Middle Black Sea Journal of Health Science /
Mid Blac Sea J Health Sci
August 2021; 7(2):168-177

RESEARCH ARTICLE
DOI: 10.19127/mbsjohs.889226

The Effect of Leg Strength and Jump Performance on Balance in Handball Players

Osman Batuhan Dulger[1](ID) Orhan Bas[2](ID)

[1]Altınordu İmam Hatip High School for Girls, Ministry of Education, Ordu, Turkey
[2]Department of Anatomy, Samsun University Faculty of Medicine, Samsun, Turkey

Received: 01 March 2021, Accepted: 31 March 2021, Published online: 30 April 2021

Abstract

Objective: The purpose of this study was to examine the effect of leg strength and jump performance on balance in handball players.

Methods: It involved the evaluation of balance, leg strength, and jump performance of licensed handball players in our region. Athletes' balance measurements were collected under three parameters (static balance with eyes open, static balance with eyes closed, and bipedal dynamic balance) using a CSMI-Tecnobody PK-252 isokinetic balance measuring device. Vertical jump was measured on a splash mat, horizontal (forward) jump on a flat surface, and leg strength with a back-leg dynamometer. Athletes' anaerobic strengths were calculated based on the Lewis formula, and all data were analyzed on SPSS 22.0 V software. At statistical analysis, a test of normality (Shapiro Wilk) was applied to determine whether data were normally distributed ($p>0.05$). Pearson correlation analysis was applied for values exhibiting normal distribution in the test results, and Spearman correlation (r) for non-normally distributed values.

Results: Negative correlation was observed between athletes' vertical jump values and bipedal average track error (ATE) and stability indicator values. Negative correlation was observed between horizontal jump and bipedal ATE values, and between leg strength data and closed-eye average medial lateral speed values. Anaerobic strength values were also negatively correlated with closed-eye average forward-backward velocity, closed-eye PM, and bipedal ATE values ($p<0.05$). Examination of the analysis results showed that balance values decreased as vertical jump, horizontal jump, leg strength, and anaerobic strength increased.

Conclusion: We concluded that an athlete would acquire better balance performance through jump, strength, strength, and anaerobic strength developing training.

Key words: Handball, Static Balance, Dynamic Balance, Leg Strength, Vertical Jump, Horizontal Jump

Suggested Citation: Dulger O B, Bas O. The Effect of Leg Strength and Jump Performance on Balance in Handball Players. Mid Blac Sea Journal of Health Sci, 2021; 7(2):168-177

Address for correspondence/reprints:

Orhan Bas

Telephone number: + +90 (505) 346 12 89

E-mail: orhanbas55@hotmail.com

Introduction

Handball is a performance sport with millions of fans and players and the subject of considerable global interest. It is highly popular with young people as one of the branches of sport that is enjoyable and easy to play, and that improves group dynamics. This interest in developed countries and Turkey has made handball a part of life, bringing it to schools and clubs (1). The sport involves movements such as jumping, running, sprinting, shooting, blocking, and pushing. Maximum muscle strength, power, and balance on one leg are especially important during jumping and shooting for the development of technical and tactical skills in handball. Improving these performance skills that affect the neuromuscular system bestows a major advantage on players (2).

Handball being a sport requiring the combined use of various motor skills means that muscle power, muscular-nervous system compatibility, endurance, speed, flexibility, mobility, anaerobic capacity, and performance reaction time in anaerobic capacity are all important components of success in dynamic and static balance (3). Scientific and technological progress has led to major advances in handball-player performance, together with all branches of sport. Research in the field of sport is aimed at improving performance and success. Individuals obliged to adapt to different situations may sometimes experience difficulty in adapting to changes around them. Corrective steps and lurch-like movements are required to prevent falls when the limit of balanced posture is exceeded. Nerve-muscle coordination and adaptation are particularly important at this point (4).

Balance occupies an important place in gymnastics, sport, dance, and games. It is essential in order to avoid accidents and to perform daily activities (5). Balance is the key to mobility and is important at all ages. Impairment of balance occurs with age, representing a risk for falls (6). Balance serves an important function in the ability to maintain bodily integrity, essential to success in sporting activities. It therefore represents the basis of dynamic sports involving sudden changes in movements (7).

Due to the multifaceted nature of handball, the purpose of the present study was to examine the effect of leg strength and jump performances of licensed handball players on balance. Measurements were performed on handball players, and the relationships and effects of parameters capable of affecting their performance were investigated. Despite an increase in professionalization in handball, research investigating the characteristic performances of elite plays is insufficient, and the number of studies evaluating handball players' performances over the entire season is very low (8).

Due to the multi-directional movement involved in handball and the absence of sufficient studies in this area, the purpose of the present research was to examine the effects of leg strength and jumping performances of licensed handball players on their static and dynamic balance. Accordingly, we performed measurements of handball players and investigated the relationships and effects of parameters affecting their performances.

Methods

Research Group

Ethical committee approval was granted once the research had been designed. Informed consent and voluntary participation forms were obtained from athletes before the tests were performed. The study was then performed with 40 male licensed handball players ranging in age between 16 and 26. Inclusion criteria were being an active and licensed player, with no disability, and no long-term ban on sporting activity.

Bulgay's (2017) study titled 'An examination of the relationship between top-rank wrestlers' leg strength and balance performance' was adopted to determine the sample size; power and sample size analysis at α (alpha) =0.05 and a test power of 95% determined a total sample size of 20 individuals five for each group. A sample size of 40 individuals was determined in the present study.

The simple random sampling method was employed to select from among athletes meeting the determined criteria and playing handball in the province of Ordu.

Data Collection

Athletes' height, weight, and birth dates were recorded before the tests commenced.

During height measurements, athletes were asked to remove their shoes and to stand in the anatomical position. The distance between a line parallel to the floor and touching the head was measured to a sensitivity of 0.1 cm.

Weight was measured before training, with the athletes wearing standard shorts and t-shirts, and without having eaten, to a sensitivity of 0.1 kg.

The information on athletes' identity documents was used to determine their ages.

The devices used in the study were a Jawon Body Composition Analyzer Model X-Scanplus II, a Holtain stadiometer, a tape measure, a digital back-leg dynamometer, a CSMI-TecnoBody PK-252 isokinetic balance system measuring device, and a Microgate jumping system-compatible jump mat

Balance Test

Balance test measurements were performed after the participants' age, surname, height, and weight values and date of birth information had been recorded onto a CSMI-TecnoBody PK-252 isokinetic balance system measuring device.

1. Static balance test: Before the measurements took place, the participants completed a 10-min warm-up consisting of a 5-min low tempo run, warm-up movements, and expansion-contraction movements. All participants were allowed to perform a trial before the test began. The athletes were placed on a platform and subjected to open-eye and closed-eye static balance measurement tests. The measurements were taken with the patient's feet at shoulder width on the CSMI-TecnoBody PK-252 balance device platform, and with the feet on lines representing the x and y axes of the platform and equidistant from the point of origin. Tests lasted 30 sec, and maintenance of body position and the participant's position were monitored from the screen. The test was recorded automatically at the end of 30 sec. The closed-eye test was then applied, with participants undergoing the same test with their eyes shut. A 1-min rest period was allowed between the tests (10).

2. Dynamic balance test: The importance of not using the support rail was emphasized during this test, which was performed with the patient in the double foot stance. Participants were instructed that the test should be completed using only the feet, in order to reduce upper body movements to a minimum. Bipedal mode was selected on the CSMI-TecnoBody PK-252 balance device, and key sensors were immobilized to allow the platform to move. Stabilometer pressure was set to a difficulty level of 5 in this test. The test was completed by following the circular route on the screen within 60 seconds and rotating the platform by five turns clockwise. The test was stopped and restarted in the event of inability to maintain balance during measurement, measurement being affected by environmental factors, or the hands making contact with the device. In the event of a participant being unable to complete the test within the specified time, the best performance up to that time was recorded as the test result (10).

The distribution of errors made during the track according to the regions on the platform are shown in the Track Errors chart, and the distribution of the participant's center of gravity by sectors is shown on the Force Variance chart. The isokinetic balance device platform was divided into eight sectors, a margin of error being calculated for each. Figure 1 shows that the highest margin of error is in the S3 sector. All sectors can be separately examined in this way. If the sector proportion exceeds 20% the device offers protocol options ranging between 2 and 88 degrees of difficulty in order to overcome the problem there or to improve balance, and participants are enabled to perform applications improving their balance skills (10).

Jump Test

Jump force can be defined can be defined as the individual jumping as far as possible in the horizontal plane or as high as possible in the vertical plane (11). Vertical jumping is particularly important in handball for blocks or for shooting toward the goal over blocks.

1***. Horizontal jump test:*** The standing long jump technique was employed to measure participants' horizontal jump performances, using a measuring tape. Participants were asked to jump forward from the start line using both legs, and the distance was measured between the start line and the closest point of contact on landing. The test was repeated twice for each individual, and the best value was recorded.

2. Vertical jump test: The vertical jump test protocol described in previous studies was applied (12). Vertical jump measurements were performed on a mat compatible with the Microgate system. Participants were asked to jump at full power, also swinging their arms, on a plastic mat, the procedure being repeated twice. The highest vertical jump distance was recorded in cm.

Leg strength test

The participant arranged his feet with the knees bent on the dynamometer bench, with the arms tensed, the back straight, and the trunk slightly inclined forward. Leg strength measurements were then performed with the participant holding the dynamometer bar and using his legs to raise it to the highest possible vertical position. The test was repeated twice, and the measurement was completed with the best data being elicited for each participant (13).

Anaerobic strength calculation: Anaerobic strength was calculated in the form of kg-m/s using the Lewis formula based on vertical jump and body weight values.

P = (√4,9 x (BW) x √V
Where P = strength (kg-m/s)
V = Vertical Jump Distance (m) and
BW = Body Weight (kg)

Statistical analysis

Statistical analyses were performed on SPSS version 22.0 software (demo version). Pearson's correlation test was applied for normally distributed descriptive statistic data, and Spearman's correlation test for non-normally distributed data. Data analysis was performed at a 95% confidence interval and at a significance level of p <0.05.

Correlation coefficients were calculated between -1 and +1. Positive correlation (+) indicates that variables move in the same direction, while negative correlation (-) indicates that they move in opposite directions.

Zero correlation indicates no relationship between increases and decreases in variables. r<0.2-0.4 is interpreted as weak correlation, r=0.4-06 as moderate correlation, r=0.6-08 as high correlation, and r=>0.8 as very high correlation (14).

Results

The mean age of the athletes in the study was 18.83±2.59 years, mean body weight was 70.78±10.30 kg, and mean height was 176.48±7.26 cm. Quantitative data were expressed in tables as mean, standard deviation, minimum, and maximum values.

Examination of the descriptive statistic values in Table 1 shows a mean research group vertical jump value of 38.16±7.11, a mean horizontal jump value of 208.19±22.75, a mean leg strength value of 140.87±29.60, and a mean aerobic leg strength value of 96.06±14.81.

In table 2 analysis of static balance values for the Examination of the descriptive statistic values shown in Table 3 revealed a mean dynamic balance bipedal balance error of 53.03±16.73 in the research group, mean bipedal strength variance of 2.07±1.17, and a mean stability indicator of 1.70±0.58. research group revealed a mean open-eye center of pressure X value of -2.15±4.47, a mean open-eye center of pressure Y value of -3.70±12.01, mean open-eye anterior-posterior deviation of 5.95±3.52, mean closed-eye standard right-left deviation of 3.73±1.52, mean open-eye forward-backward velocity of 10.20±3.30, an open-eye mean right-left velocity of 9.48±3.76, a mean open-eye area used of 377.85±262.02, a mean closed-eye circumference of 477.40±150.11, a mean closed-eye center of pressure X value of -415±8.30, a mean closed-eye center of pressure Y value of -3.53±14.73, mean closed-eye standard anterior-posterior deviation of 6.80±3.06, mean closed-eye right-left deviation of 5.23±1.62, mean closed-eye forward-backward velocity of 13.68±4.20, mean closed-eye right-left velocity of 12.00±3.94, mean closed-eye area used of 642.90±382.55, and mean closed-eye circumference of 605.18±169.28.

Analysis of the results in Table 4 revealed significant negative (-) correlation between the research group vertical jump values and bipedal mean balance error and stability indicator values, significant negative (-) correlation between horizontal jump values and bipedal mean balance error values, significant negative correlation (-) between leg strength values and closed-eye mean right-left velocity values, and significant negative (-) correlation between anaerobic strength values and closed-eye mean forward-backward velocity, closed-eye circumference used, and bipedal mean balance error values (p<0.05).

Open- and closed-eye values for static balance were determined separately. Standard anterior-posterior deviation and standard right-left deviation values were expressed as arithmetical mean plus standard deviation. The groups' mean balance was interpreted as poor as arithmetical mean plus standard deviation increased, and as good as arithmetical mean plus standard deviation decreased. The value obtained from the mean balance error in athletes' dynamic balance measurements shows the distance that the participant needs to traverse. Athletes' total dynamic balance mean balance error was expressed as a percentage (%) value. A low mean balance error percentage was interpreted as indicating good dynamic balance, and a high value as indicating poor dynamic balance (10).

Table 1. Correlation analysis results between statistic and dynamic balance measurements and vertical jump, horizontal jump, leg strength, and anaerobic strength values

	DB		HJ		LS		AS	
Measurements	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**
Open-eye- Mean center of pressure X *	0.211	0.191	0.122	0.453	-0.042	0.797	0.127	0.433
Open-eye - Mean center of pressure Y *	-0.013	0.936	-0.027	0.866	-0.007	0.966	0.100	0.538
Open-eye -Standard anterior-posterior deviation	0.031	0.851	0.130	0.425	0.256	0.111	-0.267	0.096
Open-eye -Standard right-left deviation	0.240	0.135	-0.022	0.892	-0.147	0.367	-0.046	0.779
Open-eye –Mean forward-backward velocity (mm/sec)	0.118	0.469	-0.067	0.683	0.030	0.856	-0.188	0.246
Open-eye – Mean right-left velocity (mm/sec)	0.249	0.121	0.116	0.478	-0.302	0.058	-0.052	0.748
Open-eye – Area used (mm²)	0.152	0.349	0.000	0.998	0.038	0.818	-0.211	0.191
Open-eye – Circumference used (mm)	0.232	0.149	0.012	0.943	-0.227	0.159	-0.131	0.422
Closed-eye – Mean center of pressure X *	0.168	0.299	0.302	0.058	0.012	0.944	0.043	0.792
Closed-eye – Mean center of pressure Y *	-0.045	0.783	0.030	0.856	-0.124	0.447	-0.048	0.768
Closed eye –Standard anterior-posterior deviation *	-0.262	0.102	-0.152	0.348	-0.267	0.096	-0.283	0.076
Closed-eye –Standard right-left deviation	-0.209	0.196	-0.157	0.333	-0.270	0.092	-0.218	0.177
Closed-eye – Mean forward-backward velocity (mm/sec)	-0.195	0.229	-0.173	0.286	-0.197	0.222	-0.375	**0.017***
Closed-eye – Mean right-left velocity (mm/sec)	-0.071	0.662	0.023	0.889	-0.357	**0.024***	-0.294	0.066
Closed-eye – Area used (mm²)	-0.143	0.379	0.000	0.998	-0.267	0.096	-0.309	0.053
Closed-eye – Circumference used (mm)	-0.132	0.418	-0.088	0.589	-0.292	0.067	-0.390	**0.013***
Bipedal – Mean balance error (%)	-0.495	**0.001***	-0.315	**0.047***	-0.260	0.105	-0.313	**0.049***
Bipedal – Mean strength variance (kg)	0.182	0.261	0.045	0.783	0.100	0.541	0.270	0.092
Stability indicator (°)	-0.444	**0.004***	-0.141	0.387	-0.073	0.652	-0.015	0.927

* Since open-eye mean center of pressure X, open-eye mean center of pressure Y, and closed-eye standard anterior-posterior deviation measurements were not normally distributed, Spearman rank correlation coefficients were used to analyze levels of correlation for these.
*p<0.05.

Table 2. Group static and dynamic balance data analysis

		N	Mean	SD
Static Balance (SB) (FBSD+MLSD)	Open eye (OE)	40	4.84	2.92
	Closed eye (CE)	40	6.01	2.56
Dynamic Balance (DB)	Average track error %	40	53.03	16.73

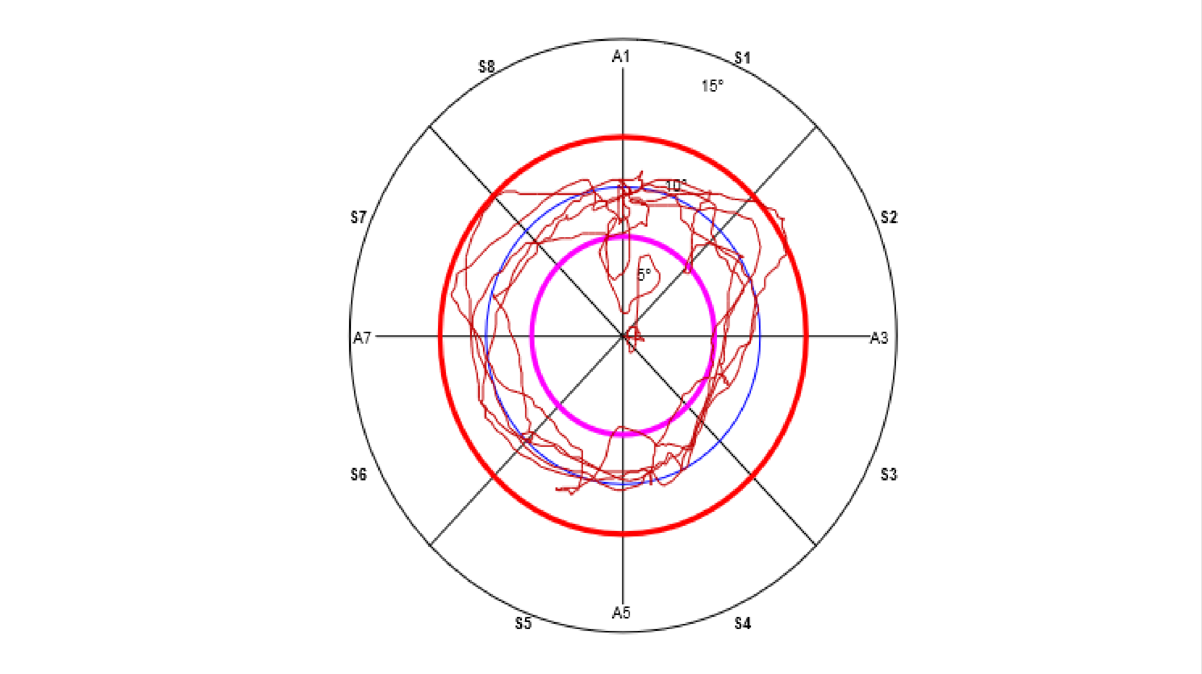

Figure 1. The track followed by the athlete inside the circle

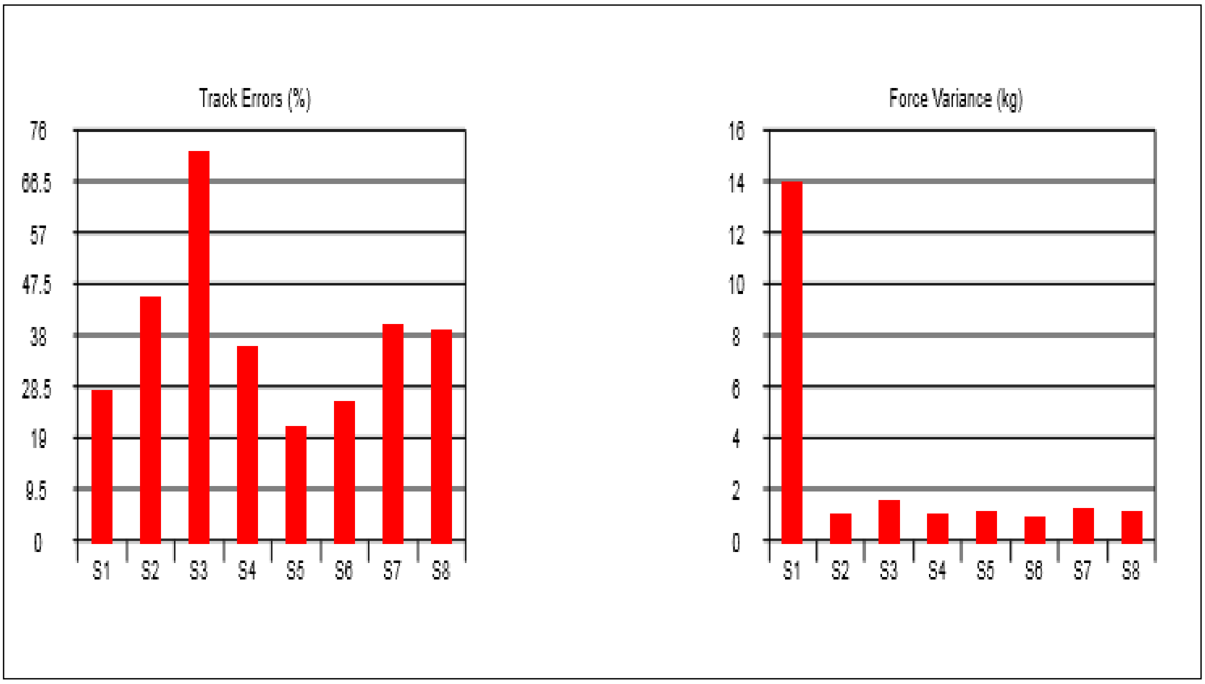

Figure 2. Measurement result charts

Discussion

This study examined the effect of handball players' leg strength and jump performance on balance. Balance is thought to impact positively on physical development involving motor skills and is a significant factor in differentiating individuals with successful sporting skills from those without (15).

In addition to technical skills and tactics, physical characteristics and powerful throwing abilities are very important in falling, jumping, twisting shots, and deceptions, all of which are frequently employed in handball. Shots involving vertical and horizontal jumping play an important role in both team victories and individual performance (16).

Yildirim (1997) reported a mean vertical jump height among elite handball players of 41.583±5.38

cm, and Gökdemir (1997) a height of 59.20±5.20 cm. Oxyzoglou et al. (2008) reported a mean vertical jump height among top-rank handball goalkeepers of 57.7±6.09 cm, compared to 56.44±5.5 cm among midfielders, and 55.71±4.48 cm among pivotal players. In their study of top-rank handball players, Yildirim and Ozdemir (2010) reported vertical jump values of 48.86±2.12 cm among players aged 17-21, and 53.07±2.27 cm among players aged 22-27. Eler (1996) reported and handball player vertical jump value of 50.66 cm, while Albay et al. (2008) measured a mean vertical jump value among university handball players of 53.80±9.07 cm. Tutkun (1995) reported a mean vertical jump height of 58.75±6.43 cm in university handball players and of 56.38±8.01 cm in top-rank national-level players. Cherif et al. (2012) reported a mean vertical jump height of 38.05±4.69 cm among elite Tunisian handball players. The mean vertical jump height among handball players in the present study was 38.16±7.11 cm (Table 1).

The vertical jump values were lower than the results generally reported in the previous literature. These differences may possibly be attributable to variations in explosive strength in the leg muscles, jumping technique, the elasticity of the muscles employed in jumping, training differences, and length of time as athletes.

One previous study investigated the relationship between balance and triple jump, vertical jump, and balance performance among footballers. The authors found no correlation between footballers' balance performances and triple jump or vertical jump distances (24).

Analysis of relationships between vertical jump data and open- and closed-eye static balance and bipedal dynamic balance values in the present research revealed negative (-) correlation between vertical jump and dynamic balance mean balance error and stability indicator values ($p<0.01$). It may therefore be concluded that dynamic balance values will decrease as vertical jump performance increases, and that dynamic balance will be positively affected (Table 1).

Oxyzoglou et al. (2008) reported a mean horizontal jump distance of 206.62±16.23 cm among top-rank foreign handball goalkeepers, 208±22 cm among wingers, 201.21±11.79 cm among midfielders, and 202.21±11.79 cm among pivotal players.

The mean horizontal jump distance among the handball player group in the present research was 208.19±22.75 cm. This was compatible with previously reported horizontal jump distances in the literature.

Significant negative (-) correlation was observed between horizontal jump data and dynamic balance mean balance error ($p=0.047$). A decrease in dynamic balance mean balance error may therefore be expected as horizontal jump performance increases. It may therefore be concluded that dynamic balance is positively affected with increased horizontal jump performance (Table 1).

Zorba et al. (2014), reported leg strength of 127.65±4.51 kg in 2nd league handball players, The mean leg strength of the handball players in the present study was 140.87±29.60 kg (Table 1).

One previous study examined the relationship between leg strength and balance performance among top-rank wrestlers. The authors reported significant correlation between left leg hamstring and quadriceps strength and left leg posterolateral and posteromedial balance performances (9). Tekin (2016) investigated the relationship between balance and strength and reported that both parameters can support one another and that this can be effective in training models. One study investigated increases in muscle and strength balance following balance training concluded that balance training contributed to the acquisition of muscle strength, and that muscular inequalities could be eliminated following balance training (27). Akcesme and Aktug (2018) reported positive correlation between isokinetic leg strength and balance performance, leg volume, and leg mass in football players.

Soyuer et al. (2006) reported a correlation between lower extremity muscle strength and balance. In a study of young male athletes, Mohammadi et al. (2012) also reported improvement in static and dynamic balance together with an increase in leg strength following six-week strength training involving the leg muscles. Siriphorn and Chamonchant (2015) reported improvement of balance skills following Wii board balance exercises among weightlifters and an increase in lower extremity muscle strength. In a study of healthy individuals from different age groups, Muehlbauer et al. (2005) reported significant correlation between lower extremity muscle strength and balance. A study investigating the effect on dynamic balance of quadriceps and hamstring muscle strength in children aged 12-14 reported significantly greater right-left extension peak strength in boys than in girls. However, no correlation was observed between quadriceps and hamstring strength and dynamic balance for male and female participants either independently of gender or when gender was considered (34).

Consistent with the previous literature, negative (-) correlation was determined in the present research between leg strength data and static balance closed-eye right-left velocity (p=0.024). Better static balance may therefore be expected with an increase in leg strength (Table 1).

Albay et al. (2008) reported mean aerobic strength values of 119.06±13.26 kg-m/sn in footballers, 133.39±15.41 kg-m/sn among handball players, and 146.05±16.67 kg-m/sn in volleyball players, and concluded that handball players possessed, and also volleyball players, possessed significantly greater aerobic strength than footballers (p<0.01). The mean aerobic strength value in the present study was 96.06±14.81 kg-m/sn. The anaerobic strength values in the present study being lower than the results from the previous literature may be attributed to differences in training, the lack of activity aimed at improving aerobic strength, and the age of the athletes.

Erkmen et al. (2009) measured balance performance before and after resistance training and observed a significant decrease in balance performance in line with fatigue. Bove et al. (2005) also reported a decrease in balance performance and an increase in body oscillation following induction of fatigue. Wilkins et al. (2004) induced fatigue using a seven-station circular jogging route and observed a subsequent decrease in balance performance. Waterman et al. (2004) also detected negative changes in balance test results following fatigue caused by sporting matches.

Significant negative (-) balance was observed in the present study between anaerobic strength values and static balance closed-eye forward-backward velocity, static balance closed-eye area used, and dynamic balance mean balance error (Table 2). In the light of these findings, it may be concluded that fatigue will develop later as anaerobic strength increases, and that static and dynamic balance scores will decrease with movement, and that balance will therefore be positively affected.

Aslanoğlu et al. (2018) determined no relationship between leg strength-aerobic capacity and leg strength-anaerobic capacity in footballers. No relationship was determined between aerobic and anaerobic capacity and leg strength measured using an isometric leg dynamometer in football players.

Open- and closed-eye static balance values were determined separately in the present. Arithmetical mean and standard deviation values were calculated for standard anterior-posterior deviation and standard right-left deviation. We assumed that athletes' mean balance would be poorer as standard deviation and arithmetical means increased, and better as standard deviation and arithmetical means decreased. The value obtained from the mean balance error in athletes' dynamic balance measurements shows the distance that the participant needs to traverse. Athletes' dynamic balance was expressed as the percentage (%) of the arithmetical means of total mean balance error (Table 2). A low research group mean balance error percentage was interpreted as good dynamic balance, and a high percentage as poor dynamic balance (6). Accordingly, the data in the present study suggest that the dynamic balance of the research group was poor in the light of the high balance error percentage.

Conclusion

Examination of the relationships between vertical jump data and open- and closed-eye static balance and bipedal dynamic balance values revealed significant negative correlation between vertical jump performance and dynamic balance and stability. It may therefore be concluded that dynamic balance values will decrease as vertical jump performance increases, and that dynamic balance will be positively affected.

Significant negative correlation was also determined in this study between horizontal jump data and dynamic balance values. Accordingly, a decrease in dynamic balance values may be expected as horizontal jump performance increases. It may therefore be concluded that dynamic balance will be positively affected by an improvement in horizontal jump performance.

In agreement with the previous literature, leg strength data in this study were significantly negatively correlated with closed-eye static balance values. Accordingly, it may be concluded that static balance values will be better with an increase in leg strength.

Significant negative correlation was also determined between research group anaerobic strength values and closed-eye static and dynamic balance values. In the light of these findings, it may be concluded that static and dynamic balance scores will decrease with an increase in aerobic strength, and that balance will be positively affected. On the basis of these findings, it may be concluded that a high mean balance error percentage (ATE) indicates poor research group dynamic balance.

The findings and data from the present research show that leg strength and jump training have a positive impact on balance. We think that training aimed at increasing anaerobic strength will be useful in the improvement of balance. We therefore think that the positive contributions to balance of the methods aimed at improving strength, jump performance and balance in handball, in which these factors are exceedingly important, will result in improved success as a result of improved performance. Our study can also be applied to other areas in which these parameters are significant, to other performance criteria, and to other athlete characteristics.

Ethics Committee Approval: Clinical Studies Ethics Committee of Ordu University, Faculty of Medicine, Decision number: 2018/214 Date: 04.10.2018

Peer-review: Externally peer-reviewed.

Author Contributions: ***Concept:*** OB. D., O. B.; ***Design:*** OB. D., O. B.; ***Literature Search:*** OB. D., O. B.; ***Data Collection and Processing:*** OB. D., O. B.; ***Analysis or Interpretation:*** OB. D., O. B.; ***Writing:*** O. B.

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

Financial Disclosure: This study was supported by the Ordu University Scientific Research Coordination Office under project number B 1901.

References

1. Koc, H., Pulur, A,. Karabulut, EO. Comparison of some motor abilities of male basketball and handball players. Nigde University Journal of Physical Education and Sport Sciences Vol 5, No 1, 2011.
2. Cakir, Z. Effects of Plyometric Training on Izokinetic Knee Strength, Dynamic Balance, Anaerobic Power, Sprint and Agility in Young Handball Players. Marmara University Sports Sciences Institute, 2016.
3. Muratli S. Children and Sport – In the Light of Training Science. Ankara: Bagirgan Publishing. 1997.
4. Sahin G, Seker H, Yesilirmak M, Cadir A. An examination of the effect of balance disk exercises on dynamic balance and posture control. Journal of Sport and Performance Research. 2015; 6(1): 50-57.
5. Gunduz N. Training knowledge, İzmir: Saray Medical Publishers. 1998. p:193-194.
6. Cecel E, Kocaoglu S, Guven D, Okumus M, Gokoglu F, Yargancioglu R. The relationship between balance, age, and functional status in geriatric patients. Turkish Journal of Geriatrics. 2007;10(4): 169-172.
7. Altay F. Biomechanical Analysis of Lateral Balance Movement Following Chain Rotation at Two Different Speeds in Rhythmic Gymnastics. Ankara. Doctoral thesis, Hacettepe University. 2001.
8. Tillaar VR., Waade L., Roaas T. Comparison of The Effects of 6 Weeks of Squat Training with a Plyometric Training Programme upon Different Physical Performance Tests in Adolescent Team Handball Players. Acta Kinesiologiae Universitatis Tartuensis. 2015;(21); 75-88.
9. Bulgay C, Polat SC. An examination of the relationship between leg strength and balance performances of elite wrestlers. İnonu University Journal of Physical Education and Sport Sciences. 2017; 4(3): 59-67.
10. Cakmak E. An Examination of the Relationships between Static and Dynamic Balance and Speed and Agility in Female Footballers. Ordu. Mater's thesis, Ordu University. 2019.
11. Simsek B, Ertan H, Goktepe SA, Yazicioglu K. The effect of knee muscle strength on jumping height in female volleyball players. Exercise. 2007; 1(1): 36-43.
12. Chelly MS, Hermassi S, Aouadi R, Shephard RJ. Effects of 8-week in-season plyometric training on upper and lower limb performance of elite adolescent handball players. Journal of Strength and Conditioning Research. 2014; 28(5): 1401-1410.
13. Saygin O, Polat Y, Karacabey K. The Effect of Movement Training on Physical Fitness Characteristics in Children, F.U. Journal of Health Sciences. 2005;19(3): 205-212.
14. Albay DM, Tutkun E, Agaoglu YS, Canikli A, Albay F. An examination of various motoric and anthropometric characteristics in university handball, volleyball, and football teams. Spormetre, the Journal of Physical Education and Sport Sciences. 2008; 6(1): 13-20.
15. Bompa OT. Training Theory and Method (trans. D. Keskin and A.B. Tuner). Ankara: Bagirgan Publishing. 1998. p:432-443.
16. Tasucu E. A Determination of the Somatotype Profile of the Turkish National Men's Handball Team. Ankara. Master's thesis, Gazi University. 2002.

17. Yildirim K. An Examination of Various Motoric and Anthropometric Characteristics of Men's National Handball Team Players. Ankara. Master's thesis, Gazi University. 1997.
18. Gokdemir S. A Comparison of Physical and Physiological Parameters of Players on the Ondokuz Mayis University Men's Handball and Basketball Teams. Ankara. Master's theses, Gazi University. 1997.
19. Oxyzoglou N, Hatzimanoil D, Kanioglou A, Papadapoulou Z. Profile of elite handball athletes by playing position. Physical Training. 2008;1-10.
20. Yildirim İ, Ozdemir V. The effect of anthropometric characteristics of top-level male handball players on horizontal and vertical jump distance. Selcuk University Journal of Physical Education and Sport. 2010;12(1): 63–72.
21. Eler S. An Investigation of Some Motoric and Physiological Parameters of Senior Male Handball Players during a One-Season Training Period. Ankara. Master's thesis, Gazi University. 1996.
22. Tutkun FS. A Determination of the Dicle University Men's Handball Team Physical and Physiological Characteristics and a Comparison with the Physical and Physiological Features of Elite Level Athletes. Diyarbakir. Master's thesis, Dicle University. 1995.
23. Cherif M, Said M, Nejlaoui O, Gomri D. Influence of morphological characteristics on physical and physiological performances of Tunisian elite male handball players. Asian Journal of Sports Medicine. 2012; 3(2): 74-80.
24. Hamilton RT, Shultz SJ, Schmitz, RJ, Perrin DH. Triple-hop distance as a valid predictor of lower limb strength and power. Journal of Athletic Training. 2008; 43(2): 144-151.
25. Zorba E, Goral K, Goral S. An examination of the relationships between various physical fitness parameters in elite handball players. International Journal of Science Culture and Sport. 2014; 1: 68-76.
26. Tekin YS. An Investigation of the Balance Performance of Athletes in Athletics, Wrestling and Taekwondo. Konya. Master's thesis, Selcuk University. 2016.
27. Heitkamp HC, Horstmann T, Mayer F, Weller J, Dickhuth HH. Gain in strength and muscular balance after balance training. Intj Sports Med. 2001;22: 285-290.
28. Akarcesme, C. ve Aktug, Z. B. An investigation of the effects of 14-week volleyball training on isokinetic knee muscle strength and dynamic balance performance. İnonu University Journal of Physical Education and Sport Sciences (IUJPESS). 2018;5(1), 33-40.
29. Soyuer F, Mirza M. Relationship between lower extremity muscle strength and balance in multiple sclerosis. Journal Of Neurological Sciences (Turkish). 2006; 23(4): 257-263.
30. Mohammadi V, Alizadeh M, Gaieni A. The effects of six weeks strength exercises on static and dynamic balance of young male athletes. Social Behavioral Sci. 2012; 31:247 – 250.
31. Siriphorn A, Chamonchant D. Wii balance board exercise improves balance and lower limb muscle strength of overweight young adults. J Phys Ther Sci. 2015; 27: 41– 46.
32. Muehlbauer T, Gollhofer A, Granacher U. Associations between measures of balance and lower- extremity muscle strength/power in healthy individuals across the lifespan: A systematic review and meta- analysis. Sports Med. 2005; 45:1671–1692.
33. Kesilmis, İ ve Akin, M. Can quadriceps and hamstring muscle strength affect dynamic balance performance? Turkish Journal of Sport Sciences. 20203(1), 1-7.
34. Erkmen N, Taskin H, Sanioglu A, Kaplan T. The effect of fatigue on balance performance in footballers. Dergi Park. 2009; 4(4): 289-99.
35. Bove M, Brunori A, Cogo C, Faelli E, Ruggeri P. Effects of a fatiguing treadmill exercise on body balance. Gait & Posture. 2005; 21: 121.
36. Wilkins JC, McLeod TC, Perrin DH, Gansneder BM. Performance on the balance error scoring system decreases after fatigue. Journal of Athletic Training. 2004;39(2):156-161.
37. Waterman N, Sole G, Hale L. The effect of a netball game on parameters of balance. Physical Therapy in Sport. 2004;5(4): 200-207.
38. Arslanoglu, C., Baynaz, K., Acar, K., Mor, A., İpekoglu, G., Arslanoglu, E. The Relationship Between Leg Strength and Aerobic and Anaerobic Capacity in Football Players. Ataturk University Journal of Physical Education and Sport Sciences. 2018;20(1):37-45.