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RESEARCH ARTICLE

A COMPARISON OF LEFT AND RIGHT LEG STATIC BALANCE PARAMETERS IN YOUNG HANDBALL PLAYERS

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ABSTRACT

Purpose: The purpose of this study was to compare left and right leg balance parameters in young female handball players.

Methods: 13 athletes (age: 15.07±0.19 years; height: 162.23±5.70 cm; body weight: 57.38±4.39 kg; BMI: 21.92±0.23 kg/m²; training age: 4.23±1.36 years) volunteered for the study. Normality test of the data was done using Shapiro-Wilk test, and variation homogeneity was tested using Levene's Test of Homogeneity of Variance. When the data showed non-parametric characteristics, Mann Whitney U-Test was used; when it was parametric, Independent Sample Test was used. SPSS 17 Software was used for statistical analysis, and the significance was determined as $p \leq 0.05$.

Results: The results showed that when the mean speed of the left and right leg forward-backward velocity of the athletes was analysed, a significant difference was found in favour of the right leg ($p \leq 0.05$). Furthermore, a significant difference was found in favour of the right leg between means of the left and right leg perimeter of the athletes ($p \leq 0.05$). However, there found no difference between means of the left and right leg lateral velocity and ellipsis area of the athletes ($p \geq 0.05$).

Conclusion: These results may show that due to the training ages of the athletes (4 years), branches of the athletes did not affect the results and their improvement were still in progress. It could also be due to the dominant leg of all the athletes being their right leg and/or due to the differences in their leg strength. The most important limitation of this study could be the fact that leg strength values were not included in the study. Generally, in handball, when the dominant arm of the athlete is their right, the leg at the opposite side is the one used for jumping. Nevertheless, in individual leg balance tests done with both legs, it is expected there be no difference between the values. For these differences not to cause any sport injuries and not to negatively affect the technical move performances, it is advised that coaches have lower extremity strength and balance exercises symmetrically done.
Keywords: Balance, handball, performance, toe, motor control, postural sway

INTRODUCTION

Balance is defined as the ability to maintain the body's centre of gravity on the support centre with minimal sway or maximal stability (1). Maintaining balance while standing is seen as a fairly easy motor skill, whereas balance is a complex motor skill (2,3). Balance in sports is also an extremely important and improvable motor skill. It is an extremely essential element to perform well and increase performance (4,5).

Posture serves two important functions in the body: providing mechanical antigravity and balance. It, based on the effect of gravity, determines the position of a person in space, and thus the upright position of the body is acquired. Posture is the product of the communication of body segments with the neuromuscular system, and a good posture is one of the functions of skeletal muscles (6,7). While standing, the human body is in an unstable state due to gravity, the tilt of the ankle joints, a change of the support surface, and the influence of external forces. So as to correct these destabilizing conditions, several postural control systems become involved (8, 9). Postural control is the basic prerequisite for maintaining balance, reacting to external forces, and performing desired movements during many postures or active movements. The function of the postural control system is to be the feedback control circuit between the brain and the musculoskeletal system. Using these feedback circuits, an individual can, despite the gravity, stand with the help of skeletal muscles (10). Postural control systems consist of sensor, skeletal-muscular and central nervous systems (11). Many cognitive resources are initially needed for postural control, and even more cognitive processes are needed to ensure postural control in difficult conditions. This control is a process through which the sense of movement and position from the vestibular (auditory), visual and somatosensory systems, and sensory information received from these systems to find direction and select the desired movement are processed. Postural control is also a perceptual-motor process that involves the selection of the responses of the motor processes that provide balance or restore the lost balance. This, loss of balance, occurs when the relationship between these systems is disrupted (9,12,13).

From a biomechanical point of view, if the vertical line of the centre of gravity falls outside the support area, mechanical balance is disturbed. In this case, if the balance cannot be restored with the help of ankle and hip strategies, the individual takes a step to expand the support surface (14). The role of the muscles that move the joints, especially the ankle, knee, and hip joints, is of significance in balancing the body. There are movement strategies are available to maintain body balance while standing. These consist of the ankle, hip, and stepping strategies. The same directional sway of the whole body at the ankle that occurs when the body balance is disturbed is called the ankle strategy. In more extensive balance losses where this strategy would not be sufficient, the balance is tried to be regained by movements of the lower extremities and trunk and upper extremities in opposite direction, which is called the hip strategy (2,3).

In most of sports movements, a good dynamic balance and coordination must be obtained. When the balance is disrupted, it is necessary to have good and improved balance skills in order to recover quickly and regain postural control (5, 15). Each sports branch develops its own special postural harmonies (4,7,16). Control of balance is a complex motor skill that includes the integration of sensory inputs as well as planning and subsequent implementation of different movement patterns (17). Performing basic motor skills in sports such as jumping and hitting the ball highly correlates with the balance of the athlete (4,15). The ability to keep the body standing still is called static balance (9), and it is significant to keep the balance and sway in a controlled manner while shooting (18).

Handball is a sport in which aerobic and anaerobic energy metabolisms are used alternately, and where factors such as strength, speed, endurance, as well as flexibility, and balance affect performance. Performing desired correct technical movements and doing them fast during training or competitions require a good balance and balance control. As handball is a team sport that involves one-on-one tackles, sudden direction changes, runs at different speeds and goal kicks with different techniques, athletes need to control their posture while applying motor skills, follow teammates and opponent players using the visual clues they receive from the environment, and accordingly take the appropriate and correct position in attack or defence. Otherwise, the disruptions in technical movements may lead to a decrease in performance and additionally sports injuries (19,20,21).

Investigation of the effect of postural sway on sports branches is very significant in terms of planning balance training programs of athletes since performing high-level motor movements during training or competitions requires the control of both static and dynamic balance. In the literature review, it has been seen that there are only a few balance studies in which both handball and lower extremities are compared though there are various studies on postural sway in different sports branches. Based on these, the aim of this study is to compare left and right leg balance parameters in young female handball players.

METHODS

Participants

13 female athletes (age: 15.07±0.19 years; height: 162.23±5.70 cm; body weight: 57.38±4.39 kg; BMI: 21.92±0.23 kg/m²; training age: 4.23±1.36 years) volunteered for the study. Before the data collection, ethical approval was received from Bilecik Seyh Edebali University Non-Interventional Clinical Research Ethics Committee (Approval no: E-10333602-050.01.04-60226, Date: 24.11.2021). Since the athletes were under 18, a voluntary participation form was filled out by each athlete and their families before any test was done. Moreover, they were informed about the static uni-balance tests. These participants had been training regularly for four days in a week. Athletes that had an operation or sports injuries on their lower extremities in the last year were not included in the study. No sports injuries were experienced during or after the tests. The athletes did a 10-minute warm-up exercise at moderate intensity focusing on stretching lower extremities before the test. Then they had the static balance test.

Design of the Study

The study was completed with a U16 team within the season. The height of the athletes was measured by a stadiometer (Seca, Germany), their weight was measured by a digital scale (Desis Weighing Expert) and their balance was measured by Static Balance-Prokin 5.0 Technobody device (Pk-Manop-05-en-01 Bergamo, Italy). The measurements were done within the same day by the same researcher. Athletes had a one-minute rest between the measurements.

Height measurement: The measurement was taken by measuring the distance between the vertex of the head and the ground, following a deep inspiration while the head was in the Frankfort horizontal plane (22).

Weight measurement: Body weight was measured when athletes were in their standard sports clothes (shorts and a T-shirt) without shoes in accordance with standard techniques (22).

Body mass index measurement (BMI): Body mass index was calculated by dividing body weight (kg) by the square of the height (m^2) (22).

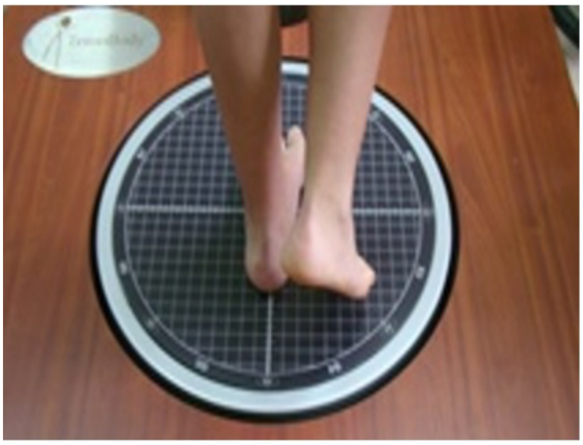

Figure 1. Unipedal (left) static balance test

Figure 2. Unipedal (right) static balance test

Static balance measurement: The static balance tests were performed in a quiet environment in the morning 2 hours after breakfast. Before the tests, the testing process was explained to the participants, and the data were entered (athletes' height, weight, and age) to the device, the balance platform was adjusted to be static, and the device was calibrated. Static balance was assessed with two tests which were standing for 30 seconds without any support with their eyes open on the left and right leg individually. The place where the athlete's foot should be placed was adjusted so as to be balanced on the lines on the platform before the test. Each athlete was asked to stand on one leg on the platform with bare feet their medial arcs on the x-axis with maximum projection. They were instructed to balance on one leg (Figures 1 and 2) and minimize upper body movements with their arms at sides or their hands on their waist and also to look at the screen of the device and keep themselves at point 0 (Figure 3) during the test (30 seconds). Furthermore, the athletes were told that

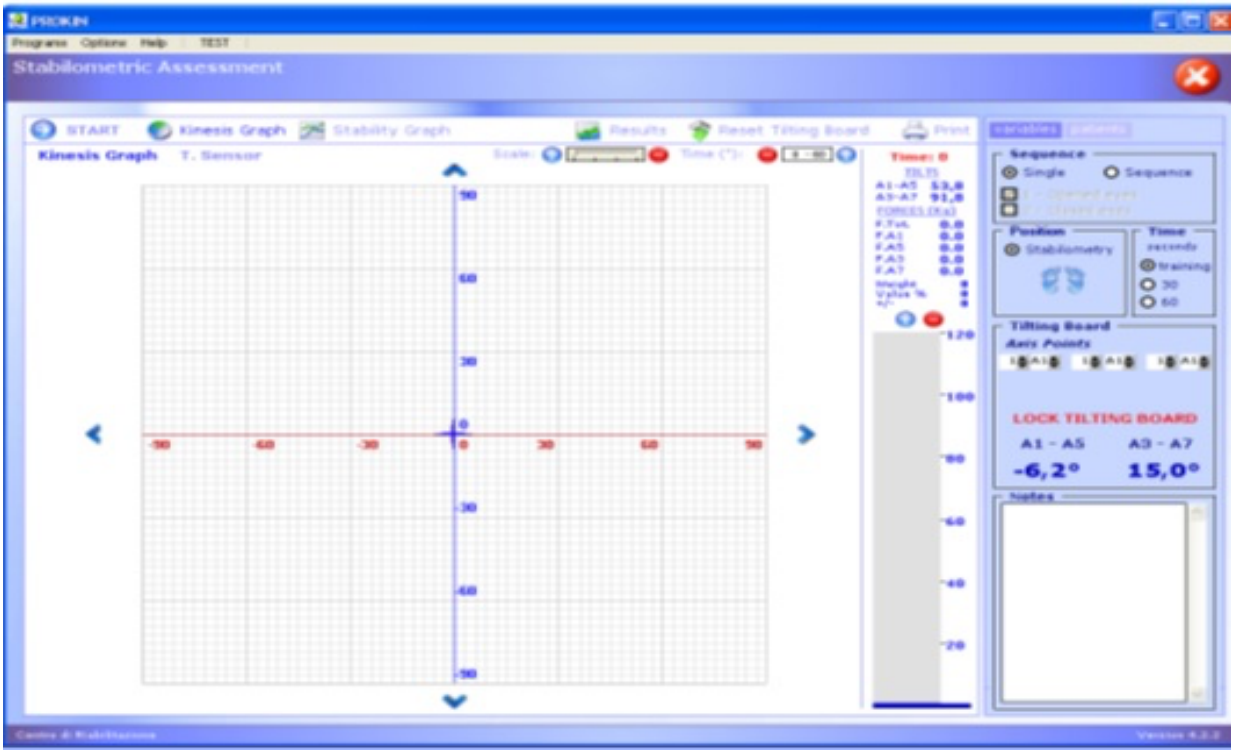

Figure 3. Unipedal balance test's screen view

during the test, they should not talk and that they should stay calm and focus on the test itself. To minimize the upper body movements, they were informed that the fewer sways at the target shown on the screen, the better one-leg static balance test values they would get. Additionally, athletes were notified that the leg that was not on the floor could be held to the side with a slight bend at the knee and it should, however, not touch the other leg or any other place as a support; otherwise, the test would be considered invalid and needed to be repeated. Trials were not allowed to eliminate the learning effect. After giving the instructions for the test, the first test was performed. After each test, the device was recalibrated. When the first test was completed, each participant was given 30 seconds to sit down and rest and adjust the other foot properly on the platform. Then they started the second test. During the tests, the participants were given no oral feedback unless it was needed. The means of centre of pressure X (C.o.P.X), centre of pressure Y (C.o.P.Y), forward-backward velocity, medium-lateral velocity, perimeter and ellipse area were taken into consideration while the data was assessed. Prokin 5.0 (Prokin System 5.0 Pk-Manop-05-en-01 Bergamo, Italy) was the device used to measure the unipedal (left and right leg) static balance.

Statistical Analysis

SPSS 17 Software was used for statistical analysis, and the significance was determined as $p \leq 0.05$. Normality test of the data was done using Shapiro-Wilk test, and variation homogeneity was tested using Levene's Test of Homogeneity of Variance. When the data were non-parametric, Mann Whitney U-Test was used to measure the differences between the left and right leg forward-backward velocity and left and right leg perimeter. The parametric data, however, was analysed with Independent Sample T-Test to determine the differences between left and right leg lateral velocity and left and right leg ellipse area.

RESULTS

When Table 1 is examined, it can be seen that the mean age of the athletes was 15.07±0.19 years, mean height was 162.23±5.70 cm, mean weight was 57.38±4.39 kg, mean BMI was 21.92±0.23 kg/m², mean training age was 4.23± 1.36, mean of left leg forward-backward velocity was 41.07±8.60 mm/sec, mean of right leg forward-backward velocity was 34.23±12.28 mm/sec, mean of left leg lateral velocity was 34.53±9.76 mm/sec, mean of right leg lateral velocity was 30.84±11.86 mm/sec, mean of left leg ellipse area was 1536.23±327.61 mm², mean of right

Table 1. Descriptive data of demographic and static balance parameters

Parameters	n	Minimum	Maximum	x̅	sd
Age (years)	13	15	16	15.07	0.19
Height (cm)	13	156.00	174.00	162.23	5.70
Weight (kg)	13	50.80	63.00	57.38	4.39
BMI (kg/m²)	13	18.16	25.16	21.92	0.23
Training age (years)	13	3.00	7.00	4.23	1.36
Left Leg Forward-Backward Velocity (mm/sec)	13	30.00	53.00	41.07	8.60
Right Leg Forward-Backward Velocity (mm/sec)	13	23.00	59.00	34.23	12.28
Left Leg Lateral Velocity (mm/sec)	13	22.00	53.00	34.53	9.76
Right Leg Lateral Velocity (mm/sec)	13	16.00	59.00	30.84	11.86
Left Leg Ellipse Area (mm²)	13	1079.00	2158.00	1536.23	327.61
Right Leg Ellipse Area (mm²)	13	830.00	2360.00	1332.69	449.35
Left Leg Perimeter (mm)	13	973.00	2636.00	1547.76	552.28
Right Leg Perimeter (mm)	13	558.00	2712.00	1111.38	709.70

leg ellipse area was 1332.69±449.35 mm², mean of left leg perimeter was 1547.76±552.28 mm, mean of right leg perimeter was 1111.38±709.70 mm.

When Table 2 is analysed, it can be seen that the results of the Mann Whitney U test showed a meaningful difference between the means of left and right leg forward-backward velocity and perimeters ($p \leq 0.05$). It was found out that the right leg forward-backward velocity and perimeter values were better.

When we have a look at Table 3, it is seen that the results of the Independent Sample test did not show any meaningful difference between the means of left and right leg lateral velocity and ellipse area ($p \geq 0.05$). In addition, there seen no meaningful difference between the means of left and right leg ellipse areas ($p \geq 0.05$).

DISCUSSION

The purpose of this study was to compare left and right leg balance parameters in young female handball players. When the results were examined, it was found that the comparisons of static balance parameters between the means of left and right leg forward-backward velocity and perimeters showed a meaningful difference ($p \leq 0.05$) in favour of the right leg (Table 2). However, in terms of their left and right leg lateral velocity and ellipse area means, there was no significant difference ($p \geq 0.05$) (Table 3). To perform some of the basic movements in sports, it is important to balance on one leg. For example, in soccer to improve your technique or kick the ball, one needs to be on their one leg, so balancing when keeping the right posture is highly important. Thus, the control of the footballers over their posture is assessed while standing in one leg (7). There are various scenarios including the type of shoe they wear or the field they play in that soccer players use their lower extremity movements (23). This is valid for handball as well since handball players play in different positions and perform many moves like jumping, and these require precision and speed. In handball, physical activities such as flexibility and velocity are considered as highly essential since these athletes play on courts with hard surfaces and

Table 2. Comparisons of unipedal static balance tests between right and left leg – Results of Mann Whitney U Test

Parameters	x̅	z	p
Left Leg Forward-Backward Velocity (mm/sec)	16.42	-1.95	0.05*
Right Leg Forward-Backward Velocity (mm/sec)	10.58		
Left Leg Perimeter (mm)	16.77	-2.18	0.02*
Right Leg Perimeter (mm)	10.23		

* p≤ 0.05

Table 3. Comparisons of unipedal static balance tests between right and left leg – Results of Independent Sample Test

Parameters	x̅	t	df	p
Left Leg Lateral Velocity (mm/sec)	34.54	0.86	24	0.39
Right Leg Lateral Velocity (mm/sec)	30.85			
Left Leg Ellipse Area (mm²)	1536.23	1.32	24	0.19
Right Leg Ellipse Area (mm²)	1332.69			

* $p \leq 0.05$

perform upper extremity movements such as passing or shooting which demand joint acceleration to land, manoeuvre or sprint (24, 25, 26).

It is stated that the proprioceptors in the joints and their positions as well as the lower extremity joints have a crucial key role for normal posture (7, 8, 14, 27), and taekwondo, judo, golf, tai chi trainings support this (28, 29). Lower extremity joint proprioception has a huge role in keeping the body in normal posture (8), and when one does judo, golf or tai chi, this proprioception can be improved (28, 29).

Each sport branch has a certain level of balance unique to itself. Maintaining and preserving the body position and keeping it are integral parts of most movement practices (4, 7, 16). It is necessary to maintain a balanced position in sports branches that have different competition conditions such as taekwondo, wrestling, and athletics. Static balance values on hard and soft surfaces were compared in athletes in athletics, wrestling, and taekwondo with 2-5 years of sports experience and 14-15 years of mean age. The results showed that there were statistical differences in the static balance values of the participants on one foot; however, there was no such difference in the static balance values with the tests done on soft surfaces (30). In other studies, in which one-leg balance skill was investigated, it was determined that the dynamic balance values were better in taekwondo athletes than in sedentary ones (31, 32). In another study, it was found that footballers when compared to swimmers, basketball players or sedentary participants showed better performances on one leg in terms of their C.o.P sway characteristics (33). However, when gymnasts, football, and handball players were compared, there was found no statistical difference in terms of their one-leg balance test results (34).

Muscles contract in order to move against gravity; this muscle tension stabilizes the body centre and ensures that the lower and upper extremities are effective for strong and dynamic movements. In shots such as in basketball and handball, or in strikes such as in karate, taekwondo, boxing, kickboxing, muhai-tai and wushu performed by getting support from the ground and in ground contact movements, ground reaction force emerges, and the transfer of force from lower extremities to upper extremities is done by core muscles (14, 35). As a result of balance training performed on an unstable surface using a BOSU ball for 4 weeks with 28 healthy young people, it was determined that there was an increase in dynamic postural control in the dominant leg and isometric muscle contraction strength in four selected muscle groups in the ankle (36). Other studies showed that the more one becomes proficient in gymnastics, the better postural control they have while changing from standing on two legs to one leg, which results from ability education and training (34, 37). Paillard et al. (12) worked with national and regional football players and studied their strategies and postural performances for standing on one leg. They found out that national athletes outperformed the regional athletes during the tests. The training age of the athletes is a factor affecting the postural performance while standing on one leg; however, there are bilateral differences even in elite-level players when they cannot play with their dominant leg (4).

It was stated that exercises for trunk stabilization performed with handball players on unstable surfaces give better results in stabilization of the lumbo-pelvic region and in the strengthening of the muscles in this region. Corresponding with this result, it was also presented that due to the development of closed kinetic chain movements, the angular velocity in multi-segment movements also increases (38). Furthermore, in female handball players whose mean age was 14.57±0.92 years and mean training age was 3.66±0.63 years, significant improvements were found in the static balance ellipse area values in left foot stance after plyometric training sessions performed twice a week for 10 weeks (21). In addition, in a study conducted with male taekwondo players who were university students, it was stated that there was a positive correlation between balance and anaerobic power values, and a negative significant correlation between speed values, but no significant correlation between balance and flexibility values. Another result was that some variables such as height, body weight, anaerobic power, speed, back and leg strengths had a slight determining effect on balance values in taekwondo players (39).

All these research results show that the difference in sports branch, the effect of the test surface, year of experience, other motoric and physical characteristics, and the types of training also have an effect on the balance values.

On the other hand, Olmsted et al. (40) found out that there was no statistical difference between the preferred and nonpreferred legs in amateur footballers in terms of balance function and muscle response. The study of Karadenizli et al. (41) with handball players also revealed that left and right leg balance values showed no meaningful difference. Moreover, when intervention training was done, there was not a serious improvement in one-leg balance (42).

The reasons behind the loss of balance are balance control, biomechanical constraints, cognitive processes, impairment of verticality perception, movement strategies, sensory integration, and changes. All of the auditory, visual and sensory system information contribute to this perception of verticality (12, 13). There are various studies in the literature investigating the effects of the sensor-motor process on postural control regarding sports branches. The results of some of them emphasize that the fact that experienced athletes have better balance abilities is not because they have more vestibular sensitivity, but repetitive training experiences that affect motor responses (43). However, there is also evidence that athletes' better balance ability is a result of their ability to pay attention to proprioceptive and visual cues (44).

As can be understood from the results of the study, strength can be gained with balance exercises, balance skills can be improved with training, experience is important and many other factors such as physical and motoric characteristics are related to balance skill values and have an effect on them.

When the test results of this study in which the static balance values of the dominant and non-dominant leg and stance were compared, it was revealed that there were significant differences in some variables (Table 2). These results may indicate that as the training age of all the athletes was low (4 years), the athletes were not totally affected by the branch they performed, and their improvement was in progress. It could also be due to the fact that the dominant leg of all the athletes was their right leg and/or they might have had differences in leg strength due to the asymmetries. The exclusion of leg strength values in the study is one of the most important limitations of the study. In addition, in handball, when the dominant arm is the right, the left leg, which is on the opposite side of the body, generally is the leg used for jumping. Despite having a preferred leg, it is expected that there be no differences between the balance values in the single-leg balance tests performed with both legs. Therefore, handball coaches are advised that lower extremity strength and balance exercises be performed symmetrically so that these differences will not cause sports injuries and adversely affect performance in technical movements.

Author contribution: All authors contributed equally to the process.

Conflict of Interest: No conflict of interest was declared by the authors.

Ethical Approval: Study approval was received from Bilecik Seyh Edebali Unıversity Non-Interventional Clinical Research Ethics Committee. (Approval no: E-10333602-050.01.04-60226, Date: 24.11.2021).

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