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Comparative analysis of postural stability in elite and novice recurve archers

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ABSTRACT

Introduction: Archery is a static game which needs extreme precision, strength and endurance of upper body. Besides this, postural stability is another crucial factor determining the outcome of every shot. An archer's skill is the ability to shoot the arrow in a specific time, to achieve this athlete needs to avoid unnecessary sway which can reduce stability. It has been seen that a high level of postural stability increases the aiming stability of the archers. Therefore, the purpose of the study was to compare the postural stability in Elite and Novice Recurve Archers. *Method:* 50 Novice and 50 Elite Recurve archers between the age group of 15-25 years were recruited. Postural stability was assessed using the Balance Error Scoring System (BESS) on the non-dominant leg. 3 stances (tandem, double & single-leg) on firm and foam surface were tested. The Waterloo Footedness questionnaire-revised was used to determine leg dominance. Each of the 20-second trials was scored by counting the errors accumulated by the subject. *Results:* Elite archers had significantly less number of balance error on Firm surface (8.48±3.31) p=0.006, and on Total BESS score (21.94±4.98) p=0.025 than novice archers [Firm surface (10.02±2.035), Total BESS score (24.16±4.744)]. However, there was no statistical difference for foam surface score in elite (13.46±2.84) and novice archers (14.14±4.49), p=0.368. *Conclusion*: Elite archers had significantly better postural stability on a firm surface and total score of BESS, whereas on foam testing surface both elite and novice recurve archers showed no statistical differences in the postural stabilizing ability.

Keywords: Recurve Archers, BESS, Balance, Waterloo Footedness questionnaire-revised

1. INTRODUCTION

Maintenance of an upright standing posture during bipedal standing is a demanding task (Suppiah et al., 2017). Control of upright posture is a prerequisite for physical activities in daily life and is essential for most of the human motor abilities. Postural control is an intricate task that involves one's ability to counter the movement of gravity and self-produced actions that disturb the equilibrium (Suppiah et al., 2017). It requires the incorporation of various sensory and motor components and inputs from these components have a significant role in standing balance. Different degree of postural stability is needed for different sport discipline, with this athlete develops specific balance control strategies to maintain equilibrium (Hatzitaki et al., 2015). To attain peak performance and to succeed in the game balance ability is essential for top athletes (Cerrah & Ertan, 2013).

In archery, archer has to fix their posture and aim at the center of the target face to achieve the highest score, for this they need to regulate the body fluctuations, such that the alignment of the arrow remains within the target boundary, and center of gravity within their base of support (Cerrah and Ertan 2013; Balasubramaniam et al., 2000). Being a static sport, archery requires balance, fine movement control, proper endurance, and strength of the upper body (Cerrah & Ertan, 2013). These performance variables are required to ensure shooting accuracy, and score of the shoots precisely at the upper body (shoulder girdle, and for both arms) including the trunk. In addition to strength and endurance, postural stability is another important fundamental variable responsible for the outcome of every shot (Ertan, 2009; Mohamed & Azhar, 2012). Archery requires the consistency and stability of movement (Park et al., 2016). To achieve the highest performance in the game postural stability needs to be controlled. Therefore, an archer must have precise movements to deal with postural instability (Mohamed & Azhar, 2012). When postural movements have been reduced, the archer can easily focus on the target (Spratford & Campbell, 2017) and in turn increases the aiming stability of the archer which sequentially ensures incessant flight trajectory to the target. Nevertheless, it has been seen that, irrespective of their performance level, archers are affected by postural sway (Park et al., 2016; Mononen et al., 2007). Archer's expertise also influences their ability to cope with postural stability (Mohamed & Azhar, 2012). Studies have suggested that differences between their performances must be vastly dependent upon their controlled actions, Since archers of different levels expertise (Top-level, national and novice) use equipment of the same general quality (Stuart & Atha, 1990). Due to the specific nature of the sport, throughout the aiming phase curtailing the postural movements enables greater uniformity in all shots of the game. In other target sports (pistol and rifle shooting), prevailing results have shown a relation between reduced postural movements and improved outcomes in the aiming phase (Park et al., 2016).

Existing literature support that, the demand of the sport that is being played and sporting activity in which the athlete is involved changes quiet standing balance (Hatzitaki et al., 2015; Eadric Bressel, EdD et al., 2007) and this depends on the training process. Evidence suggests that Rifle shooter (Aalto et al.,1990), to stabilize the rifle are trained to maintain a long time stable upright bipedal posture, whereas gymnasts or ballet dancers show a great sense of the balance during one-legged stance (Vuillerme et al., 2001; Matsuda et al., 2008). Elite pistol and rifle shooters have shown to have better standing balance during the upright stance than untrained subjects (Mononen et al., 2007; Aalto et al., 1990).

Therefore, archery being one of the target sport played as competitive game at Olympic Games in the country, there is a paucity of literature on the postural stability of archers having different levels of playing experience. Due to the aforementioned reason there arises a need to find out if there are any differences in posture stabilizing abilities between elite recurve archers and novice recurve archers in conditions corresponding to normal competitive shooting.

2. MATERIAL & METHODS

Study design and participants

In the present cross-sectional study, the sample size was calculated using a scientific formula. Assuming a significance level at 5% and a power of 80%, it was estimated that 50 archers should be allocated in each group. 50 Elite recurve archers playing target archery district level and above and 50 Novice recurve archers having a minimum one year of target archery experience between the age of 15 years to 25 years were recruited in the study from various Archery clubs and Sports Association in Navi Mumbai and Mumbai. Each participant signed an informed consent form after being advised of the purposes, methods of the study, and potential risks of the study. All archers were reviewed to exclude individuals with significant neurological, medical, or lower extremity conditions that could potentially have affected their balance (figure 1).

Outcome Measures

Waterloo Footedness Questionnaire-Revised

Waterloo Footedness Questionnaire-Revised (WFQ-R) (Lorin J. Elias, 1998) was used to determine to footedness of archers. It assesses the foot in 2 different situations: 1) by performing tasks with objects (e.g. kicking a ball straight towards a target or picking up a marble with the toes), and 2) stabilizing the body (e.g. standing on one leg). Items 1, 3, 5, 7, and 9 refer to tasks with objects, while items 2, 4, 6, 8, and 10 refer to body stabilization tasks. Respondents can answer: always the left (-2); often the left (-1); both (0); often the right (1) and always the right (2). The items are then scored from -2 to 2, and the total score can range from -20 to 20, according to the given answers. On the basis of addition of the item score, the footedness is categorized as: scores between -20 to -7 is Left; scores between -6 to 6 is mixed and scores between 7 and 20 is right.

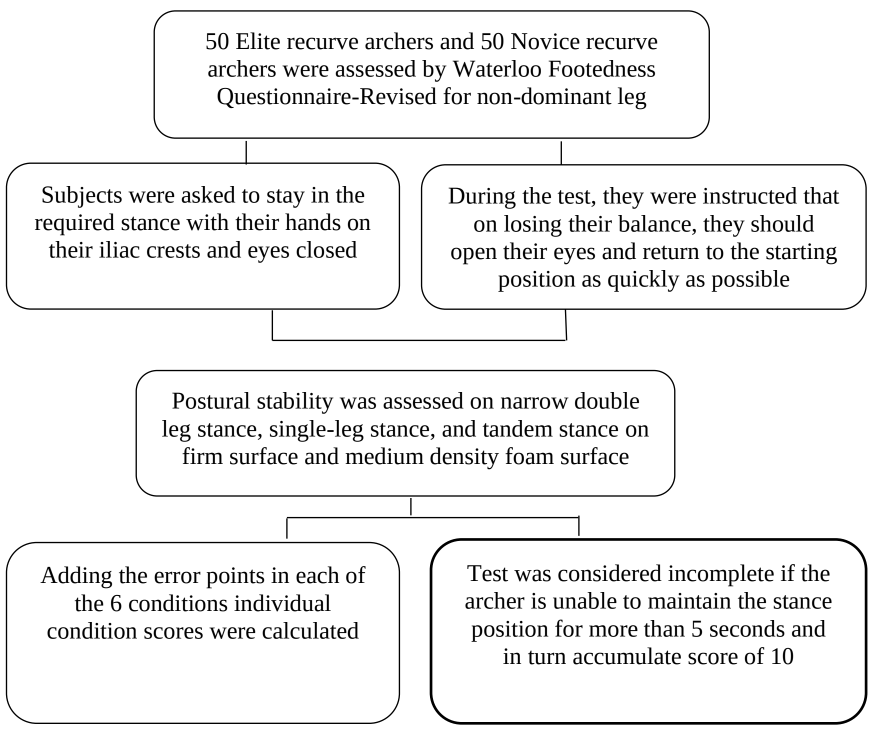


Figure 1 Flow chart

The Balance Error Scoring System (BESS)

Postural stability was assessed by the Balance Error Scoring System (BESS) (Riemann et al., 1999; McLeod et al., 2004). It incorporates 3 stances (narrow double leg stance, single-leg stance, and tandem stance) and 2 different surfaces (firm surface/floor or medium density foam). The test begins with 3 stances, on a firm/floor surface. During each stance for each 20 seconds archers were informed that they have to keep their hands-on-hips and eyes closed. The non-dominant limb was chosen as the standardized test limb across subjects. An error is accumulated if an archer opens eyes, moves the hands off of the iliac crests, steps stumble or falls, does abduction or flexion of the hip beyond 30°, lifts the forefoot or heel off and for greater than 5 seconds he/she deviates from the desired testing position. The second phase of test consists of repeating all 3 stances on the foam surface. The maximum total number of errors for any single condition is 10 and the maximum number of errors possible for each testing surface is 30. As compared with laboratory force platform measures, BESS shows good reliability and excellent intratester reliability.

Statistical analysis

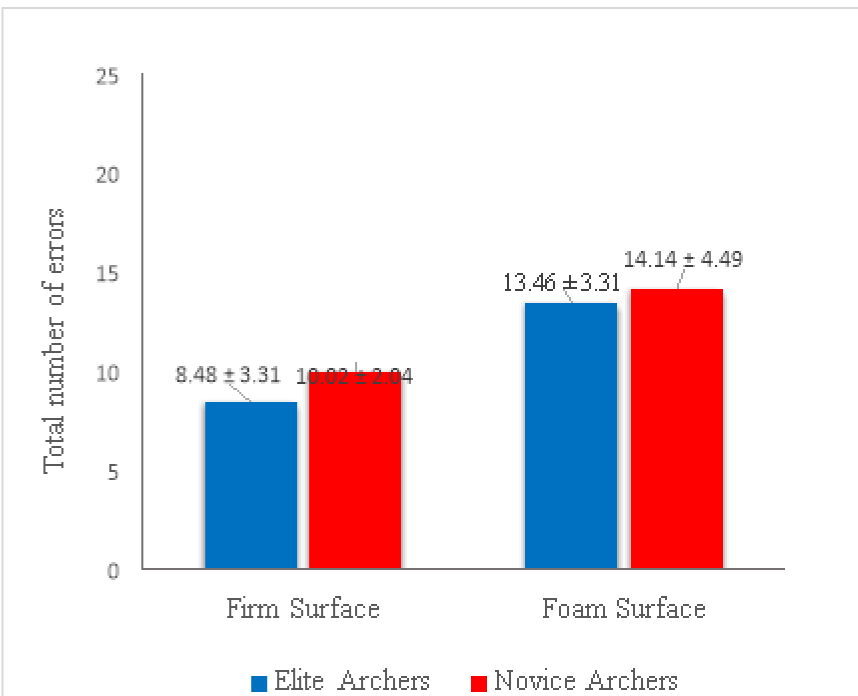
Means ± standard deviations [SD] were used to describe variables. Before using parametric tests, the assumption of normality was verified using the Kolmogorov-Smirnov test. Data were normally distributed and variance was equal between the groups. An unpaired two-tailed t-test was used to compare the means of the BESS score between elite and novice recurve archers. A probability level of $p<0.05$ was used as an indicator of statistically significant results in these analyses. The analysis was performed using the SPSS software statistical package (version. 16.0, SPSS Inc., Chicago, IL).

3. RESULTS

Table 1 Descriptive statistics of Archers

	Elite Archers N=50	Novice Archers N=50
	Mean ± SD	
Age (Years)	19.46 ± 2.91	18.16 ± 2.98
Height (Cms)	162.28 ± 9.98	151.57 ± 12.08
Weight (Kgs)	54.32 ± 9.64	46.46 ±12.76
BMI (Kg/M^2)	20.5 ± 2.57	20 ± 4.17

Abbreviation: BMI = body mass index



Graph 1 Balance Error Scoring System errors between elite and novice recurve archers on different test surfaces

Table 2 Balance Error Scoring System Errors between elite and novice recurve archers on different test surfaces

BESS Score	Elite Archers N=50	Novice Archers N=50	P-Value
	Mean ± SD		
Firm Surface	8.48 ± 3.31	10.02 ± 2.04	0.006***
Foam Surface	13.46 ± 2.84	14.14 ± 4.49	0.368
Total Score (summation of firm and foam surface score)	21.94 ± 4.98	24.16 ± 4.74	0.025**

*P-value < 0.05 indicates significant differences between groups; *** Extremely significant, ** Very significant

Abbreviation: BESS= Balance Error Scoring System

100 archers (50 elite recurve archers and 50 novice recurve archers) completed the BESS test and their scores were analyzed for the statistical differences. In the present study the mean age and BMI of elite archers was 19.46 ± 2.91years, 20.5 ± 2.57 respectively. While novice archers had a mean age of 18.16 ± 2.98 years and the mean BMI is 20 ± 4.17 (Table 1). For between-group analysis of outcome measure, an unpaired two-tailed t-test was used (Graph 1, Table 2). The result of the present study shows that elite archers had significantly less number of balance error on Firm surface p=0.006, and on the total score of BESS p=0.025 than novice archers. However, there was no statistical difference for foam surface score in elite and novice archers p=0.368, both groups showed an equal number of BESS errors (figure 2).

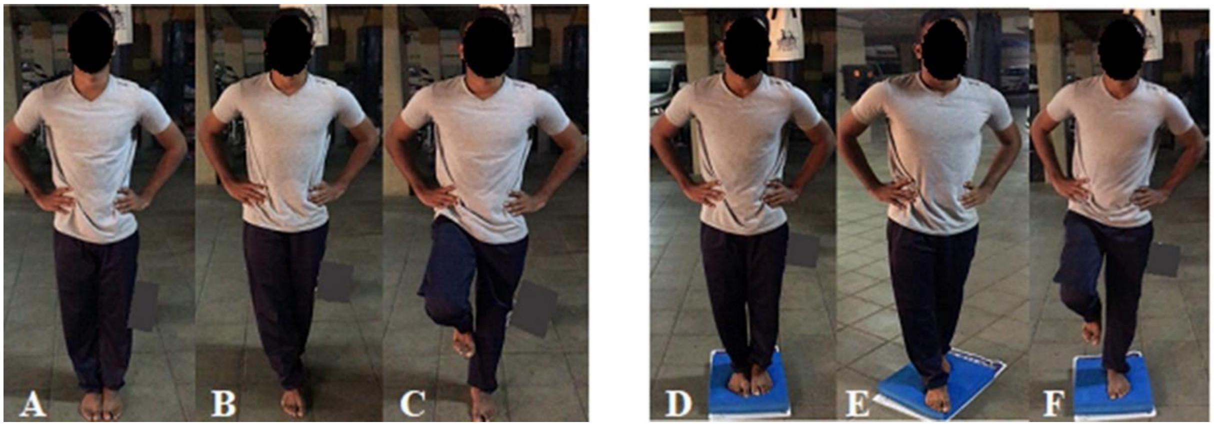


Figure 2 Assessment of balance on firm and foam surface using Balance Error Scoring System
A & D= Double leg stance on firm (A) and foam (D) surface; B & E=Tandem leg stance on firm (B) and foam (E) surface;
C & F= Single leg stance on firm (C) and foam (F) surface

4. DISCUSSION

Postural stability can be characterized by the ability to minimize postural sway, and the postural strategy corresponds to the special involvement of proprioceptive information and the contribution of visual-vestibular information in balance regulation (Paillard, 2014). The goal of the present study was to compare differences in postural stabilizing abilities between elite and novice recurve archers involved in target archery. Postural stability was assessed at outdoor shooting fields to ensure that the testing environment thoroughly resembles the actual shooting environment and climatic circumstances. All prior studies were lab-based in an enclosed environment that did not resemble the actual shooting conditions (Cerrah & Ertan, 2013; Balasubramaniam et al., 2000; Park et al., 2016; Mononen et al., 2007; Eadric Bressel et al., 2007). The results of the study indicate that elite archers had significantly better postural stability on a firm surface and total score of BESS, whereas on foam testing surface both elite as well as novice recurve archers showed no statistical differences in the postural stabilizing ability, indicating an equal number of BESS error counted in both the groups.

Superior postural stabilizing abilities of elite recurve archers on a firm surface (Table 2) can be attributed to the inherent body system. The human body has an integrated visual, vestibular, and somatosensory system to maintain postural stability. The information from these 3 systems has a considerable role in standing balance (Hatzitaki et al., 2015; Massion, 2017). According to practice-based automaticity theories, athletes require minimal attentional demands to complete the task when they are highly trained on the postural task (Nicolas Vuillerme & Nougier, 2004). Similarly, elite archers are highly trained to achieve good shooting performance. Therefore, they can minimize their intentional demands on the performance because it has been regulated by the body system. Also, it is theorized that a more experienced postural control system will show smaller postural sway magnitudes during a given task compared to a less refined. These notions are supported by prevailing literature that elite athletes show smaller sway magnitudes when compared to either non-elite athletes or non-athletes (Williams et al., 2016; Lamoth et al., 2009). Prior studies suggest that level of expertise is directly proportional to cognitive mechanisms (ability to maintain, focus and process information), therefore expert athletes can perform independently (Nicolas Vuillerme & Nougier, 2004; Gautier et al., 2008). It has been noted that due to years of training and tournaments experts athletes of different sports tend to increase their automatic ability of controlling postural sway resulting in better postural sway during upright stance (Nicolas Vuillerme & Nougier, 2004). Thus, allowing them to control their posture to attain peak outcomes (Mohamed & Azhar, 2012). Therefore, based on their level of expertise and years of training the movements of expert archers are predetermined rather than controlled. Similar results were also observed in the present study since the elite archers were involved in target archery from the district level and above. Therefore, they can concentrate on improving the skills of shooting to acquire intent shooting performance (Nicolas Vuillerme & Nougier, 2004; Gautier et al., 2008). Also a study by Paillard T (Paillard, 2019), suggested that in both specific postural conditions and decontextualized postural conditions related to the sport practiced, expert athletes have the best postural performance. However, postural tasks performed in different postural conditions should resemble the sport practice stance. Similarly, in the present study firm/ stable surface closely resembles the actual shooting environment and condition in which archers practice or competes.

Statistically significant reduction in total BESS errors (Table 2) was seen in elite recurve archers. During balance assessment, the total score of BESS accounts for the summation of firm surface and foam surface score. As discussed above, compare to novice recurve archers elite recurve archers had less balance errors on a firm surface. Thus, we hypothesized that improved balance on the firm surface condition could have led to a decrease in total BESS errors in elite archers than in novice archers. In the present study it was observed that, there was no statistical difference in the BESS score between elite and novice recurve archers on the foam surface (Table 2). A study by D.S. Blaise Williams III et al. suggested that the training paradigm or environment in which an athlete competes is associated with unique postural control strategies (Williams et al., 2016) and reflects in the maintenance of equilibrium during erect stance and has a considerable role in excelling the sensorimotor skills of athletes (Hatzitaki et al., 2015). Archery is a static and precision sport requiring archers to hit targets at various distances. The discipline of the sport of archery is such that, it does not require unstable surface as a prerequisite to it. Archers for practice sessions and tournament train themselves on a firm surface. Therefore, we speculate that the introduction of novel unstable surface for task assessment could be the reason for elite and novice archers to have a non-significant difference in the BESS score on the foam surface.

In the present study, the elite archers were categorized as archers playing archery district level and above. Therefore, how top-level archers differ in maintaining postural stability from the national level and the state level archers is not understood. Hence, further studies should focus on assessing the postural stabilizing abilities of top-level archers in comparison with others. Also, archers with different age groups can be studied for the comparison since the present study includes archers between the age group of 15-25 years.

5. CONCLUSION

From the findings of the present study it is concluded that elite recurve archers had statistically significant better postural stability as compared to novice recurve archers on firm or stable surface, which closely resembles their sport practice. However, when assessed on an unstable surface, both elite and novice recurve archers showed no difference in postural stabilizing abilities. Therefore, present results may be useful to coaches and physiotherapists for optimizing the performance of archers by developing sport-specific training strategies and postural training programs that bring about the necessary requirement of the game.

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Informed consent

Written informed consent was obtained from all individual participants included in the study.

Ethical approval for study protocol

The study was approved by the Institutional ethics committee [DYP/IEC/01-003/2019], Padmashree Dr. DY Patil Medical College, Hospital and research center, Navi Mumbai.

Authors' contributions

Dr.Pranita Ganjave carried out the study design, data collating, data analysis and interpretation, and drafted the manuscript.

Dr.Ajit Dabholkar conceived the study, participated in its design, helped to draft the manuscript; provided a critical review of the manuscript.

All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

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Conflict of interest

The authors declare no competing interest

Data and materials availability

All data associated with this study are present in the paper.

Peer-review

External peer-review was done through double-blind method.

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