain the balance on the ball of toes of foot for the maximum possible duration. The time duration between the assumption of the position and the loosing of the stable position was taken as the score of the stork balance test. In its measurement three trials were given for each athlete and the time of the longest balance for dominant leg was recorded (Gladwell & Samantha 2006, Hatzitaki *et al*., 2002).

ii. **Y - Balance test:** This test is used to assess dynamic balance of the dominant leg. Prior to testing, the limb length of dominant leg was measured. Single-leg balance on dominant leg was maintained while reaching as far as possible with the non dominant leg in three different directions i.e. anterior, posteromedial and posterolateral, performed on the dominant leg. Each test was repeated three times and the maximum reach in each direction was recorded. The results were calculated taking limb length into consideration, to determine a "composite reach distance". The composite score was calculated by summing the reach distance in the three directions, dividing by three times limb length, and multiplying by 100 (Plisky *et al*., 2009; Shaffer *et al*., 2013).

iii. **Modified Beiring Sorensen test:** This test is used for endurance capacity of posterior spinal musculature. The subjects were positioned in prone lying position with pelvis at edge of the treatment table with the pelvis and legs well stabilized manually. Initially the subjects supported their upper extremity on stool/bench in front of table until they were instructed to cross their arm and assume a horizontal position which is to be maintained as long as possible. Total time (in seconds) was manually recorded using digital stopwatch (Alexis *et al*., 2006; Bliss & Teeple, 2005; Leetun *et al*., 2004; Jacqueline *et al*., 2006; Mcgill *et al*., 1999).

iv. **Prone Plank test:** Total time (in seconds) for which athlete was able to maintain horizontal position in prone lying position (i.e. the time between the assumption of the horizontal position up to the moment when they lost the

horizontal position), was manually recorded using digital stopwatch up to two decimal to test spinal extensor stabilizer's ability against flexion moment (Schellenber *et al*., 2007). Subjects from the prone lying positions were required to maintain the whole body weight on the forearm and toes while lifting all intermediate segments off the plinth. The maximum duration for which they could maintain the position was the performance of the test (Mcgill, 2001).

Study Design

This is an exploratory study that has employed method of data collection and analysis quantitatively. The purpose of this study was to compare the lower extremity static & dynamic balance and the core stability performance in bodybuilders, weightlifters & wrestlers.

Statistcal Analysis

SPSS 17.0 is used for data analysis. Analysis of Variance (ANOVA) test was used to compare the difference of lower extremity balance and core stability performance in bodybuilders, weightlifters & wrestlers. In all the analyses, 5% critical value ($p<0.05$) was considered to indicate statistical significance. Where 'F' values were found to be significant, LSD post-hoc test was applied to identify direction and degree of differences between the three groups.

RESULTS

It is evident from **Table 2** that the results of Analysis of Variance (ANOVA) among three groups with regard to Static Balance were found to be statistically significant ($P<0.05$).

Table 2. Analysis of Variance (ANOVA) of Static Balance among Bodybuilders, Weightlifters and Wrestlers

Source of variance	Sum of Squares	Df	Mean Square	F-ratio	Sig.
Between Groups	34.042	2	17.021	3.414	0.04
Within Groups	284.139	57	4.985		

F .05 (2, 57)

Since "F" ratio 3.414 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 three groups with regard to static balance. The results of post-hoc test have been presented in **Table 3** below.

Table 3. Analysis of Least Significant Difference (LSD) post hoc test of Static Balance among Bodybuilders, Weightlifters and Wrestlers

Group (A)	Group (B)	Mean Difference (A-B)	Sig.
Bodybuilders	Weightlifters	-1.211	.092
(Mean=7.57)	Wrestlers	.600	.399
Weightlifters	Bodybuilders	1.211	.092
(Mean=8.78)	Wrestlers	1.811*	.013
Wrestlers	Bodybuilders	-.600	.399
(Mean=6.97)	Weightlifters	-1.811*	.013

**Significant at .05 level*

A glance at **Table 3** shows that the mean value of body builders was 7.57 whereas weightlifters had mean value of 8.78 and the mean difference between both the groups was found to be 1.211. The p-value .092 shows that the weightlifters had demonstrated better on static balance than bodybuilders though not significantly. The mean value of wrestlers was 6.97 and the mean difference between bodybuilders and wrestlers was found to be 0.600. The p-value 0.399 shows that the bodybuilders had demonstrated better on static balance than wrestlers though not significantly. The mean difference between weightlifters and wrestlers was found 1.811. The p-value 0.013 shows that the weightlifter had demonstrated significantly better on static balance than their counterpart's wrestlers.

Table 4. Analysis of Variance (ANOVA) of Composite Balance among Bodybuilders, Weightlifters and Wrestlers

Source of variance	Sum of Squares	Df	Mean Square	F-ratio	Sig.
Between Groups	365.142	2	182.571	8.452	0.001
Within Groups	1231.185	57	21.600		

F .05 (2, 57)

It is evident from **Table 4** that the results of Analysis of Variance (ANOVA) among three groups with regard to composite balance were found to be statistically significant ($P<0.05$). Since "F" 8.452 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 three groups with regard to composte balance. The results of post-hoc test have been presented in **Table 5** below.

Table 5. Analysis of Least Significant Difference (LSD) post hoc test among Composite Balance among Bodybuilders, Weightlifters and Wrestlers

Group (A)	Group (B)	Mean Difference (A-B)	Sig.
Bodybuilders	Weightlifters	-.385	.794
(Mean=116.39)	Wrestlers	-5.415*	.001
Weightlifters	Bodybuilders	.385	.794
(Mean=116.77)	Wrestlers	-5.030*	.001
Wrestlers	Bodybuilders	5.415*	.001
(Mean=121.80)	Weightlifters	5.030*	.001

**Significant at .05 level*

A glance at **Table 5** shows that the mean value of bodybuilders was 116.39 whereas weightlifters had mean value of 116.77 and the mean difference between both the groups was found to be 0.385. The p-value 0.794 shows that the weightlifters had demonstrated better on composite balance than bodybuilders though not significantly. The mean value of wrestlers was 121.80 and the mean difference between bodybuilders and wrestlers was found to be 5.415. The p-value 0.001 shows that the wrestlers had demonstrated significantly better on composite balance than bodybuilders. The mean difference between weightlifters and wrestlers was found 5.030. The p-value 0.001 shows that the wrestlers had demonstrated significantly better on composite balance than their counterpart's weightlifters. The graphical representation of responses dynamic and static balance among three groups of strength athletes has been exhibited in **Figure 1**. It is evident from **Table 6** that the results of Analysis of Variance (ANOVA) among three groups with regard to Anterior Dynamic Balance were found to be statistically insignificant ($P>0.05$). Since "F" ratio 2.688 was not found statistically significant, therefore, there is no need to apply post hoc test.

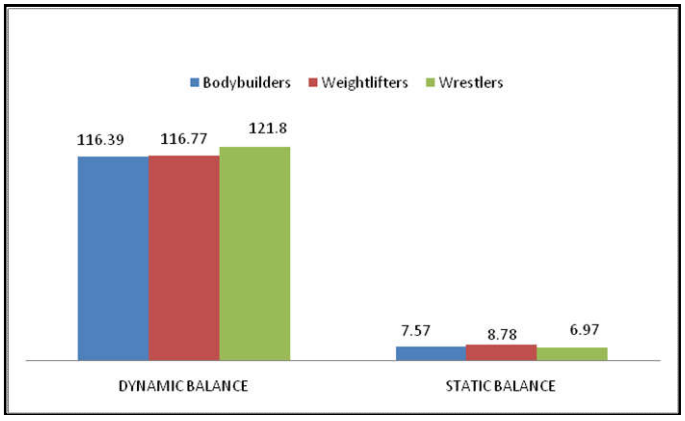

Figure 1. Mean comparison of Dynamic & Static Balance in Bodybuilders, Weightlifters & Wrestlers

Table 6. Analysis of Variance (ANOVA) of sub-variable Anterior Balance of Y balance test among Bodybuilders, Weightlifters and Wrestlers

Source of variance	Sum of Squares	Df	Mean Square	F-ratio	Sig.
Between Groups	59.031	2	29.515	2.688	0.077
Within Groups	625.833	57	10.980		

F .05 (2, 57)

Table 7. Analysis of Variance (ANOVA) of sub-variable Posteromedial Balance of Y balance test among Bodybuilders, Weightlifters and Wrestlers

Source of variance	Sum of Squares	Df	Mean Square	F-ratio	Sig.
Between Groups	394.337	2	197.169	8.767	0.000
Within Groups	1281.885	57	22.489		

F .05 (2, 57)

It is evident from **Table 7** that the results of Analysis of Variance (ANOVA) among three groups with regard to posteromedial balance were found to be statistically significant (P<0.05). Since "F" 8.767 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 three groups with regard to posteromedial balance. The results of post-hoc test have been presented in **Table 8** below.

Table 8. Analysis of Least Significant Difference (LSD) post hoc test of Posteriomedial Balance of Y balance test among Bodybuilders, Weightlifters and Wrestlers

Group (A)	Group (B)	Mean Difference (A-B)	Sig.
Bodybuilders	Weightlifters	-2.510	.100
(Mean=113.45)	Wrestlers	-6.240*	.000
Weightlifters	Bodybuilders	2.510	.100
(Mean=115.96)	Wrestlers	-3.730*	.016
Wrestlers	Bodybuilders	6.240*	.000
(Mean=119.69)	Weightlifters	3.730*	.016

**Significant at .05 level*

A glance at **Table 8** shows that the mean value of bodybuilders was 113.45 whereas weightlifters had mean value as 115.96 and the mean difference between both the groups was found to be 2.510. The p-value 0.100 shows that the weightlifters had demonstrated better on posteromedial balance than bodybuilders though not significantly. The mean value of wrestlers was 119.69 and the mean difference between bodybuilders and wrestlers was found to be 6.240. The p-value 0.000 shows that the wrestlers had demonstrated significantly better on posteromedial balance than bodybuilders. The mean difference between weightlifters and wrestlers was found 3.730. The p-value 0.016 shows that the wrestlers had demonstrated significantly better on posteromedial balance than their counterpart's weightlifter.

Table 9. Analysis of Variance (ANOVA) of sub-variable Posteriolateral Balance of Y balance test among Bodybuilders, Weightlifters and Wrestlers

Source of variance	Sum of Squares	Df	Mean Square	F-ratio	Sig.
Between Groups	91.777	2	45.888	3.773	0.029
Within Groups	693.287	57	12.163		

F .05 (2, 57)

It is evident from **Table 9** that the results of Analysis of Variance (ANOVA) among three groups with regard to posterolateral balance were found to be statistically significant (P<0.05). Since "F" 3.773 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 three groups with regard to posterolateral balance. The results of post-hoc test have been presented in **Table 10** below.

Table 10. Analysis of Least Significant Difference (LSD) post hoc test among Posterolateral Balance among Bodybuilders, Weightlifters and Wrestlers

Group (A)	Group (B)	Mean Difference (A-B)	Sig.
Bodybuilders	Weightlifters	-.550	.620
(Mean=115.62)	Wrestlers	-2.855*	.012
Weightlifters	Bodybuilders	.550	.620
(Mean=116.17)	Wrestlers	-2.305*	.041
Wrestlers	Bodybuilders	2.855*	.012
(Mean=118.48)	Weightlifters	2.305*	.041

**Significant at .05 level*

A glance at **Table 10** shows that the mean value of bodybuilders was 115.62 whereas weightlifters had mean value as 116.17 and the mean difference between both the groups was found to be 0.550. The p-value 0.620 shows that the weightlifters had demonstrated better on posterolateral balance than bodybuilders though not significantly. The mean value of wrestlers was 118.48 and the mean difference between bodybuilders and wrestlers was found to be 2.855. The p-value 0.012 shows that the wrestlers had demonstrated significantly better on posterolateral balance than bodybuilders. The mean difference between weightlifters and wrestlers was found 2.305.

The p-value 0.041 shows that the wrestlers had demonstrated significantly better on posterolateral balance than their counterpart's weightlifters. The graphical representation of responses of anterior, posteromedial & posterolateral balance among three groups of strength athletes has been exhibited in **Figure 2**.

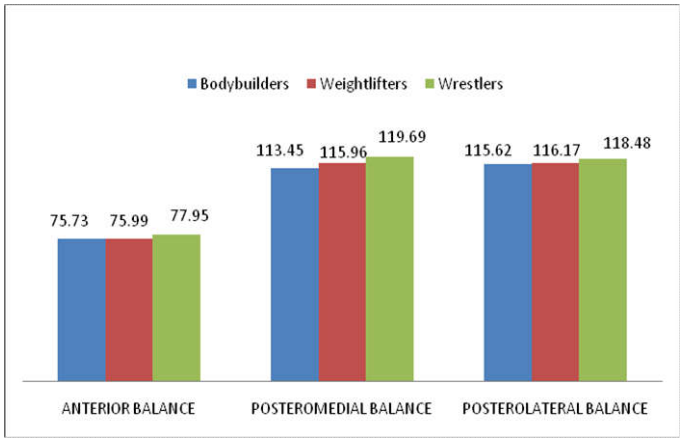

Figure 2. Mean comparison of Anterior, Posteromedial & Posterolateral Balance in Bodybuilders, Weightlifters & Wrestlers

Table 11. Analysis of Variance (ANOVA) of trunk endurance of Core Stability among Bodybuilders, Weightlifters and Wrestlers

Source of variance	Sum of Squares	Df	Mean Square	F-ratio	Sig.
Between Groups	2356.033	2	1178.017	3.370	0.041
Within Groups	19923.700	57	21.600		

F .05 (2, 57)

It is evident from **Table 11** that the results of Analysis of Variance (ANOVA) among three groups with regard to trunk endurance were found to be statistically significant (P<0.05). Since "F" 3.370 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 three groups with regard to trunk endurance. The results of post-hoc test have been presented in **Table 12** below.

Table 12. Analysis of Least Significant Difference (LSD) post hoc test of trunk endurance of Core Stability among Bodybuilders, Weightlifters and Wrestlers

Group (A)	Group (B)	Mean Difference (A-B)	Sig.
Bodybuilders	Weightlifters	-5.750	.335
(Mean=72.50)	Wrestlers	9.450	.115
Weightlifters	Bodybuilders	5.750	.335
(Mean=78.25)	Wrestlers	15.200*	.013
Wrestlers	Bodybuilders	-9.450	.115
(Mean=63.05)	Weightlifters	-15.200*	.013

**Significant at .05 level*

A glance at **Table 12** shows that the mean value of bodybuilders was 72.50 whereas weightlifters had mean value as 78.25 and the mean difference between both the groups was found to be 5.750. The p-value 0.335 shows that the weightlifters had demonstrated better trunk endurance than bodybuilders though not significantly. The mean value of wrestlers was 63.05 and the mean difference between bodybuilders and wrestlers was found to be 9.450. The p-value 0.115 shows that the bodybuilders had demonstrated better trunk endurance than wrestlers though not significantly. The mean difference between weightlifters and wrestlers was found 15.200. The p-value 0.013 shows that the weightlifters had demonstrated significantly better trunk endurance than their counterpart's wrestlers.

Table 13. Analysis of Variance (ANOVA) of prone plank performance among Bodybuilders, Weightlifters and Wrestlers

Source of variance	Sum of Squares	Df	Mean Square	F-ratio	Sig.
Between Groups	972.084	2	486.042	3.228	.047
Within Groups	8583.397	57	150.586		

F .05 (2, 57)

It is evident from **Table 13** that the results of Analysis of Variance (ANOVA) among three groups with regard to prone plank performance were found to be statistically significant (P<0.05). Since "F" 3.228 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 three groups with regard to prone plank performance. The results of post-hoc test have been presented in **Table 14** below.

Table 14. Analysis of Least Significant Difference (LSD) post hoc test of prone plank performance among Bodybuilders, Weightlifters and Wrestlers

Group (A)	Group (B)	Mean Difference (A-B)	Sig.
Bodybuilders	Weightlifters	-2.426	.534
(Mean=81.20)	Wrestlers	7.063	.074
Weightlifters	Bodybuilders	2.426	.534
(Mean=83.62)	Wrestlers	9.489*	.018
Wrestlers	Bodybuilders	-7.063	.074
(Mean=74.13)	Weightlifters	-9.489*	.018

**Significant at .05 level*

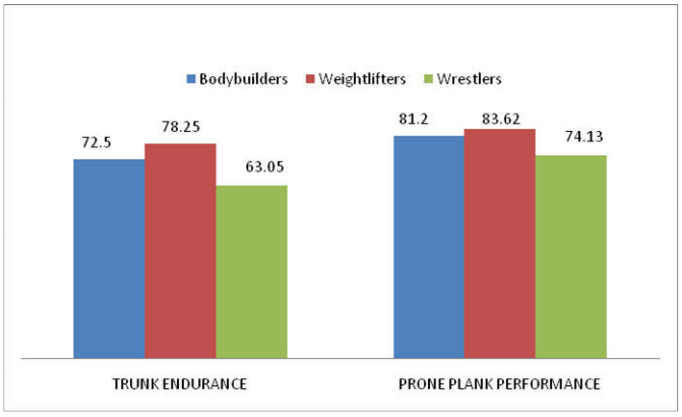

Figure 3. Mean comparison of Core Stability in Bodybuilders, Weightlifters & Wrestlers

A glance at **Table 14** shows that the mean value of bodybuilders was 81.20 whereas weightlifters had mean value as 83.62 and the mean difference between both the groups was found to be 2.426. The p-value 0.534 shows that the weightlifters had demonstrated better on prone plank performance than bodybuilders though not significantly. The mean value of wrestlers was 74.13 and the mean difference between bodybuilders and wrestlers was found to be 7.063. The p-value 0.074 shows that the bodybuilders had demonstrated better on prone plank performance than wrestlers though not significantly. The mean difference between weightlifters and wrestlers was found 9.489. The p-value 0.018 shows that the weightlifters had demonstrated significantly better on prone

plank performance than their counterpart's wrestlers. The graphical representation of responses has been exhibited in **Figure 3.**

DISCUSSION

We hypothesized that balance and core stability scores would be different among athletes competing in different types of strength sports. Female wrestlers demonstrated inferior static balance and core stability compared with weightlifters. But, they demonstrated better dynamic balance compared to both weightlifters and bodybuilders. However, when different sub-variables of dynamic balance i.e. anterior, posteromedial and posterolateral balance were compared, no significant difference in anterior balance was observed among the three groups but significant differences were seen in posteromedial and posterolateral balance among three groups. It was noted that wrestlers demonstrated superior posteromedial and posterolateral balance than the weightlifters and bodybuilders. Within our study, the statistical differences observed among sports may, in part, be related to the difference in the leg strength, lower extremity muscular endurance or flexibility. Also, the differences could be also because of the difference in requirement of the sports. As the wrestlers are moving in different directions in the wrestling ring while wrestling with the opponent so they require more dynamic balance whereas weightlifters and bodybuilders need to lift and lower the weight when standing in the stationary position, therefore maintenance of static balance is more important for weightlifters and bodybuilders. It is also observed from our study that core stability is comparatively more beneficial in improving static balance than dynamic balance. As it can be clearly seen that the weightlifters and bodybuilders demonstrated superior core stability as well as static balance than wrestlers. The result of this study is consistent with the results of Aggarwal *et al*. (2010) who suggested significant correlation of the lower extremity static balance performance with the core stability in sagital plane. It is clear that higher core stability performance allows optimal and long sustained contraction of deeper spinal stabilizer muscles which are responsible for effective control of spine's position in sagital plane and better control of COG (Aggarwal *et al*., 2010). Whereas wrestlers showed only better dynamic balance but inferior core stability. Thus, it is clear that dynamic balance could be more related to lower extremity muscle strength, endurance and flexibility than core strength. From our study, athletic trainers would bene t from knowing that the balance training program should not focus only on exercises to improve balance but also on improving core strength, lower extremity flexibility, muscular strength and endurance.

Conclusion

Firstly, the female wrestlers have lower static balance performance and core stability performance as compared to weightlifters and bodybuilders whereas they have superior dynamic balance among the three groups. Secondly, no significant difference in anterior balance was observed among the three groups but significant differences were seen in posteromedial and posterolateral balance among three groups when different sub-variables of dynamic balance were compared. Thirdly, core strength has comparatively greater role in improving static balance than dynamic balance.

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