

Sport-Specific Differences in Static and Dynamic Balance: A Comparative Investigation

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Abstract

Background: Balance is a critical component of athletic performance and injury prevention. Static and dynamic balance are the two components of balance. Static balance involves the ability to balance in a stable environment whereas dynamic involves the ability to maintain equilibrium during movement. These abilities can vary based on different individuals. Emerging evidence suggests that sports-specific demands may significantly influence their development.

Objectives: Sport-specific differences in static and dynamic balance were analysed and discussed.

This study investigated the relationship between static and dynamic balance abilities in athletes.

Methods: Eighty athletes aged 12-18 years from four different sports (gymnastics, judo, soccer, and hockey) participated. Static balance was assessed using the Balance Error Scoring System (BESS) on both firm and foam surfaces. Dynamic balance was evaluated using the Star Excursion Balance Test (SEBT).

Result: Results indicated significant differences in both dynamic and static balance performance across the sports statistically. Gymnasts demonstrated superior static and dynamic balance compared to the other three groups ($p < 0.05$). Judo athletes also exhibited better static balance than hockey and soccer players ($p < 0.05$).

Conclusion: These findings suggest that sport-specific sensorimotor demands may influence the development of balance skills. This information can be used to inform the design of sport-specific balance training programs for injury prevention and performance enhancement.

Keywords: Athletes, balance, balance error scoring system, sports, star excursion balance test.

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Introduction

Balance is a complex mechanism which involves maintaining stability and control of the body while moving or stationary. Balance plays a significant role in a young athletes' performance and injury prevention¹.

The selection of different sports for this comparative study was based on varied biomechanical and sensorimotor demands of the following sports, giving us more insight into how these sporting activities influence balance and postural control.

Gymnasts perform exercises which involve physical activity with artistry which often involves complex movements. They use various appliances like bars, beams, vaults, rings etc. to perform their sport. Most of their skills require increased strength, mobility, flexibility and exaggerated range of motion².

Athletes playing soccer often require good coordination and strength. They require skills to perform motions like passing, shooting, and dribbling the ball while wearing cleated or non-cleated shoes and running on different surfaces like artificial or non artificial turf³.

Judo is a martial art where players are required to have incredible leg strength and balance to perform grappling, throwing and submission moves on the tatami-mat on bare foot.

High balance function of the body is needed to support the load on the toes and plantar surface⁴.

Field hockey players use a stick to hit a small hard ball across a field and into a goal.

This sport requires players to maintain controlled balance and stability while running, changing directions, tackling, and striking the ball.

We theorized that the discussed sports demand different mechanics, giving us more insight into how these sporting activities influence balance and postural control.

Review of Literature

Comparison of static and dynamic balance in young female collegiate soccer, gymnasts and basketball.

Eadric Bressel, EdD, Joshua C Yonker, MS, LAT, ATC, John Kras, EdD, and Edward M Heath, PhD.

This article studied static and dynamic balance using BESS and SEBT respectively in collegiate Soccer, gymnasts and basketball players.

Results show that gymnasts performed better in static balance by having an error score 55% lower than the basketball group.

Soccer players performed better in the SEBT by 7% showing better dynamic balance as compared to basketball.

Results show no significant difference between static and dynamic balance between gymnasts and soccer players. Basketball players showed inferior static balance as compared to gymnasts and reduced dynamic balance as compared to soccer players².

Static and dynamic balance in young athletes

Leonardo Ricotti

Biorobotics Institute – Scuola Superiore Sant'Anna, Pontedera (Pisa), Italy

This article discusses the significance of improving static and dynamic balance in young athletes at different ages. It also talks about how different sports require different postural control and sensorimotor abilities. It further analyses existing literature on athletes at different age ranges and playing sports at different levels. This study highlights the further need for study based on different balance mechanics at different ages and different sports⁵.

Dynamic Balance Differences as Measured by the Star Excursion Balance Test Between Adult-aged and Middle-aged Women

Lucinda E. Bouillon, PT, PhD and Joshua L. Baker, PT, PhD

Dynamic balance was tested between Adult aged and Middle aged women in this study. Lucinde et al studied 53 healthy recreationally active women that were divided based on age into 2 groups. (n=29) aged 23-39 y.o and (n=24) aged 40-54 y.o.

Each participant performed the SEBT in anteromedial, medial and posteromedial directions

in randomized order. Results showed significant difference in the scores, with younger women performing approximately 7 cm more in all three directions as compared to older group ⁶.

The Comparison of Balance Ability Between Judo Players and Non- Athletes

Ching-Cheng Chiang, Jinn-Yen Chiang, Tzyy-Yuang Shian

This study focused on comparison of Static and dynamic balance in Judo players vs non athletes. The groups consisted of 10 elite judo players (mean age 21.2 ± 1.5 years) and 10 non athletes (mean age 19.2 ± 1.9 years)

Static and dynamic balance was tested by using the Kistler force plate system and tensiometer. They assessed the difference of balance on single leg stance with eyes closed, Center of Pressure (COP) of body sway and time of recovery. Results show significant difference between static and dynamic balance between the two groups. Judo players had a smaller radius of body sway COP in static tests than the non-athlete group. In dynamic balance there was a significant difference between the recovery times between the groups⁷.

Unilateral balance performance in female collegiate soccer athletes.

Jennifer L Thorpe, Kyle T Ebersole

This study investigated strength and postural control on the SEBT in NCAA Division I female collegiate soccer and non soccer athletes (non soccer n=11, soccer n=12). Isokinetic strength testing was done for all participants in different positions: supine ankle dorsiflexion and plantar flexion, seated leg extension and flexion and supine hip extension and flexion.

In addition these athletes performed maximal SEBT reaches in anterior, medial and posterior directions on both limbs.

Results indicated SEBT test results are similar for both limbs in both groups. Soccer groups had significantly better scores as compared to non soccer athletes. SEBT scores did not have correlation to strength tests. It concluded that SEBT score differences might be due to neuromuscular factors and sport related adaptations ⁸.

Comparison of the static and dynamic balance performance in young, middle-aged, and elderly healthy people.

by Mei-Yun Liaw, Chia-Ling Chen, Yu-Cheng Pei, Chau-Peng Leong, Yiu-Chung Lau

Chang Gung Medical Journal.

In this study, static and dynamic balance were compared based on age. A total of 107 healthy individuals (n=107) divided into young (16-39 years), middle age (40-59 years) and elderly (60 years and above) groups.

Balance was assessed by computerized dynamic posturography (CDP) on smart balance master. The subtests were as follows: "subtest 1, eyes open, fixed support platform; subtest 2, eyes closed, fixed platform; subtest 3, eyes open, fixed platform; subtest 4, eyes open, swaying platform; subtest 5, eyes closed, swaying platform; subtest 6, swaying visual surround, swaying platform." Motor balance control tests included limit of stability test at 75% in 8 directions: left-right and forward-backward rhythmic weight shift test (RWS)

The tests concluded that elderly individuals tend to use more hip strategy when balancing on swaying support surfaces with low to no visual surround. Elderly individuals also showed increased reaction time and lower directional control in balance performance ⁹.

Aim and Objectives

Aim:

This study aimed to investigate and compare static and dynamic balance performance across athletes from soccer, gymnasts, judo and hockey disciplines.

Objectives:

The specific objectives of this investigation were to:

- Quantify static balance performance on both firm and foam surfaces and score it based on BESS.
- Evaluate dynamic balance performance using the Star Excursion Balance Test (SEBT).
- Determine and compare inter-sport differences in static balance performance.
- Determine and compare inter-sport differences in dynamic balance performance.

Method and Methodology

STUDY DESIGN: Observational, between-groups design. Independent variables included sports-played and limb (dominant and nondominant).

STUDY SET UP: KridaPrabodhini athletic training facility (Balewadi sports centre) and Loyola high school football centre.

SAMPLING METHOD: Convenient

SAMPLE SIZE: 80 ($n=80$), Judo ($n=20$), Hockey ($n=20$), Gymnastics ($n=20$) and Soccer ($n=20$)

MATERIALS: measuring tape, pencil, markers, adhesive tape, thera board, stopwatch.

Inclusion Criteria

- Age 12 to 18 athletes
- At least 2 years to 5 years of athletic training
- No injury in the past 6 months.

Exclusion Criteria

- Athletes with any injury,
- Athletes with vestibular problems.

Procedure

The study was reviewed and approved by Sancheti Institute College of Physiotherapy. This study took

place at KridaPrabodhini athletic training facility (Balewadi sports centre) and Loyola high school football centre. Permission was obtained from all the above mentioned centers.

Participants were selected based on the inclusion and exclusion criteria. Informed consents were obtained from the participants and their athletic coaches before beginning the study.

Star excursion balance test (SEBT) was used to measure dynamic balance in this test.

Balance error scoring system (BESS) was used to assess static balance. Theraboard was used as the unstable surface and a tiled floor was used as a stable surface for this test.

SEBT: Dynamic balance

This test consisted of forming a star shaped grid by using 8 lines of 120 cm in length each. All these lines were made in 45 degree angle increments. We used athletic tape to make this grid on a firm tiled surface. A small circle was made in the center of the star which marked the position of the stance foot.

As per Gribble and Hertels protocol, the participant would stand on one leg in the center circle and try to reach maximum distance in all eight directions using the other leg. The athletes were instructed to do a touchdown with the reach leg without putting too much weight to support. If the participant would support on the reach leg or lose balance on the support leg then the trial was repeated¹⁰.

Three trials were performed and there was a 120 sec rest given in between each trial. Participants were given 180 secs to familiarize themselves with SEBT before performing the trial.

Measurements: Each reach distance was measured by putting a chalk mark corresponding to the reach foot. A measuring tape was used to calculate the distance to the nearest millimeter.

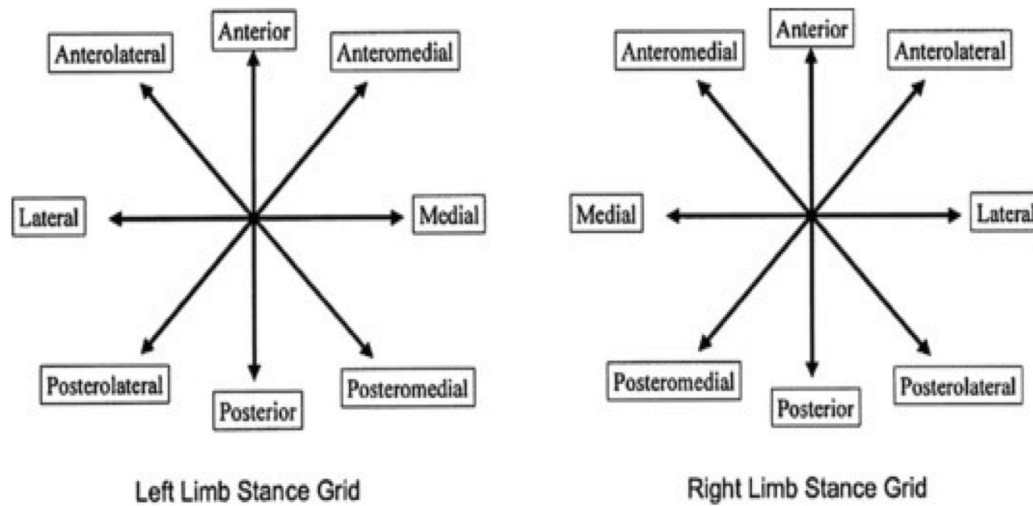


Figure 1: SEBT testing grid

The testing grid for the Star Excursion Balance Tests. The directions are labelled based on the reach direction in reference to the stance limb source: Hertel et al. 2006)¹⁰.

BESS : Static balance

Participants performed this test for 20 secs on foam and firm surfaces in 3 different stages:

1st: Feet together

2nd: Single leg stance (non-stance leg at 90 degree knee flexion)

3rd: Tandem stance

They were instructed to stand with hands on their hips and eyes closed.

Measurements

Once the participant has assumed each position, a 20 second timer was started and errors were measured. An error was rated when one of the following occur:

1. Moving hands off iliac crest
2. Opening the eyes
3. Step stumble or fall
4. Abduction or flexion of hip beyond 30 degrees
5. Lifting forefoot or heel off the testing surface
6. Remaining out of the proper testing position for greater than 5 seconds.

Maximum total number of errors for any single condition is 10¹¹.

Results

Static Balance

Table 1. BESS score for different athletes on different surfaces and the total score

SURFACE	HOCKEY	JUDO	GYMNAST	SOCCER
FIRM	6.15 (30)	2.52(30)	3.4 (30)	4.6 (30)
FOAM	9.02 (30)	5.8 (30)	4.9 (30)	10.18 (30)
Total	15.17	8.32	8.30	14.78

Data Analysis

Static Balance

Data analysis was done using Statistical Package for Social Sciences (SPSS) software.

A two way Analysis of variable (ANOVA) was done to compare mean error scores on different surfaces (firm and foam) across different sports.

As inferred from Table 1. the BESS score for Judo players was the least on firm surface 2.52 (i.e. 8.4%) followed by Gymnasts having a score of 3.4 (i.e. 11.33%) followed by soccer and hockey players having values 4.6(i.e. 15.33%) and 6.15 (i.e. 20.5%) respectively.

Static balance on foam surface is shown best by Gymnasts having a BESS score of 4.9 (i.e. 16.33% error) second best shown by Judo players having a score of 5.8 (i.e. 19.33% error), followed by hockey and soccer players having scores of 9.02(i.e. 30.6% error) and 10.18 (i.e. 33.9% error) respectively. Post-hoc Tukey's test indicated significant differences between hockey/soccer and gymnasts/judo across both surfaces ($p<0.05$).

Static Balance is proved to be better in gymnasts having an error score of 8.30 followed by judo players having a total error score of 8.32 followed by soccer and hockey players. The difference in the total scores are significant as indicated by post-hoc Tukey's test ($p<0.05$).

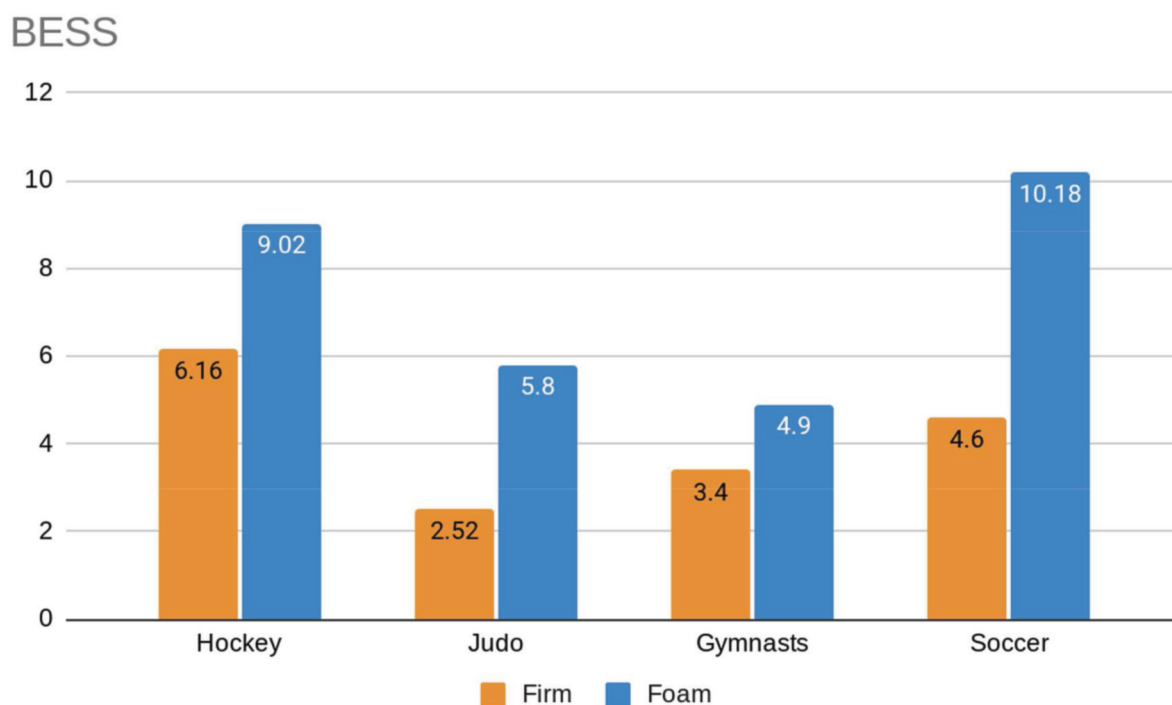


Figure 2: Error scores for different sports on different surfaces

Dynamic Balance

Calculations

Limb length % of all the positions (i.e. Ant, Ant-Lat, Lat, Post-Lat, Post, Post-Med, Med, Ant-Med.) were calculated by using the formula:

$$\text{Limb Length \%} = \frac{\text{Excursion distance}}{\text{Limb length}} \times 100$$

Summation of Limb Length % of all the positions were done for each player for both limbs and the mean of that was taken for every sport. A one way ANOVA test was done to compare the value between these four sports.

Depicted in Table 2. is the mean limb length percentages of different sports. A one way ANOVA study shows significant differences in dynamic balance across sports. Post-hoc Tukey findings reveal that gymnasts had the highest limb length % of 935.58 followed by hockey of 866.85, judo at 811.56 and finally soccer at 782.86. Significant differences were indicated between gymnasts and the rest of the athletes ($p < 0.05$)

Table 2. Comparing summation of limb length % of different sports.

Sports	Hockey	Judo	Gymnasts	Soccer
Summation of Limb length %	866.85	811.56	935.58	782.86

A graphical representation of limb length percentage in different sports is depicted in Graph 2.

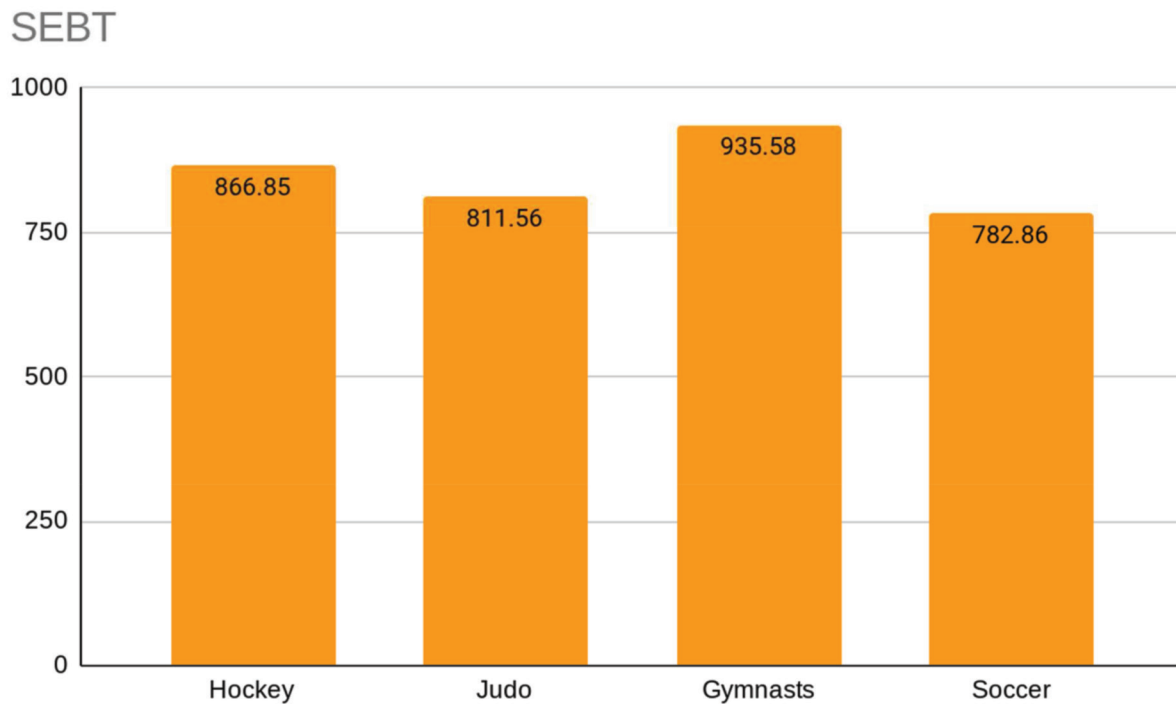


Figure 3: Limb length percentage for different sports

Discussion

This study reveals distinct variations in static and dynamic balance capabilities among athletes participating in different sports. Gymnasts demonstrated superior performance in both static and dynamic balance assessments compared to judo, soccer, and hockey players. Furthermore, judo athletes exhibited enhanced static balance compared to their soccer and hockey counterparts.

These findings suggest a correlation between the specific sensorimotor demands inherent in each sport and the development and expression of balance

proficiency. The observed performance variations may be attributed to factors such as the characteristic movement patterns of each sport, the playing surfaces involved, and the degree of emphasis placed on balance training within each discipline. These results offer practical implications for coaches and athletic trainers in the design of sport-specific balance training regimens aimed at optimizing athletic performance and potentially mitigating injury risk.

Further investigation is warranted to elucidate the underlying mechanisms contributing to these inter-sport differences and to evaluate the efficacy

of targeted balance interventions for athletes across various sports. Future research should consider controlling for potentially confounding variables such as training volume, skill level, and history of musculoskeletal injury to more precisely isolate the influence of sport participation on balance abilities. Additionally, the inclusion of measures assessing related factors such as proprioception, strength, and range of motion would contribute to a more comprehensive understanding of the multifaceted determinants of balance performance in athletes.

The literature seems to support that athletes undergoing static and dynamic balance training have lesser incidences of ankle sprains and other musculoskeletal injuries as compared to the control group¹².

A study conducting static and dynamic balance between female soccer, basketball, and gymnastic athletes discussed that the study will help prescribe different exercises to different athletes to strengthen their performance and reduce injuries².

In addition to knowing which balance training programs are effective, athletic trainers and physical therapists would benefit from knowing which athletes require more balance training to reduce musculoskeletal injuries.

Conclusion

This study successfully demonstrates significant clinical and statistical differences in balance between the four sports: judo, hockey, gymnastics, and soccer. The gymnasts showed superior balance in both static and dynamic measures as compared to the other sports highlighting the importance of flexibility and their sports unique sensorimotor demands.

Judo athletes also showed enhanced static balance scores as compared to hockey and soccer players further supporting the notion of how sport specific training shapes balance abilities. These findings offer valuable insights to coaches, athletic trainers, and sport physiotherapists to develop targeted balance training programs to reduce risk of injuries and improve performances.

Study Limitations

This study acknowledges various limitations that require considerations. Athletes strength and proprioceptors were not assessed prior to the test. The potential of these factors playing an influential role in static and dynamic balance across sports could not be determined. Furthermore, the lower extremity and trunk ROM of these athletes were not measured. The variations in ROM to the balance performances remain unclear. These limitations warrant further need for studies taking into account these variables and its effects on static and dynamic balances.

Scope For Future Studies

To broaden the findings of this investigation, several avenues for future research are proposed. Firstly, increasing the sample size will improve generalizability of the study with more statistical data. Secondly, doing a detailed analysis on male and female athletes will give a better understanding of how gender plays a role in dynamic and static balance. Finally, a study comparing dominant and non dominant legs will give a better insight on lateralized balance control strategies and their potential impacts on sport-specific performance.

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