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ORIGINAL RESEARCH

Comparison of static and dynamic balance ability according to gender in athletes- a cross sectional study

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Abstract

The aim of the present study was to compare the balance ability between genders in elite athletes. A total of 152 athletes, 76 female and 76 male, from 10 different branches with similar demographic characteristics included to the study. A computerized balance platform (BT4, HUR Labs Oy, Tampere, Finland) was used to determine balance ability of the athletes. Static balance measurement, with eyes open and closed stability test on hard and soft ground; dynamic balance measurement was evaluated with forward, backward, left and right functional reach test and Romberg values calculated by the device. It was determined that the Romberg value of female athletes was higher than that of male athletes (p= 0.025). It was determined that the area scanned by female athletes in static balance ability on fixed ground with eyes open was less than that of male athletes (p= 0.025); the length drawn by female athletes in static balance ability on soft ground with eyes open was less (p= 0.010) and their scanning speed was slower (p= 0.007). Static balance ability of female athletes were significantly better than male athletes, and female athletes interpreted visual inputs better than male athletes in static balance ability. We recommend training with visual inputs and visual exercises in order to increase balance performance, especially in female athletes.

Keywords: Balance, gender, sports, performance, Romberg.

Introduction

Balance is defined as the ability to maintain the center of gravity of the body on the support surface (Nashner, 2014). In order to maintain balance, proprioceptive, visual and vestibular information coming from the outside is processed in the extrapyramidal system, cerebellum, reticular formation and cerebellar cortex. The nerve-muscle interaction that occurs as a result of the processed sensory data creates the body posture in which the support surface and the center of gravity are the most optimal, and the balance is maintained (Means et al., 1996). Balance is divided into two types: static and dynamic balance. The ability to control postural oscillations without moving on a stable ground is defined as static balance. The ability to create an appropriate posture of postural changes that occur during movement in accordance with stimuli coming from outside the body is defined as dynamic balance (Duncan et al., 1990). The factors affecting the balance are the center of gravity, the gravity line and the support surface (Nashner, 2014). Increasing the distance of the center of gravity to the support surface, narrowing the

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support surface and increasing the distance of the gravity line to the center of gravity adversely affect the balance (Lion et al., 2009; Nashner, 2014). The last limit which a person can reach without losing his/her balance by lying down without changing the support surface is defined as the limit of stability (LoS). When the body makes an oscillation that will go beyond the LoS limit, the person activates the protective mechanisms again by changing the support surface to maintain his/her balance, otherwise the balance will be disturbed and a fall will occur (Nashner, 2014).

Balance ability is one of the most important parameters related to sports performance (Hrysomallis, 2011; Jadczak et al., 2019). There are many studies in the literature on the balance ability of athletes (Jadczak et al., 2019). While there are studies showing that high balance ability in athletes have an effect on motor responses resulting from repetitive training rather than vestibular sensitivity (Balter et al., 2004; Šarabon & Kozinc, 2020), there are also studies showing that this high balance ability is due to the ability to pay attention to proprioceptive and visual inputs (Zipori et al., 2018). However, it is also known that there are differences in balance ability between different sports branches (Herpin et al., 2010; Hrysomallis, 2011; Mononen et al., 2007). For example, in the shooting sports branch, static balance is at the forefront and in an advanced state, while in the fencing sport, dynamic balance is at the forefront and in a more advanced state (Herpin et al., 2010). For this reason, the sports branch plays a big role under the sensory-motor adaptation mechanism (Hrysomallis, 2011; Mononen et al., 2007). There are also differences in balance abilities among athletes at different levels (elite-amateur) in the same branch (Hrysomallis, 2011; Jadczak et al., 2019). For this reason, the level of the athlete was also seen as a factor affecting the ability of dynamic and static balance (Gorman et al., 2012; Hrysomallis, 2011; Jadczak et al., 2019).

On the other hand, one of the factors affecting the balance is gender (Mickle et al., 2011). There are anatomical and physiological differences in male and female. These differences are likely to affect the balance ability. Studies examining the relationship between balance and gender in the literature have been conducted on participants in childhood and high school (Gorman et al., et al., 2012; Mickle et al., 2011), but studies evaluating the effect of the gender factor on balance ability in elite athletes are limited. For this reason, we aimed to compare the static and dynamic balance skills of male and female athletes matched in terms of sports branches, age and sports levels. Therefore, the purpose of this study is to compare the balance ability between genders in elite athletes.

Methods

This case matched study conducted at the Ministry of Youth and Sports, Sports General Directorship, Department of Health Services, Center of Athlete Training and Health Research, Ankara. Athletes were screened for eligibility criteria and included to the study from February 2021 and April 2021. The research data were provided from the athletes who applied to the department of sports health and education research center and volunteered to participate in the study. The athletes were informed about the details of the study. The necessary information about the study was provided to the athletes whose compliance with the criteria for inclusion in the study was determined by a sports medicine specialist. Verbal and written consent was obtained from the athletes older than 18 and parents of athletes under the age of 18 and their oral and written consent was obtained. Ethical approval was taken from Ankara Yıldırım Beyazıt University Social and Humanities Ethical Committee (2021/495/79), and it was carried out in accordance with the Code of Ethics of the World Medical Association also known as a declaration of Helsinki.

Procedure

Being at least 3 years license athletes, right leg dominance and voluntary to include to the study were determined as inclusion criteria. Being in sports for less than three years, ongoing pain in the lower extremities, an orthopedic problem or a surgical procedure performed on the lower extremities and being an acute or chronic sports disability or disease, left leg dominance were determined as exclusion criteria. The evaluation of the athletes who met the study criteria was carried out within one day. After the date of birth of the athletes was verbally informed, the dominant leg information was asked with which foot he/she hit the ball (Brophy et al., 2010), the height length was measured with a tape measure, and the body weight was evaluated with a digital scale and recorded by a physiotherapist. A general examination and evaluation was performed by a sports medicine specialist and evaluated their suitability for the study and after that the eligible athletes were send for evaluation. The balance ability was assessed by the same physiotherapist. The current or previous disease and/or injury history or presences of athletes were evaluated by a sports medicine specialist and their examinations were performed. Athletes who were not provided with similar age and demographic characteristics in female and male athletes were not included in the statistical analysis.

Participants

A total of 232 licensed athletes were invited to the study and 152 athletes who had the inclusion criteria included to the study. 76 female (age= 16.66 ±1.70 years, body height= 1.64±0.07 meter, body weight= 57.12±8.23 kg, body mass index= 21.17±2.30 kg/m^2, sport year= 6.34±2.92) and 76 male (age= 16.70±1.69 years, body height= 1.75±0.07 meter, body weight= 66.69±9.98 kg, body mass index= 21.86±2.89 kg/m^2, sport year= 6.47±3.28), who played the same sport and had similar demographic characteristics, were included in the study (Table 1).

Static and Dynamic Balance Measurements

The HUR Smart Balance measurement device (BT4, HUR Labs Oy, Tampere, Finland) was used to evaluate the static and dynamic balance of the athletes. Balance assessments were made between 9-11 am, as the athletes did not train and after breakfast. Before the actual measurement, the athletes were taught the test by making a trial. Athletes were allowed to step on the measuring floor of the device in a static position without any support with their bare feet. For static balance, the athlete was evaluated 4 times for 30 seconds each. The athlete was kept motionless on the hard floor with eyes open on the first measurement, eyes closed on the hard floor on the second measurement; eyes open on the soft floor (a soft foam of the device) on the third measurement, eyes closed on the soft floor on the fourth measurement. As a result of the measurements, the speed, distance, and area values of each assessment were recorded. As a result of the test, less scanned area and length and faster scanning indicates better balance. After the static balance measurement, the "Romberg Value (RQ)" was obtained by the device to determine the effects of visual inputs on postural stability (RQ= 100*(area with eyes closed/ area with eyes open)). The Romberg value is classified as low between 0-50, normal between 50-300, high between 300-350, and very high at values of 350 and above when the eyes are open. On the other hand, the Romberg value is classified as low between 0-65, normal between 65-365, high between 365-450, and very high at 450 and above when eyes are closed. High results at the Romberg value indicate significant effects of visual inputs on postural stability, while low results indicate that visual inputs have no effect on postural stability (BT4, HUR Labs Oy, Tampere, Finland User's Manuel).

Dynamic balance measurements were made on the device. In the dynamic balance measurement, the functional reach distance, which is the last point at which the athlete can reach right, left, forward and backward, without breaking the contact between the sole of the foot and the measurement ground, was recorded. A warm-up was done before each measurement. Dynamic balance measurement was evaluated for eight seconds in each direction with eyes open. Each measurement was repeated three times. The amount of reach of the athlete was calculated as the shift of weight transfer on the device. The mean of three measurements was used in statistical analysis.

Data Analyses

Statistical analysis was performed with IBM SPSS Statistics version 20.0 statistic package (SPSS Inc. NY, USA). The sample size was calculated using G*Power Software. The sample size with 0.80 effect size, 5% type I error, and 80% statistical power conditions was calculated at least 64 athletes in each group. However, to increase the power of the research, 76 athletes were included to each group based on volunteering. The conformity of the variables to the normal distribution was determined by analytical methods (Kolmogorov Smirnov test). The data were summarized by number % (percentage), mean and standard deviation. The results of balance parameters of female and male athletes were compared according to their eligibility level with Mann Whitney-U Test or Independent samples *t*-test. The statistical significance level was taken as $p<0.05$.

Results

A total of 152 athletes, including 76 female and 76 male, from 10 different branches with similar demographic characteristics participated in the study. It was determined that the ages of female and male athletes and their sports ages were similar and that they had similar body mass index ($p>0.05$). It was determined that the height lengths and body weights of female athletes were less than male athletes ($p<0.05$; Table 1).

Table 1
Demographic characteristics of athletes and information about the year of sports and sports branch.

Variables	Female Athletes (n= 76) Mean ± SD	Male Athletes (n= 76) Mean ± SD	p
Age (year)	16.66 ±1.70	16.70 ± 1.69	0.890¥
Height (m)	1.64 ± 0.07	1.75 ± 0.07	<0.001*
Body weight (kg)	57.12 ± 8.23	66.69 ± 9.98	<0.001*
BKI (kg/m^2)	21.17 ± 2.30	21.86 ± 2.89	0.139¥
Sports Year (year)	6.34 ± 2.92	6.47 ± 3.28	0.937¥
Sports branch	Athletics (n= 58), %38.1	Archery (n= 10), %6.6	Ski (n= 4), %2.6
	Gymnastics (n= 14), %9.2	Swimming (n= 10), %6.6	Karate (n= 28), %18.4
	Weightlifting (n= 2), %1.3	Taekwondo (n= 12), %7.9	Judo (n= 8), %5.3
	Curling (n= 6), %4		

*SD: Standard Deviation *: Independent Sample t-test, ¥: Mann Whitney U test, BKI: Body Mass Index*

It was determined that the Romberg value of female athletes was higher than that of male athletes (*p*= 0.025). The area scanned by female athletes in static balance ability on fixed ground with eyes open was less than that of male athletes (*p*= 0.025); the Romberg value was higher than that of male athletes (*p*= 0.037). The Romberg value was higher in the static balance ability of female athletes on a fixed floor with their eyes closed than in male athletes (*p*= 0.037). The length drawn by female athletes in static balance ability on soft ground with eyes open was less (*p*= 0.010) and their scanning speed was slower (*p*= 0.007). The weight transfer rates of male and female athletes on the left side and on the right side were similar in the position with eyes open and eyes closed and on two different floors (*p*>0.05. Female athletes had less right-reaching distances than male athletes (*p*= 0.014). There was no difference between the distances of reaching forward, backward, and left (*p*>0.05; Table 2).

Discussion

Balance ability is one of the most important parameters related to sports performance (Hrysomallis, 2011). As a result of this study, which was conducted to compare the balance ability of male and female elite athletes, it was determined that the balance ability of female athletes was better than male athletes, and female athletes used visual inputs more. However, it was determined that the weight transfer rates of male and female athletes to the right and left sides were similar, but that male athletes had more functional reach to the right side.

One of the most important parameters that form the basis of sports performance is balance. Balance ability is at the center of the fitness abilities unique to the sports branch of the person. Thanks to these ability, a person plays an important role in maintaining the position of the body during sudden changes in direction, stopping, starting, moving and holding an object in sports ability (Zemková, 2014). Due to the fact that men and women differ anatomically and physiologically, the balance ability of men and women have been compared by many researchers based on the idea that there may be differences between the balance ability of men and women (Condon & Cremin, 2014; Gorman et al., 2012; Mickle et al., 2011; Mnejja et al., 2022; Olchowik et al., 2015; Quintana et al., 2022). In these studies, there are studies showing that there are differences between the balance ability of men and women (Condon & Cremin, 2014; Mickle et al., 2011; Mnejja et al., 2022; Quintana et al., 2022). In the literature, it is stated that due to the anatomical and physiological differences between men and women, women's balance skills are better than men (Condon & Cremin, 2014; Gorman et al., 2012; Mnejja et al., 2022; Quintana et al., 2022). For this reason, in order to minimize the effect of anatomical and physiological differences, research is usually done in childhood when balance skills are not fully developed. In some of these studies conducted in the childhood age group, it is seen that girls have better balance ability than boys (Mickle et al., 2011; Condon & Cremin, 2014). We have not found any studies in the literature comparing the balance ability of male and female athletes. The results of this study, which compared the balance ability of female and male athletes, showed that the gender-based balance ability difference in the literature and reported

Table 2
Comparison of static and dynamic balance ability of athletes (Mean ± SD).

Variables			Female Athletes	Male Athletes	p
	Romberg Value		1660.76 ± 11171.45	208.03 ± 137.02	0.025¥
Static Balance					
	Stable Ground with Eyes Open	Length (mm)	438.60 ± 2055.41	585.43 ± 3258.56	0.144¥
		Area (mm^2)	235.66 ± 939.79	533.04 ± 3235.34	0.025¥
		Speed (mm/sn)	14.52 ± 68.48	19.54 ± 108.64	0.101¥
		Romberg Value	1940.83 ± 11399.20	310.93 ± 892.59	0.037¥
		Left side weight transfer (%)	51.88 ± 47.64	51.89 ± 46.43	0.887¥
		Right side weight transfer (%)	59.96 ± 55.97	59.96 ± 57.09	0.887¥
	Stable Ground with Eyes Closed	Length (mm)	696.53 ± 3046.23	669.98 ± 2935.86	0.384¥
		Area (mm^2)	493.31 ± 2012.67	554.24 ± 2545.61	0.900¥
		Speed (mm/sn)	23.24 ± 101.52	37.36 ± 162.47	0.447¥
		Romberg Value	1940.83 ± 11399.20	310.93 ± 892.59	0.037¥
		Left side weight transfer	51.80 ± 48.69	51.94 ± 46.77	0.886¥
		Right side weight transfer (%)	60.04 ± 54.92	59.90 ± 56.75	0.886¥
	Soft Ground with Eyes Open	Length (mm)	488.95 ± 2283.54	614.89 ± 3140.02	0.010¥
		Area (mm^2)	291.19 ± 1022.93	558.20 ± 2952.77	0.131¥
		Speed (mm/sn)	16.25 ± 76.14	20.53 ± 104.70	0.007¥
		Romberg Value	832.08 ± 4591.22	431.55 ± 1047.92	0.252¥
		Left side weight transfer (%)	51.98 ± 49.23	51.87 ± 45.86	0.719¥
		Right side weight transfer (%)	59.87 ± 54.34	59.98 ± 57.67	0.719¥
	Soft ground with Eyes Closed	Length (mm)	893.78 ± 3859.51	871.28 ± 3674.00	0.809¥
		Area (mm^2)	941.82 ± 4111.26	777.16 ± 2547.56	0.707¥
		Speed (mm/sn)	29.76 ± 128.66	28.67 ± 122.53	0.580¥
		Romberg Value	832.08 ± 4591.22	431.55 ± 1047.92	0.252¥
		Left side weight transfer	51.92 ± 50.38	51.76 ± 46.68	0.638¥
		Right side weight transfer (%)	59.92 ± 53.16	60.08 ± 56.84	0.638¥
Dynamic Balance					
	Reaching Forward		4.25 ± 2.66	4.12 ± 2.71	0.722¥
	Reaching Backwards		4.51 ± 3.21	4.52 ± 2.87	0.957¥
	Reaching to the Left		5.98 ± 1.67	6.19 ± 1.49	0.415*
	Reaching to the Right		6.08 ± 1.37	6.65 ± 1.45	0.014*

**: Independent Sample T test, ¥: Mann Whitney U Test*

in the general population was valid for elite athletes, and revealed that female athletes had better balance ability than male athletes. However, there are various studies in the literature showing that anthropometric characteristics affect balance ability (Alonso et al., 2012; De Maio et al., 2021; Jeronymo et al., 2020). In a study, it was stated that the anthropometric variable that most affected the postural balance was the height, and this effect was higher especially in men than in women (Alonso et al., 2012). Many anthropometric features such as the pelvic structure of women due to their anatomical and physiological structures, their short stature and therefore their center of gravity close to the ground, and differences in lower extremity alignment may cause good balance even in women (Olchowik et al., 2015; Sekulic et al., 2013). Although the fact those women are shorter than men in our study is a finding that supports women's better balance skills than men, we think that this is not the only reason. For this reason, there is a need for further studies in which statistical analyzes with adjusted anthropometric factors are performed.

Vision has an effect on postural stability (Alcock et al., 2018; Zipori et al., 2018). In many studies conducted, it has been observed that postural oscillation is more in the closed position of the eyes compared to the open position of the eyes (Bruyneel et al., 2018; Saftari & Kwon, 2018). In this context, the Romberg value helps us to interpret the effects of visual inputs on postural stability, a high Romberg value indicates that visual inputs have significant effects on postural stability, while a low Romberg value indicates that visual inputs have no effect on postural stability (Bruyneel et al., 2018; Paolucci et al., 2018). When the results of our study were examined, it was determined that the overall Romberg value and the Romberg value on the fixed floor with the eyes open and closed and the Romberg value on the soft floor with the eyes open were higher in female athletes than in male athletes. This result can be interpreted as the fact that female athletes maintain their balance and postural stability better compared to men by interpreting visual inputs better when their eyes are open on a stable surface. For this reason, we can say that training with visual inputs and visual exercises especially in female athletes can also be effective in improving balance performance. Indeed, in a study conducted to investigate the effect of ocular-motor exercises on the limit of dynamic visual acuity and stability in female basketball players in a way that supports the results of our study, it is stated that oculo-motor exercises can be used to increase the stability limit and dynamic visual acuity in basketball players and other dynamic sports (Minoonejad et al., 2019). Similarly, there are studies in the literature showing that visual exercises also affect balance performance (Correia et al., 2021; Durall, 2012; Jandaghi et al., 2021). However, we think that more studies are needed to reveal the effects of these exercises on the balance of both female and male athletes.

Gender is one of the most important parameters affecting sports performance (Sandbakk et al., 2018). In a study that examined gender-specific balance and related parameters in athletes, it has been stated that balance ability is significantly related to agility performance in male athletes, but this relationship is not valid for women, and balance should be considered as a potential predictor of agility in male athletes (Sekulic et al., 2013). While balance ability is one of the parameters that affect sports performance, some other parameters that affect sports performance, such as fat percentage and muscle mass, affect balance ability. Studies have shown that whole body muscle strength, core muscle strength and extremity muscle strength affect balance ability (Granacher et al., 2013; Muehlbauer et al., 2015). As a result of the present study, although the ratios of weight transfer to the right and left sides of female and male athletes were similar, it was determined that the amount of functional reach of male athletes to the right side, which is the dominant side, was higher than female athletes. Considering that the dominant sides of the male and female athletes included in the study are the same and the right side, we think that this result may have been caused by other factors that may affect the balance. As a result of this study, the fact that male athletes have more functional reach to the right side, which is the dominant side, may be due to the greater muscle strength of male athletes. However, muscle strength measurement was not performed in our study i order to investigate the relationship that would support this idea. While this situation can be seen as a limitation of our study, it can also constitute a pioneering idea for future studies.

Our study has certain limitations. The limitations of this study are that not all of the athletes do the same sport (the development of different balance parameters, dynamic and static, of athletes in different branches) and that other performance parameters such as muscle strength that may affect the balance have not been examined. Therefore, our results may not be generalizable to athletes in all branches. We think that further studies are needed in which other parameters that are specific to the branch and may affect balance are normalized and compared between genders.

Conclusion

In conclusion the static balance ability of female athletes was significantly better than male athletes, and it was determined that female athletes interpreted visual inputs in static balance ability better than male athletes. For this reason, especially in female athletes, we recommend training with visual inputs and visual exercises in order to increase balance performance.

Authors' Contribution

Study Design: BA, HYA, BP, TK; Data Collection: BA, HYA, BP; Statistical Analysis: BA, HYA, TK; Manuscript Preparation: BA, HYA, TK; Funds Collection: BA, TK.

Ethical Approval

The study was approved by the Ankara Yıldırım Beyazıt University of Social and Humanities Ethical Committee (2021/495/79) and it was carried out in accordance with the Code of Ethics of the World Medical Association also known as a declaration of Helsinki.

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The authors declare that the study received no funding.

Conflict of Interest

The authors hereby declare that there was no conflict of interest in conducting this research.

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