Human Biology Review (ISSN 2277 4424) 2 (2) 2013
Original scientific paper (Sharma et al. pp. 193-203)
Revised and Accepted on April 20, 2013


# Effects of Dynamic Neuromuscular Analysis Training on Static and Dynamic Balance in Indian Female Basketball Players

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***ABSTRACT:*** *The aim of this paper was to investigate the effects of dynamic neuromuscular analysis on static and dynamic balance of Indian state level female athletes. It was hypothesized that the training protocol would improve both static and dynamic components of the balance, improving dynamic balance more than static. A total of 43 randomly selected state level female basketball players aged 16 -18 years participated in the study. The subjects were further divided into two groups, viz. Dynamic Neuromuscular Analysis (DNA) group (n=23) and control group (n = 20). Pre and post static balance was tested to all the subjects by Stork Balance Test (SBT) and Balance Error Scoring System (BESS), and dynamic balance was measured by Star Excursion Balance Test (SEBT). DNA intervention of 90 minutes was given for 6 weeks while the control group followed traditional training. Results showed a significant improvement both in static and dynamic balance (p<0.001). It might be concluded that 6 week DNA training designed for the prevention of ACL injuries could also improve both static and dynamic balance in Indian female basketball players.*

*Keywords: Dynamic Neuromuscular Analysis, static and dynamic balance, Indian female basketball players.*

## INTRODUCTION

Basketball is one of the most popular team sport in the world. Apart from basic hand eye co-ordination, basketball also requires flexibility, agility, strength and endurance. Lower limb is the most frequently injured in this game (Deitch *et al*., 2006; Murphy *et al*., 2003) out of which, 25% injuries occur on the knee (Fernandez *et al*., 2007). Anterior Cruciate Ligament (ACL) is one of the most commonly injured ligaments in the knee (Boden *et al*., 2000). A torn ACL usually occurs through a twisting force being applied to the knee whilst the foot is firmly planted on the ground or upon landing (valgus collapse with the knee close to full extension combined with external or internal rotation of the tibia) (Olsen *et al*., 2007) called non contact ACL injury or a result from a direct blow to the knee, usually the outside, as may occur during a tackle, known as direct ACL injury (Geli *et al*., 2009). The rate for non-contact ACL injuries ranges from 70 to 84% of all ACL tears in both female and male athletes (Geli *et al*., 2009). Females injure their ACL 4 to 6 times more frequently than their male counterparts (Paterno *et al*., 2004). The factors affecting this predominance have been considered to be divided into hormonal (estrogen), anatomical (narrow intercondylar notch, wider pelvis and greater Q angle) environmental (playing style) and neuromuscular (dominance of quadriceps muscle recruitment for dynamic stability) (Boden *et al*., 2000).

The reason for understanding factors leading to predominance of ACL injury in female athletes is for administering prevention strategies. While there have been efforts focused on ACL injury treatment strategies, it is well established that surgical reconstruction does not reduce the increased risk for developing post traumatic knee complications (Ekstrand *et al*., 2006). Also, apart from the short- and long-term physical impairments, ACL injury causes personal and professional impairment for athletes, with high costs in rehabilitation for both athletes and sports institutions (Gottlob *et al*., 1999). Thus, the prevention of non-contact ACL injuries has become a major milestone in sports traumatology.

Although there is an abundance in the research literature about the factors causing ACL injury, there are only a few techniques addressing its prevention. Out of these, the focus of current prevention programs is mainly on neuromuscular control (Boden *et al*., 2000). Neuromuscular control refers to unconscious activation of the dynamic restraints surrounding a joint in response to sensory stimuli (Griffin *et al*., 2000). It has been reported that neuromuscular training programs are effective for improving measures of performance by increasing power, agility, and speed (Kraemer *et al*., 1998). Female athletes may especially get benefited from multi component neuromuscular training because they often display decreased levels of strength and power compared with their male counterparts (Kraemer *et al*., 2003). Considering all the facts, in the present study, an attempt has been made to investigate the effects of Dynamic Neuromuscular Analysis (DNA) on balance which is an essential component to excel the performance in basketball.

## MATERIAL AND METHODS

*Subjects:*

The present intervention study was based on randomly selected 43 Indian state level female basketball players aged 16–18 years (mean age 17.6 years) from Govt. Senior Secondary School for Girls, Mall Road, Amritsar, Punjab, India. The subjects were further divided into two groups, viz. Dynamic Neuromuscular Analysis (DNA) group (n=23) and control group (n = 20). The age of the subjects were recorded from the date of birth registered in their institution. A written consent was obtained from the subjects. The data were collected under natural environmental conditions in morning (between 8 AM. To 12 noon). It was compulsory to continue at least two third of the training for their readings to be included in the results. These subjects attended an average of 15 training sessions lasting for 60 to 90 minutes each. The study was approved by the local ethics committee. Prior to beginning of the training protocol, both static balance and dynamic balance was assessed by using Stork balance test, Balance Error Scoring SystemBESS (static) and Star Excursion Balance Test (SEBT) (dynamic).

**Stork Balance Test**

Stork balance test was performed with both right (Stork R) and left (Stork L) legs of the subject. The athlete was asked to remove her shoes, place the hands on her hips, then position the non-supporting foot against the inside knee of the supporting leg. The athlete was given one minute to practice her balance. After that she was asked to raise her heel to balance on the ball of her foot. The stopwatch was started as the heel was raised from the floor. The stopwatch was stopped if any of the following occurred: the hand(s) came off the hips; the supporting foot swiveled or moved (hopped) in any direction; the non-supporting foot lost contact with the knee; or the heel of the supporting foot touched the floor. The total balanced time was recorded (Ogwumike and Tijani 2011).

**Balance Error Scoring System**

The athlete was asked to stand first on ground and then on foam pad(10*10*2.5") without shoes. They were required to attain 3 positions (double leg, single leg, tandem) on each of the surface for 20 seconds each with eyes closed. Each of the twenty-second trial was scored by counting the errors, or deviations from the proper stance, accumulated by the athlete. Counting of the errors was done only after the individual had assumed the proper testing position. An error was credited to the athlete when any of the following occurred : moving of hands off the iliac crests; opening of the eyes; step stumble or fall; abduction or flexion of the hip beyond 30°; lifting the forefoot or heel off of the testing surface; remaining out of the proper testing position for more than 5 seconds. 10 was the maximum total number of errors for any single condition (Bressel *et al*., 2007).

**Star Excursion Balance Test (SEBT)**

Star excursion balance test was performed with both right (SEBT R) and left (SEBT L) legs of the subject. The testing grid consisted of 8 lines, each 120 cm in length extending from a common point at 45° angle increments and was created using standard white athletic tape placed on a firm, textured tile surface. A small dot was marked in the middle of the grid and athletes were asked to center the stance foot over during testing. Keeping the heel from getting off the athlete was asked to reach maximum distance in all 8 directions using the tip of the free leg (Herrington *et al*., 2009).

**Intervention procedure**

**Group 1:** Before the intervention, athletes were shown videos of the jumps that they had to perform. They were given practice trials to learn the jump before the start of the training session. Each session maintained a 1:5 training ratio so as to give ample attention to quality of techniques being followed by the athletes. An assistant recorded the time for which each exercise was carried out (with the help of a stopwatch), the number of repetition and the order of the exercise. During the intervention, the athletes needed to be given auditory and visual feedback of the correct techniques of the jumps and if they were making any faults, they needed to be stopped immediately and corrected as the whole purpose of the training would be wasted if they were allowed to continue performing faulty techniques (Prapavessis and McNair 1999). When the athlete fatigued to a level where her ability to correctly continue the exercise declined, she was instructed to stop immediately. Every training session aimed at providing new challenge for the athlete while maintaining the quality of the present day session (Paterno *et al*., 2004).

The athlete took part in the training 3 days a week, every alternate day for 60 to 90 minutes according to the days protocol. At the beginning of the session, the players were instructed to follow active warm up session of jogging, backward jogging, lateral shuffling and carioca and post training they performed cool down stretching for at least 15 minutes (Paterno et al. 2004). After every jump session they were given a rest period of 30 seconds each (Hewett *et al*., 2001).

The intervention program consisted of the following protocol:

| Phase 1 | Week 1 | Week 2 |
|---|---|---|
| Wall jumps | 20s | 20s |
| Tuck Jumps | 15s | 15s |
| Broad jump stick(hold) landing | 10 reps | 10 reps |
| Squat jump | 20s | 20 sec |
| Double leg barrier jump | | |
| Side to side | 20s | 20s |
| Back to front | 20s | 20s |
| 180˚ jump | 20s | 20s |
| Bounding in place | 25s | 25s |
| Balance (both feet-3 sets) | 30s | 30s |
| Phase 2 | Week 3 | Week 4 |
| Wall jumps | 20s | 20s |
| Tuck Jumps | 20s | 20s |
| Broad jump, vertical | 8 reps | 12 reps |
| Squat jump | 20s | 20s |
| Single leg hop stick(R and L) | 10 reps | 15 reps |
| Double leg barrier jumps | | |
| Side-to-side | 25s | 25s |
| Back-to-front | 25s | 25s |
| lunge jump | 20s | 20s |
| Bounding for distance | 5reps | 5 reps |
| Balance drills | | |
| Both feet(2 sets) | 30s | 30s |
| R and L( 1 set each) | 30s | 30s |

| Phase 3 | Week 5 | Week 6 |
|---|---|---|
| Wall jumps | 20s | 20s |
| Box drops-180˚ vertical | 12 reps | 8 reps |
| Jump jump jump- vertical | 8 reps | 5 reps |
| Squat jumps | 15s | 15s |
| Single leg X hop(R and L) | 20s | 20s |
| Scissors jumps | 20 sec | 15 sec |
| Jump into bounding | 5 reps | 5 reps |
| Hop, hop, stick landing( R and L) | 8 reps/leg | 8 reps/leg |
| Balance drill (R and L- 2 set each) | 20s | 20s |

**Group 2:** The control group was not given any neuromuscular training but was only allowed to follow the traditional training being given by the coaches.

**RESULTS**

Table 1 shows the descriptive statistics of selected variables in DNA group. Pre test showed lower mean values in SEBT R(34.06), SEBT L(35.74), Stork L(6.43) and Stork R(11.35) and higher mean values in BESS (6.26) as compared to the post test mean values(42.03, 42.88, 10.83, 14.96,0.23 and 1.61 respectively). However, significant differences ($p < 0.05$-0.001) were noted in all the variables studied between pre and post tests with DNA intervention.

**Table 1. Descriptive statistics of selected variables in Dynamic Neuromuscular Analysis**

| Variables | Pre test | | Post test | | t-value |
|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | |
| SEBT R | 34.06 | 6.69 | 42.03 | 5.07 | 7.907** |
| SEBT L | 35.74 | 5.53 | 42.88 | 4.49 | 7.178** |
| BESS | 6.26 | 2.39 | 1.61 | 1.07 | 11.472** |
| STORK L | 6.43 | 5.68 | 10.83 | 5.27 | 6.254** |
| STORK R | 11.35 | 14.35 | 14.96 | 11.15 | 3.795* |

*Significant at 0.05 level **Significant at 0.001 level.

**Table 2. Descriptive statistics of selected variables in control group**

| Variables | Pre test | | Post test | | t- value |
|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | |
| SEBT R | 32.89 | 6.64 | 32.53 | 6.57 | 0.852 |
| SEBT L | 33.10 | 5.86 | 32.76 | 5.34 | 0.926 |
| BESS | 5.15 | 3.31 | 4.60 | 2.58 | 0.772 |
| STORK L | 4.70 | 3.24 | 5.05 | 2.81 | 0.637 |
| STORK R | 5.75 | 3.65 | 5.65 | 3.85 | 0.462 |

**Table 3. Correlation matrix of selected variables with DNA in Indian female basketball players**

| Variables | HT | WT | SEBT R | SEBT L | BESS | Stork L | Stork R |
|---|---|---|---|---|---|---|---|
| HT | 1 | .647** | -.127 | -.058 | .328 | .040 | -.100 |
| WT | | 1 | -.394* | .285 | .285 | -.102 | -.190 |
| SEBT R | | | 1 | .860** | .259 | .042 | .259 |
| SEBT L | | | | 1 | .197 | .025 | .184 |
| BESS | | | | | 1 | .237 | .089 |
| Stork L | | | | | | 1 | .687** |
| Stork R | | | | | | | 1 |

*Significant at 0.05 level **Significant at 0.01 level.

Table 4. Correlation matrix of selected variables in control group in Indian female basketball players

| Variables | HT | WT | SEBT R | SEBT L | BESS | Stork L | Stork R |
|---|---|---|---|---|---|---|---|
| HT | 1 | .385* | .171 | .196 | .027 | .387* | .057 |
| WT | | 1 | -.299 | -.136 | -.046 | .190 | .185 |
| SEBT R | | | 1 | .814** | -.241 | -.270 | -.017 |
| SEBT L | | | | 1 | -.042 | -.062 | -.136 |
| BESS | | | | | 1 | .256 | -.073 |
| Stork L | | | | | | 1 | .128 |
| Stork R | | | | | | | 1 |

*Significant at 0.05 level **Significant at 0.01 level.

Table 2 shows the descriptive statistics of selected variables in control group. Pre test values showed higher mean values in SEBT R (32.89), SEBT L (33.10), BESS (5.15), Stork R (5.75) and lower mean values in Stork L (4.70) in comparison to the post test mean values (32.53, 32.76, 4.60,5.65, 5.05 respectively). Nonetheless, no significant differences were found in any case.

Correlation matrix of selected variables with DNA training in Indian female basketball players are shown in table 3. Statistically significant correlations ($p < 0.05$-$0.01$) were found between weight and height, SEBT R, SEBT R and L and stork R and L.

Table 4 showed the correlation matrix of selected variables with control group in Indian female basketball players. Statistically significant correlations ($p < 0.05$-$0.01$) were found between height and weight and stork L, between SEBT R and L.

**DISCUSSION**

Though the game of basketball was invented and developed in North America, nowadays, it has become one of the most popular sports around the globe. During competitions and practice sessions, players are to involve in heavy schedules which requires careful short- and long-term planning of their training programs. Anterior Cruciate Ligament (ACL) is one of the most commonly injured ligaments in the knee (Boden *et al*., 2000). It was also reported that with application of DNA technique, the frequency of ACL injury reduced (Hewett *et al*., 2001). In the present study, an attempt was made to investigate the correlations of DNA training with static and dynamic balance with the background that ACL deficient patients appeared to have deficiencies in their dynamic postural control (Herrington *et al*., 2009).

In the present study, static balance was tested by stork standing test and balance error scoring system. Highly significant improvements were seen in intervention group (DNA training) as compared to control group. In this group, errors of BESS decreased ($p < 0.002$) and time taken by athletes in stork standing balance test increased post intervention ($p < 0.001$).

Dynamic Balance was measured by Star Excursion Balance Testing (SEBT), in which highly significant improvements ($p < 0.001$) in the measures of SEBT were seen with DNA training protocol in comparison with control group athletes.

It was demonstrated that female athletes who participated in a neuromuscular training program demonstrated greater dynamic knee stability than females who had undergone training (Hewett *et al*., 1996). Results of our study were in congruence with the earlier report (Hewett *et al*., 2001), wherein significant improvements were found both in static and dynamic balance tests with intervention.

The effect of neuromuscular training on serious knee injury rates in female athletes was also reported (Hewett *et al*., 1999). Untrained female athletes had a significantly higher incidence of serious knee injury than trained athletes of both the sexes, whereas trained female athletes had no change from untrained male athletes, thereby concluding that neuromuscular training reduced injury incidence in female athletes (Hewett *et al*., 2001).

Neuromuscular training programs that included active warm up, plyometrics exercises, and weight training were advocated to increase performance and to decrease injury risks in female athletes in jumping sports (Chandy and Grana, 1985). Neuromuscular training showed significant decrease of 50% in valgus and varus moments at the knee, and peak - impact force decrease of 80% of mean body weight in female athletes when landing from a jump. Valgus and Varus torques at the knee served as significant predictors of peak landing forces. High impact forces might be related to high knee injury rates (Hewett *et al*., 1996).

The improvements seen in DNA training could be associated with the fact that DNA training addressed the "3 way neuromuscular imbalance", reducing dangerous varus and valgus torques at the knee that were related to increased impact forces (Hewett *et al*., 1996), addressed the quadriceps dominance and overcame it, and addressed the side to side imbalance between dominant and non dominant limbs which were proved to cause more lower limb injuries in female athletes (Hewett *et al*., 2001). However it was also reported that balance component improved following the pre season training designed to help decrease ACL injuries (Paterno *et al*., 2004).

## CONCLUSION

From the findings of the present study, it might be concluded that 6 week DNA training program designed for the prevention of ACL injuries could improve both static and dynamic balance in Indian female basketball players.

## PRACTICAL IMPLICATIONS

The data presented in the present study carry immense practical applications and should be useful in training program development in basketball.

## ACKNOWLEDGEMENTS

Authors are thankful to the authorities of Govt. Senior Secondary School, Amritsar, Punjab, India and the participant basketball players of the institute for their cooperation in collecting the data.

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**Citation: Sharma A, Arora M and Koley S. 2013. Effects of Dynamic Neuromuscular Analysis Training on Static and Dynamic Balance in Indian Female Basketball Players. Hum Bio Rev 2 (2): 193-203**