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## Effect of proprioceptive training along with breathing and imagery on performance of gymnasts at various levels

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### Abstract

Thirty Two male gymnasts, under the age groups under-13 and above-13 of Sports Authority of India Training Scheme at LNCPE were selected for the study. They were further divided into experimental groups and control groups. The test variables were 1) test for proprioception on Biodex Balance System (BBS), which included nine parameters: overall stability index, its mean deflection and standard deviation, anterior/posterior deflection, its mean deflection and standard deviation, medial/lateral deflection, its mean deflection and standard deviation and 2) gymnastics performance test specifically designed for the purpose and 3) breathing and imagery. The pre-tests were taken for all the gymnasts and the experimental groups underwent 8 weeks proprioceptive training on BBS; during tests were taken after that and again the experimental groups underwent proprioceptive training along with breathing and imagery for 6 more weeks. Post-tests were then conducted for all the gymnasts. The post-tests revealed significant improvement in the performance and certain parameters of test for proprioception of gymnasts of the experimental groups as a result of training. This study shows that such training may be included in the regular training programme of gymnasts.

**Keywords:** Proprioceptive training, biodex balance system, gymnasts, breathing, imagery, stability index

### 1. Introduction

Recent developments in the field of sport sciences have made movements in gymnastics finer and finer. This is such a sport where researches on the topics like proprioception and balance have brought about a dramatic change. From the year 1906 when the term proprioception was coined by Sherrington, various studies have been done in this area but they have been mainly focused on clinical purposes and the terms like “proprioceptive deficit,” “proprioceptive training” and “proprioceptive rehabilitation” are being used increasingly in sports medicine. But in the recent years studies are being conducted to relate proprioceptive training with the improvement in performance of various sports. And gymnastics is a sport completely evaluated in terms of balance and its fineness. In gymnastics, most of the events require extraordinary balance abilities and gymnasts do not react with as large a “startle response” to sudden imbalances as non-gymnasts (Bosco, 1973; Debu *et al.* 1988; Kioumourtzoglou *et al.* 1997) [3-5].

Based on the principle of exercise specificity and the multidimensional aspects of proprioception, training programs should be customized to target the systems involved in balance control, particularly the muscular, visual, vestibular, and soma to-sensory systems. Amount of sensory information fed to the central nervous system in order to facilitate appropriate motor reactions allow the individual to maintain balance under a variety of conditions. The Biodex Balance System (BBS) is a simple, efficient balance screening and training tool. It evaluates neuromuscular control by quantifying the ability to maintain dynamic postural balance on an unstable surface. Here the present investigation is an effort in this direction to evaluate the effect of proprioceptive training along with breathing and imagery on performance of gymnasts of different age groups. The subordinate purposes of the study were:

- To compare the gymnasts in their measures of dynamic balance with open eyes and closed eyes on both feet on the Biodex Balance System (BBS).

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- To compare their measures of dynamic balance with eyes open and closed on each foot (Right and Left) separately on the Biodex Balance System.
- To investigate the effect of proprioceptive training on the performance of gymnasts'.
- To investigate the effect of proprioceptive training with breathing and imagery on the performance of gymnasts'.

## 2. Material & methods

### 2.1 Participants

For the purpose of the present experiment thirty two gymnasts of STC (SAI Training Center) scheme under the age group 9-19 years with mean and standard deviation of  $14.34 \pm 3.62$ , were selected as subjects. They were further divided into two groups of under-13 years (13 included) and above-13 years with mean and standard deviation of  $11.06 \pm 1.39$  and  $17.62 \pm 1.5$  respectively. The gymnasts were then further randomly divided into an experimental and control group of eight each in both groups.

### 2.2 Test variables

The test variables chosen for the study were 1) Tests for proprioception on BBS 2) Performance tests in gymnastics and 3) Breathing and Imagery. All the gymnasts underwent a few practice sessions on the BBS machine and then pre-test scores were taken. The requirements and purpose of the study were explained to the subjects before starting the testing procedures.

#### 2.2.1 Assessment of proprioception

The Biodex Balance System evaluates neuromuscular control by quantifying the ability to maintain dynamic postural balance on an unstable surface. It is using the latest microprocessor and high-resolution LCD display technology. It is easy to follow as prompts lead the person through test and training protocols. All test parameters are documented and included in a choice of full size reports that print in minutes following the test. Balance testing is mainly used to (1) determine limits of stability, (2) identify fall risks candidates, and (3) determine ankle and knee status. Three different types of balance training can be given through this system:

- Proprioception and stabilization exercise
- Range of motion exercise
- Weight shift exercise

The proprioceptive training process starts with a completely firm surface. After that it progresses to a variety of stability levels, up to 20 degrees of support surface tilt, to ensure increased stimulation of joint mechanoreceptors. For the present experiment Comprehensive Limits of Stability report was taken as a criteria and assessment was done in these variables for both feet and either foot separately with eyes open and closed. This report gives the exact values of Stability Indexes, their Mean deflections and Standard Deviations.

#### 2.2.2 Performance test in Gymnastics

The investigator designed the test with the help of the guide and concerned coaches, keeping in view the design of the present investigation, where the basic movements are important. Mainly ten basic skills were selected for the test. The test was designed by the investigator with the help of the guide and coaches keeping in view of the requirements, nature of the sport and the criteria involved in the present

experiment. The skills were performed in combination with each other, not in an isolated manner and were rated on a ten-point scale. The skills selected for the test were as follows:

- 1) Forward roll
- 2) Back roll
- 3) Back roll with open leg.
- 4) Handstand roll
- 5) Cart-Wheel
- 6) Round-Off
- 7) Front handspring
- 8) Scale-T
- 9) Jump 360°
- 10) Split

#### 2.2.3 Breathing and Imagery

Breathing and imagery was used here as psychological skill training programme and is a component that is difficult to measure accurately. Hence it was the feelings that was asked and noted (feedback from the trainees) and their performance was taken as a measure to assess the same. The breathing and imagery training programme was designed by the investigator; keeping in view the age of the subjects and nature of the sport; with the help of the guide. Initially the gymnasts were finding it difficult to concentrate on the instructions given by the instructor, but by the 2<sup>nd</sup> week they were able to concentrate more. They were given practice 5 days a week, and each session of 15-20 minutes.

#### 2.3 Tester competencies and Reliability of tests

Tester competency was evaluated along with reliability of the tests. Reliability of the tests was established by test-retest method. Gymnastics' performance test was evaluated by three different judges on a 10-point scale (A, B & C) and their reliability was tested by test-retest method that is presented in Table-1.

**Table 1:** Reliability of the Judges for the Gymnastics' Performance Test

Judges	Correlation
A	0.78
B	0.95
C	0.83

#### 2.3.1 Administration of tests and collection of data

The pre-tests were conducted for all the gymnasts, one at a time, having sufficient rest interval in between. After the pre-tests, proprioceptive training was given to the gymnasts of the experimental group for a period of 8 weeks; three sessions a week, and each session for a gymnast included five repetitions of 30 seconds each. They were given training in dynamic limits of stability from easy (first four weeks) to hard (last four weeks) in the same Balance System. The training was imparted on dynamic limits of stability owing to the reason that the performance was more on the same line.

After 8 weeks training on the Biodex Balance System, all the gymnasts were tested in their performance and dynamic balance. All the gymnasts of the experimental group underwent another 6 weeks training on the Biodex Balance System along with Breathing and Imagery. For the final analysis, after the training all the gymnasts were administered the post-test on performance and proprioception in the same parameters in which pre-tests were taken.

## 3. Results & Discussion

In the present investigation, for different variables pre-test

was taken followed by the training. The during-test scores were taken after 8 weeks of proprioceptive training on Biodex Balance System (BBS) and post-test scores were taken after the completion of 14 weeks training program (8 weeks On BBS and 6 weeks On BBS along with Breathing & Imagery). In order to examine the hypotheses of the study descriptive statistics and Analysis of variance (ANOVA) was employed for the present investigation in all the variables. A significant F, obtained as a result of ANOVA, does not point out which of the three groups differ among themselves. In such cases, the comparison of the differences between means for any two groups was done using a rigorous method called Scheffe's procedure.

Scheffe's post-hoc test was applied to find out the differences among the sub scores of that variable at different intervals of experiment. Scheffe's tests are multiple comparison and range tests. Once it is determined that differences exist among the means, post-hoc range tests and pair wise multiple comparisons can determine which means differ. Range tests identify homogeneous subsets of means that are not different from each other

SPSS package was used for different statistical tools analyzed.

**4. Discussions**

To start with the discussion, the descriptive statistics of age (in years), height (in centimeters) and weight (in kilograms) of all the subjects opted for the study has been presented in Table 2.

Table 2 indicates the descriptive scores of age, height and weight of the subjects. The mean and standard deviation of age, height and weight are U-13 (11.06±1.39), A-13 (17.62±1.5), total (14.34±3.62); U-13 (140.13±10.86), A-13 (164.13±7.75), total (152.15±15.35) and U-13 (29.5±7.46), A-13 (52.18±8.73), total (41.15±14.28) respectively.

**Table 2:** Descriptive Statistics of Age, Height & Weight of the Subjects

Descriptive Statistics			
		Mean	Standard Deviation
Age	(U-13)	11.06	1.39
	(A-13)	17.62	1.5
Total		14.34	3.62
Height	(U-13)	140.13	10.86
	(A-13)	164.18	7.75
Total		152.15	15.35
Weight	(U-13)	29.5	7.46
	(A-13)	52.81	8.73
Total		41.15	14.28

The data analyzed for the performance tests have been presented. The analysis of variance (ANOVA) of all the three scores of performance has been presented below. The descriptive statistics of all the four groups i.e. A-13 experimental group (V1), A-13 control group (V2), U-13 experimental group (V3) and U-13 control group (V4) is presented in Table 3.

**Table 3:** Pre-During and Post training descriptive scores of the performance tests of all the four groups

Descriptives									
		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
V1	s1	8	6.0200	.79577	.28135	5.3547	6.6853	5.05	7.20
	s2	8	7.2350	1.00001	.35356	6.3990	8.0710	6.01	8.32
	s3	8	7.9275	1.28154	.45309	6.8561	8.9989	6.25	9.58
	Total	24	7.0608	1.28279	.26185	6.5192	7.6025	5.05	9.58
V2	s1	8	4.8313	1.60460	.56731	3.4898	6.1727	3.05	7.50
	s2	8	4.9638	1.60382	.56703	3.6229	6.3046	3.25	7.50
	s3	8	5.1812	1.82345	.64469	3.6568	6.7057	3.25	8.00
	Total	24	4.9921	1.61249	.32915	4.3112	5.6730	3.05	8.00
V3	s1	8	4.5938	1.26076	.44575	3.5397	5.6478	2.58	6.17
	s2	8	5.7650	1.09857	.38840	4.8466	6.6834	4.00	7.28
	s3	8	7.5663	.72658	.25688	6.9588	8.1737	6.50	8.47
	Total	24	5.9750	1.60356	.32733	5.2979	6.6521	2.58	8.47
V4	s1	8	3.4938	1.17473	.41533	2.5116	4.4759	2.00	5.20
	s2	8	3.6975	.98609	.34863	2.8731	4.5219	2.50	5.00
	s3	8	4.0688	1.05727	.37380	3.1849	4.9526	2.50	5.50
	Total	24	3.7533	1.05606	.21557	3.3074	4.1993	2.00	5.50

Table 3 indicates the descriptive scores of the performance tests of all the four groups. The pre (s1), during (s2) and post-test (s3) mean and SD of the V1 Group is 6.02±0.79, 7.23±1.00 and 7.93±1.28; in the V2 group is 4.83±1.60, 4.96±1.60 and 5.18±1.82; in the V3 group is 4.59±1.26, 5.76±1.09 and 7.56±.73 and in the V4 group is 3.49±1.17,

3.69±.98 and 4.07±1.06 respectively. The obtained ANOVA scores of both the groups i.e. U-13 and A-13 (experimental and control) in the present experiment in all the variables of proprioceptive ability have been shown in Table 4 and Table 5 to give a clear-cut view of the training imparted and their results.

**Table 4:** Analysis of Variance (ANOVA) Scores in Proprioceptive Ability of various groups in both the age groups

Serial No.	Type	Variable	Experimental Groups		Control Groups	
			A-13 yrs.	U-13 yrs.	A-13yrs.	U-13 yrs.
1)	<b>BFEO</b>					
1.1		OSI	7.47*	2.25	0.03	0.79
1.2		MD of OSI	6.62*	2.41	0.18	0.65
1.3		SD of OSI	7.16*	1.36	0.12	0.20
1.4		AP SI	8.25*	2.74	0.06	1.02
1.5		MD of APSI	2.39	1.18	1.14	3.02
1.6		SD of APSI	4.28*	1.08	0.01	0.44
1.7		ML SI	4.19*	2.05	0.39	1.60
1.8		MD of MLSI	0.82	2.15	0.41	1.03
1.9		SD of MLSI	3.80*	2.17	0.30	0.56
2)	<b>BFEC</b>					
2.1		OSI	3.18	0.94	0.14	0.25
2.2		MD of OSI	3.45	1.15	0.16	0.17
2.3		SD of OSI	6.00*	1.20	0.24	0.33
2.4		AP SI	1.12	0.46	0.59	0.28
2.5		MD of APSI	2.71	1.54	0.47	1.61
2.6		SD of APSI	2.88	0.16	0.01	1.41
2.7		ML SI	5.47*	2.15	0.50	0.71
2.8		MD of MLSI	3.67*	1.19	0.01	0.27
2.9		SD of MLSI	4.60*	0.10	0.36	0.68
3)	<b>LFEO</b>					
3.1		OSI	4.52*	0.94	0.12	0.05
3.2		MD of OSI	4.38*	1.21	0.11	0.21
3.3		SD of OSI	4.00*	0.33	0.38	0.56
3.4		AP SI	5.13*	0.79	0.23	0.38
3.5		MD of APSI	1.30	0.71	1.15	0.46
3.6		SD of APSI	1.71	0.33	0.16	0.13
3.7		ML SI	2.35	1.23	0.13	0.91
3.8		MD of MLSI	2.34	4.17*	0.52	2.07
3.9		SD of MLSI	1.48	0.33	0.03	0.63

\*Significant at  $0.05 > 3.47$  (2, 21 df)

Table 4 reveals that in the experimental groups there were significant difference seen in certain variables but no significant difference were seen in any of the variables in the control group. This may be as a result of proprioceptive training on the Biodex Balance System. The experimental groups and control groups had their regular practice but the gymnasts of the experimental groups had undergone an additional training on the Biodex Balance System.

Table 5 reveals that in the experimental groups there were

significant difference seen in certain variables but no significant difference were seen in any of the variables in the control group. In the above 13 years experimental group the obtained f values in the variables standard deviation of overall stability index and anterior/posterior stability index of right foot eyes open type are greater than the table value  $\{0.05 > 3.47$  (2, 21 df)}, thus indicating significant differences in these variables as a result of training.

**Table 5:** Analysis of Variance (ANOVA) Scores in Proprioceptive Ability of various groups in both the age groups

Serial No.	Type	Variable	Experimental Groups		Control Groups	
			A-13 yrs.	U-13 yrs.	A-13yrs.	U-13 yrs.
4)	<b>LFEC</b>					
4.1		OSI	1.31	3.50*	0.49	0.14
4.2		MD of OSI	1.30	4.03*	0.43	0.32
4.3		SD of OSI	1.22	2.13	0.89	0.21
4.4		A/P SI	1.14	2.21	0.71	0.18
4.5		MD of A/PSI	0.04	0.15	0.32	1.52
4.6		SD of A/PSI	3.52	2.44	0.05	3.18
4.7		M/L SI	1.04	1.70	0.58	0.02
4.8		MD of M/LSI	1.52	4.52*	0.54	0.62
4.9		SD of M/LSI	0.62	1.10	1.18	0.12
5)	<b>RFEO</b>					
5.1		OSI	4.29	0.54	0.47	1.72
5.2		MD of OSI	3.13	0.59	0.38	1.81
5.3		SD of OSI	6.00*	0.48	0.47	1.51
5.4		A/P SI	4.89*	0.71	0.76	1.33
5.5		MD of A/PSI	1.52	0.03	1.54	0.87
5.6		SD of A/PSI	1.68	0.84	0.58	1.41
5.7		M/L SI	2.26	0.26	0.03	1.91
5.8		MD of M/LSI	0.60	0.46	1.01	2.72

5.9		SD of M/LSI	2.39	0.24	0.53	2.27
6)	<b>RFEC</b>					
6.1		OSI	1.68	0.15	0.14	0.03
6.2		MD of OSI	1.89	0.22	0.43	0.07
6.3		SD of OSI	1.35	0.02	0.29	0.03
6.4		A/P SI	1.47	0.40	0.26	0.04
6.5		MD of A/PSI	0.62	0.52	0.01	0.19
6.6		SD of A/PSI	0.19	0.34	0.72	1.02
6.7		M/L SI	2.87	0.64	0.24	0.47
6.8		MD of M/LSI	0.48	1.61	0.20	0.91
6.9		SD of M/LSI	1.16	1.19	1.31	0.80

\*Significant at  $0.05 > 3.47$  (2, 21 df)

In the U-13 experimental group the obtained *f* values in the variables overall stability index, its mean deflection and mean deflection of medial/lateral stability index of left foot eyes closed type are greater than the table value  $\{0.05 > 3.47$  (2, 21 df)}, thus indicating significant differences in these variables as a result of training. However no significant difference was seen in the variable of right foot eyes open type. Most of the gymnasts were right footed and research shows that more often the right leg is considered to be the quicker one or the weaker one when considered with reference to balance. This may be owing to the reason that these components need longer time than it was given in the present condition.

The purpose of the present study was to investigate the effect of proprioceptive training along with breathing and imagery on the performance of gymnasts at various levels. Based on the purpose of the study and hypothesis stated, the analysis has resulted in the following finding:

1. In the both feet eyes open type the obtained *f* value in the variables overall stability index, its MD & SD, anterior/posterior stability index & its SD, medial/lateral stability index & its SD of the experimental group of A-13 years were greater than the required value of 2.57 at 0.005 level of confidence. This signifies the improvement owing to the balance Training. There has been significant difference from during test to post test in anterior/posterior stability index showing the effect of breathing and imagery training. These training for longer duration could bring about significant changes in other parameters too.
2. In the both feet eyes closed type the obtained *f* value in the variables SD of overall stability index, medial/lateral stability index, its MD & SD in the experimental group of A-13 years were greater than the required value of 2.57 at 0.05 level of confidence.
3. In the left foot eyes open type the obtained *f* value in the variables overall stability index, its MD & SD, anterior/posterior stability index in the A-13 years; and mean deflection of medial/lateral stability index in the U-13 years' of the experimental groups were greater than the required value of 2.57 at 0.05 level of confidence. Further, with closed eyes, where the degree of difficulty becomes more the obtained *f* value in the variables standard deviation of anterior/posterior stability index in A-13 years; mean deflection of overall stability index, mean deflection of medial/lateral stability index in the U-13 years of the experimental groups were greater than the required value of 2.57 at 0.05 level of confidence. Thus, signifying the improvement in dynamic balance.
4. In the right foot eyes open type the obtained *f* value in the variables overall stability index, & its standard deviation, and anterior/posterior stability index, overall stability index, in the A-13 years of the experimental group were greater than the required value of 2.57 at 0.05 level of confidence

To conclude, regarding proprioception, the proprioceptive training that was given on the Biodex Balance System proves to be very effective in improving the players' proprioceptive ability. This is noted as a result of significant improvement been shown in the entire test types except of the right foot eyes closed type (Morgan, 2005). In the performance test involving selected skills, the obtained '*f*' value is much greater than the tabulated value, in the experimental groups of both the age categories. Thus showing significant improvement in the performance of skills as a result of proprioceptive training along with breathing and imagery.

Thus, it can be said that balance training with the help of a machine can bring tremendous change in the ability of the player because this gives them to see their score by themselves and they can analyse where they fall in their score according to the requirement. Also the equipment used in the present study has variations that become challenging for the players to understand their body position sense in a better way.

## 5. Conclusions

Within the limits and limitations of the present study, the analysis was made based on the purpose of the study and hypothesis stated, the following findings were arrived at:

In the variable test for proprioception, comprehensive limits of stability report scores were recorded and computed in six test items and the findings are as follows:

1. In the both feet eyes open type, significant changes were seen in the parameters of overall stability index, its mean deflection & standard deviation, anterior/posterior stability index & its standard deviation, medial/lateral stability index & its standard deviation of the experimental group of Above-13 years. However, there has been significant difference from during test to post test in anterior/posterior stability index showing the effect of breathing and imagery training. These training for longer duration could bring about significant changes in other parameters too.
2. In the both feet eyes closed type, significant changes were seen in the parameters standard deviation of overall stability index, medial/lateral stability index, its mean deflection & standard deviation in the experimental group of Above-13 years.
3. In the left foot eyes open type, significant changes were seen in the parameters overall stability index, its mean deflection & standard deviation, anterior/posterior stability index in the Above-13 years; and mean deflection of medial/lateral stability index in the Under-13 years of the experimental groups.
4. In the left foot eyes closed type, significant changes were seen in the parameters standard deviation of anterior/posterior stability index in Above-13 years; mean deflection of overall stability index, mean

deflection of medial/lateral stability index in the U-13 years of the experimental groups.

5. In the right foot eyes open type, significant changes were seen in the parameters overall stability index, & its standard deviation, and anterior/posterior stability index, overall stability index, in the A-13 years of the experimental group.

#### **6. Besides, these findings also highlight various other facts like**

- a) When tested in both feet type (eyes open and closed) it has been found to be more beneficial for the higher age group. This may be mainly attributed to the fact that joint position-sense is shown to deteriorate with age (Skinner *et al.* 1984) <sup>[6]</sup>.
- b) Findings in the test type with left foot (eyes open and closed), clearly shows that such training is effective for gymnasts of all age group. Moreover, left being the dominant leg in various skill performances this is a vital factor in increasing the gymnastics' performance.
- c) To add further in the factor of right foot test type (eyes open and closed), it is evident that right foot eyes closed type is highly complicated actions and requires more time for training this particular component in all age group.
- d) Overall the whole training has shown to affect the higher age group more than the gymnasts of lower age group.

The present study, call for further investigation of the effects of proprioceptive training on various other sports involving certain other psychological variables and for longer duration of training.

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