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Investigation of parameters affecting throwing velocity and accuracy in handball

Neslihan AKÇAY[1], Kerem Can YILDIZ[1], Sezer TANRIÖVER[1], Mehmet Ali KANI[1], Mustafa Şakir AKGÜL[1], Fatma Neşe ŞAHİN[2]

[1]Karabuk University, Hasan Dogan School of Physical Education and Sports, Karabük, Turkiye
[2]Ankara University, Faculty of Sports Sciences, Ankara, Turkiye

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Abstract

Handball is a team sport in which changing direction, running fast-slowly, jumping, throwing, throwing accuracy, and tackles are at the forefront. For basic throws in the game, throwing speed and accuracy are important factors for a successful throw. In this context, the aim of this study is to evaluate the effects of body composition, isokinetic strength, handgrip strength, and static and dynamic balance parameters on throwing speed and accuracy in handball players. A total of 20 male handball players with an average age of 14.95±0.24 years and an average sports age of 4.15±0.44 years participated in the study voluntarily. Body composition, static and dynamic balance, hand grip strength, shoulder and arm rotation, throwing velocity and accuracy tests were performed on the athletes. While a negative correlation was found between body weight (r=-0.61), body mass index (r=-0.66), body muscle mass (r=-0.5), body fat mass (r=-0.58), Body fat % (r=0.61), Dominant arm muscle (r=-0.52) parameters and throwing accuracy, a positive correlation was found between dominant hand grip (r=0.59) and dominant arm shoulder internal rotation strength (r=0.59), non-dominant arm shoulder internal rotation strength parameters and throwing velocity ($p<0.05$). No correlation was found in the static and dynamic balance parameter. In line with the findings of the study, the static and dynamic balance parameters of the handball players did not have an effect on the throwing velocity and accuracy. However, while anthropometric characteristics such as body weight, body fat percentage and mass, and muscle mass had an effect on throwing accuracy, it can be said that hand grip strength, isokinetic shoulder internal and external rotation strength were effective on throwing velocity.

Keywords: Balance, handball, strength, throwing accuracy, throwing velocity

Hentbolda atış hızı ve isabetine etki eden parametrelerin incelenmesi

Öz

Hentbol yön değiştirme, hızlı-yavaş koşma, sıçrama, atmanın, isabetin ve ikili mücadelecin ön planda olduğu bir takım sporudur ve oyun içinde temel atışlarda, başarılı bir atış için atış hızı ve isabetlilik önemli bir faktördür. Çalışmanın amacı, hentbolcularda vücut kompozisyonu, izokinetik kuvvet, el kavrama kuvveti, statik ve dinamik denge parametrelerinin atış hızına ve isabetine etkisinin değerlendirilmesidir. Çalışmaya yaş ortalamaları 14.95±0,24 yıl olan 20 erkek hentbol oyuncusu gönüllü olarak katılmıştır. Sporculara vücut kompozisyonu, statik ve dinamik denge, el kavrama kuvveti, omuz ve kol rotasyon, atış hızı ve isabet testleri yapılmıştır. Vücut ağırlığı(r=-0,61) vücut kütle indeksi(r=-0,66), vücut kas kütlesi(r=-0,50), vücut yağ kütlesi(r=-0,58), vücut yağ(r=0,61), baskın kol kası (r=0-0,52) parametreleri ile atış isabeti arasında negatif korelasyon bulunurken, baskın el kavrama(r=0,59) ve baskın kol omuz iç rotasyon kuvveti (r=0,59), baskın olmayan kol omuz iç rotasyon kuvveti parametreleri ile atış hızı arasında pozitif korelasyon bulunmuştur. Statik ve dinamik denge parametresinde herhangi bir korelasyon bulunmamıştır. Çalışmanın bulguları doğrultusunda, hentbol oyuncularının statik ve dinamik denge parametrelerinin atış hızı ve isabeti üzerinde etkisi bulunmamıştır. Ancak, vücut ağırlığı, vücut yağ yüzde ve kütlesi, kas kütlesi gibi antropometrik özellikleri atış isabeti üzerinde etkiye sahipken, el kavrama kuvveti, izokinetik omuz internal ve external rotasyon kuvveti atış hızında etkili olduğu söylenebilir.

Anahtar Kelimeler: *Atış hızı, atış isabeti, denge, hentbol, kuvvet*

Sorumlu Yazar/Corresponded Author: Neslihan AKÇAY, **E-posta/e-mail:** neslihanozcan@karabuk.edu.tr
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INTRODUCTION

Handball is a fast-paced contact sport that requires physical effort capacity to resist violent contacts and high-intensity physical actions during training and competition (Gorostiaga et al., 2006; Bragazzi et al., 2020). It is also a team sport in which changing direction, running fast-slowly, jumping, throwing, throwing accuracy, and tackles are at the forefront (Ravier & Demouge, 2016). The basic factors required for success in handball can be listed as maximal strength, strength, balance, speed, endurance, throwing velocity and accuracy (Karcher & Buchheit, 2014; Saavedra et al., 2018). For basic throws in the game, throwing speed and accuracy are important factors for a successful throw (Van den Tillaar & Ettema, 2003; Gorostiaga et al., 2006; Van den Tillaar & Ettema, 2007;).

Physical characteristics of handball players are an important parameter for throwing velocity and accuracy (Debanne & Laffaye, 2011). It is observed that these are related to the physical profiles of the athletes and that taller and fatter athletes can throw faster with the effect of their mass (Van den Tillaar & Ettama, 2004; Wagner et al., 2010). Studies in the literature show parallelism with the findings of our study, but studies on body composition, throwing velocity and accuracy are insufficient.

While defending in the game, the players constantly apply force both to their own bodies and to the opposing player in order to prevent the forward players of the opposing team and upset their balance (Tokgöz & Aydın, 2022). During the game, balance and body posture play a very important role in handball. The good static and dynamic balance ability of the athlete ensures that the necessary movements are performed in a proper and coordinated manner (Kayacan & Makaracı, 2017; Tokat & Günay, 2022). Dynamic and static balance is of great importance for using the most appropriate technique, adapting to the in-game variables, and strength transfer between the upper and lower extremities (Şimşek & Ertan, 2011; Taşkın et al., 2015). Moreover, the strength of the arm used for shot should be evaluated together with the upper extremity and shooting technique, optimal harmony of body parts, and lower extremity strength. Furthermore, the strength of the throwing arm should be evaluated not only with the upper extremity, but also with throwing velocity and accuracy, the harmony of the body parts at this time, and the strength of the lower extremity (Ferragutt et al., 2018).

Throwing in handball is a complex skill that includes both mechanical and motor skills involving directions of movement (Fradet et al., 2004; Van den Tillaar & Ettema, 2007). Strength is an important factor for throwing velocity and accuracy. Although the throwing

motion creates a wide kinetic chain that starts with the foot's contact with the ground and continues until the ball is released, it is the upper extremity that transfers the strength that occurs in directing the motion to the ball. For this reason, strength in the shoulder, elbow, wrist joints, arm, forearm, and hand segments, which determine the position of the arm in air, are shown as important factors that ensure throwing accuracy (Hamill & Knutzen, 2003). In this context, in addition to technical and tactical abilities, muscular force and strength (maximal isometric power) should not be ignored in order to be successful in both men's and women's handball (Cherif et al., 2016; Hermassi et al., 2019). This strength of the player naturally also affects throwing velocity that will be produced while throwing (Makaracı, 2021).

In this context, the aim of this study is to evaluate the effects of body composition, isokinetic strength, hand grip strength, static and dynamic balance parameters on throwing velocity and accuracy in handball players.

METHOD

Research group

A total of 20 male handball players with an average age of 14.95±0.24 years and an average sports age of 4.15±0.44 years and without any health problems participated in the study voluntarily. The study procedures followed the principles outlined in the Declaration of Helsinki and were approved by Karabuk University, Non-interventional Clinical Ethics Committee (2023/1267).

Study design

Study measurements were completed in 2 days. The athletes carried out a routine warm-up protocol including 10 minutes of dynamic and static exercises on both days. Body composition, static and dynamic balance, hand grip strength, shoulder internal and external rotation strength tests were performed on the athletes on the 1st day and the data were recorded. On the second day, throwing velocity and accuracy tests determined in the handball field were applied on the athletes, and then the study was completed. The athletes who train regularly at least 3 days a week were included in the study. The athletes participating in the study were informed about the aim and content of the study at the beginning of the study and then all participants signed an “Informed Consent Form” stating that they voluntarily participated in the study.

Data collection tools

Height and Body Analysis Measurement: While the height (cm) of the participants was measured with a stadiometer, Inbody 270 body analysis measuring device was used for the body weight (kg), Body mass index (BMI) (kg/m^2), body fat percentage (%), body fat mass (kg) and body muscle percentage (%).

Static and Dynamic Balance: Postural stability test (PST) and stability limit test (SLT) performed to determine the static and dynamic balance levels of the participants were carried out with the BioSway portable balance system (Biodex BioSway, USA) (Eser, 2019) PST is a test that measures the ability to hold the center of gravity above the support surface. In this test, the participants were asked to stand on their two feet on the platform and try to keep the point showing the center of gravity on the monitor in front of them stable. This system calculated how much the participants deviated from the desired point in the sagittal and frontal planes during the test and gave the lateral-medial balance index and the anterior-posterior balance index. SLT represents the maximum angle at which the participants can lie with their feet stable, without bending their knees and without losing their balance. During SLT, the participants were asked to move the center of gravity while trying to stand on both feet without oscillating on the balance platform, according to the flashing of the patterns seen on the monitor in front of them, and to keep the center of gravity in that area until the target point stopped flashing (Sekulic et al., 2013). During the test, the system automatically directed 8 directions (3 forward, 3 back, 2 sides) to random target points once. The test was repeated 3 times and the average value was taken and the stability limit test values of the participants were recorded.

Hand Grip Strength: Dominant and nondominant hand grip strength measurements of the participants were performed in the standing position. After the dynamometer was adjusted according to the hand sizes of the subjects, the participants were allowed to stand on their side at an angle of 10-15° from their shoulders. The maximum grip strength of dominant and nondominant hands was measured when participants felt ready. Two attempts were made for both hands and the highest values were recorded as dominant and nondominant hand grip strength (Innes, 1999; Tokat & Keskin, 2023).

Isokinetic Shoulder Strength: LaFayette brand digital hand dynamometer was used to measure the dominant and non-dominant shoulder, internal and external rotation strength. The device can give data such as peak power, time to reach peak power, total test time, and average strength in kg, Newton, and pounds. Before starting the test, the athletes were verbally informed

about the test and a trial was made to all the athletes in order to familiarize them with the device. During the test, the "make test" technique, which requires isometric contraction, was applied. (Make test is the protocol of applying maximum force against the device by the person being measured while the measuring person holds the dynamometer steady). All measurements were taken twice by the same trainer with the same hand from the participants. In the test, the participants were lying on a flat surface in the supine position without support. Then, the dominant and non-dominant shoulder internal and external rotation strength was measured and recorded twice (Kesilmiş & Manolya, 2020).

Throwing Velocity: The ball throwing velocity of the participants were determined using the Stalker Solo2 brand (Plano, USA) radar. The ball throwing velocity of the participants was measured using the 7m throw while standing with the dominant arm and they were asked to throw at the highest speed they could apply. All participants performed the same for 3 times and their best scores were recorded (Dündar et al., 2018).

Throwing Accuracy: The participants were asked to shoot shots to the designated areas of the handball goal in order to evaluate their throwing accuracy performance. Four net target areas of 50 cm x 50 cm width were placed on the right-left, lower, and upper corners of the handball goal. The athlete threw whichever of the four targets s/he wanted. The handball players were asked to shoot 10 shots at the targets using the high basic shooting technique with a resistance step, in accordance with the three-step rule of handball, without crossing the 9 m shooting line from the middle playmaker position. After each throwing, the other balls in the safe at a distance of 11 meters were taken one by one and 10 shots were completed. For this test, two attempts were given, and the best of the two attempts was evaluated as the test result. A 3 min rest was given between the attempts. In this study, the most commonly used high basic shooting technique with a resistance, which is the most commonly used one in previous studies and matches regarding similar shooting types (Pilça & Altun, 2019).

Data analysis

Data analysis was performed using IBM SPSS 27 package and Microsoft Excel 2019 programs. Spearman Rank Correlation was applied to determine whether there was a significant relationship between the parameters. The statistical significance level was accepted as $p<0.05$.

FINDINGS

Table 1. The relationship between body composition and throwing velocity and accuracy (n=20)

Parameters	Mean±S.d	Throwing Velocity(km/h) Mean±S.d	r	p	Throwing Accuracy(score) Mean±S.d	r	p
Height (cm)	172.20±0.44	68.50±1.74	0.40	0.08	5.60±0.79	-0.15	0.53
Body weight (kg)	66.72±4.15		0.11	0.63		-0.61	**0.00***
Body mass index (kg/m^2)	22.17±1.02		0.05	0.85		-0.66	**0.02***
Body muscle mass (kg)	55.46±2.35		0.27	0.25		-0.5	**0.03***
Body fat mass (kg)	11.25±2.15		-0.28	0.24		-0.58	**0.00***
Body fat %	14.73±1.85		-0.41	0.07		-0.61	**0.00***
Dominant arm muscle (kg)	2.92±0.16		0.41	0.07		-0.52	**0.02***
Dominant arm fat (kg)	0.69±0.18		-0.47	**0.04***		-0.46	**0.04***

*=p<0.05

When Table 1 was examined, a positive correlation was found between height (cm), body weight (kg), body mass index (kg/m2), body muscle mass (kg), dominant arm muscle (kg) and shooting speed (km/h) while no significant relationship was detected (p<0.05). While a negative correlation was observed with body fat mass (kg), body fat percentage (%) and dominant arm fat (kg) parameter, a significant correlation was found only with dominant arm fat (kg) (p<0.05). Moreover, while a negative correlation was observed between all body composition parameters and throwing accuracy (score), a statistically significant relationship was found between all parameters except height (cm) and throwing accuracy (score) (p<0.05).

Table 2. The relationship between static balance and throwing velocity and accuracy (n=20)

Parameters	Mean±S.d.	Throwing Velocity(km/h) Mean±S.d	r	p	Throwing Accuracy(score) Mean±S.d	r	p
Overall stability index (score)	0.35±0.02	68.50±1.74	0.20	0.39	5.60±0.79	-0.03	0.33
Anterior/posterior index (score)	0.29±0.02		-0.03	0.91		-0.23	0.34
Medial/lateral index (score)	0.13±0.01		0.07	0.78		0.07	0.77

*=p<0.05

When Table 2 was examined, a positive correlation was found between the overall stability index (score) and the medial/lateral index (score) and the firing rate (km/h), while a negative correlation was found between the anterior/posterior index (score) and throwing velocity (km/h), and no statistically significant relationship was found between the static

balance parameters and throwing velocity (km/h) at the 95% confidence interval ($p<0.05$). Moreover, while a negative correlation was observed between the overall stability index (score) and the anterior/posterior index (score) and the throwing accuracy (score), a positive correlation was observed with the medial/lateral index (score). No statistically significant relationship was observed between static balance parameters and throwing accuracy (score) at the 95% confidence interval ($p<0.05$).

Table 3. Relationship between dynamic balance and throwing velocity and accuracy (n=20).

Parameters	**Mean±S.d**	**Throwing Velocity(km/h) Mean±S.d**	**r**	**p**	**Throwing Accuracy(score) Mean±S.d**	**r**	**p**
Total time (sec)	32.2±0.97	68.50±1.74	0.00	0.99	5.60±0.79	0.08	0.75
Overall (score)	57.7±2.34		0.23	0.32		0.18	0.45
Forward (score)	63.75±4.5		0.38	0.09		0.13	0.58
Backward (score)	64.7±4.29		0.21	0.38		-0.02	0.94
Left (score)	61.15±3.04		0.01	0.95		0.03	0.89
Right (score)	64.3±3.08		0.25	0.29		-0.13	0.57
Forward left (score)	59.9±2.89		0.08	0.74		0.27	0.24
Forward right (score)	64±3.47		0.38	0.09		-0.00	0.99
Backward left (score)	55.1±3.12		-0.02	0.95		0.38	0.10
Backward right (score)	62.05±3.24		0.06	0.79		-0.13	0.59

*=$p<0.05$

When Table 3 was examined, a positive correlation was found between all parameters except backward left (score) and throwing velocity (km/h), but no significant relationship was detected ($p<0.05$). Moreover, while a negative correlation was observed between throwing accuracy (score) and backward (score), right (score), forward right (score) and backward right (score), a positive correlation was observed with other parameters. No statistically significant relationship was found between the dynamic balance parameters and throwing accuracy (score) parameters at the 95% confidence interval ($p<0.05$).

Table 4. The Relationship between grip strength and throwing velocity and accuracy (n=20).

Parameters	Mean±S.d	Throwing Velocity(km/h) Mean±S.d	r	p	Throwing Accuracy(score) Mean±S.d	r	p
Dominant hand grip (kg)	39.31±1.65	68.50±1.74	0.54	**0.05***	5.60±0.79	-0.22	0.35
Nondominant hand grip (kg)	38.14±1.59		0.42	0.06		-0.29	0.21

*=p<0.05

When Table 4 was examined, a positive correlation was found between dominant hand grip strength (kg) and non-dominant hand grip strength and throwing velocity (km/h), while a significant correlation was found only with dominant hand grip strength (kg) (p<0.05). No statistically significant correlation was found between non-dominant hand grip strength and throwing velocity (km/h) (p<0.05). Moreover, while a negative correlation was observed between hand grip strength (kg) parameters and throwing accuracy (score), no statistically significant correlation was found in the 95% confidence interval (p<0.05).

Table 5. Relationship between isokinetic strength and throwing velocity and accuracy (n=20).

Parameters	Mean±S.d	Throwing Velocity(km/h) Mean±S.d	r	p	Throwing Accuracy(score) Mean±S.d	r	p
Dominant arm shoulder external rotation strength (kg)	13.18±0.55	68.50±1.74	0.44	0.06	5.60±0.79	-0.35	0.13
Nondominant arm shoulder external rotation strength (kg)	13.03±0.48		0.43	0.06		-0.21	0.36
Dominant arm shoulder internal rotation strength (kg)	16.79±0.62		0.59	**0.00***		-0.17	0.47
Nondominant arm shoulder internal rotation strength (kg)	16.46±0.51		0.54	**0.01***		-0.14	0.56

*=p<0.05

When Table 5 was examined, a positive correlation was found between the shoulder internal and external rotation force (kg) of the dominant arm and the nondominant arm and the throwing velocity (km/h), whereas a significant correlation was found only for the shoulder internal rotation force (kg) of the dominant arm and the nondominant arm (p<0.05). In addition, although a negative correlation was found between the shoulder external and internal rotation force (kg) of the dominant and non-dominant arm and throwing accuracy (score), no statistically significant relationship was found (p<0.05).

DISCUSSION AND CONCLUSION

In line with the findings of the study, no statistical significance was found between the static and dynamic balance parameters and throwing velocity and accuracy. A statistical significance was found between anthropometric features such as body weight (r=-0.61), body mass index (r=-0.66), body muscle mass (r=-0.50), body fat mass (r=-0.58), Body fat % (r=0.61) and throwing accuracy ($p<0.05$) while a statistical significance was found between Dominant arm muscle (r=-0.52), dominant arm shoulder internal rotation strength (r=0.59) and throwing accuracy ($p<0.05$).

Fleck et al. (1992) revealed that isokinetic strength parameters, namely elbow extension, shoulder abduction, shoulder internal rotation and external rotation affect handball throwing velocity. In some studies, when the relationship between throwing velocity and shoulder rotator muscles was examined, it was reported that internal rotation and external rotation of the shoulder were related to angular velocity (Bayios et al., 2001; Dauty et al., 2005; Andrade et al., 2016). There are other studies showing that strength and power measures also positively affect throwing velocity (Van den Tillaar & Ettema, 2004; Marques et al., 2007; Chelly et al., 2010). On the other hand, Zapartidis et al. (2007) stated that there is a moderately strong and significant positive relationship between throwing velocity and lower and upper extremity muscle strength. However, in studies that are not parallel to the findings of our study, no relationship was found between upper body strength and throwing velocity. No correlation was found between 1-rep maximum bench press peak power and throwing velocity (Van den Tillaar & Ettema, 2004; Chaouachi et al., 2009). Chelly et al. (2010) stated that the reason why the shot accuracy velocity did not increase in parallel with the training was the fact that the shot accuracy rate was not only a strength-dependent phenomenon. Çetin and Balcı (2015) stated that the upper extremity strength levels of handball players did not have any significant effect on shot accuracy rate. In parallel with these studies, Hermassi et al. (2011), in their study on handball players, revealed that the increase in strength did not cause a significant change in 9m free throw performances, and this result was due to the fact that throwing velocity and accuracy were closely related to the technical capacities of the athletes. In line with the studies in the literature, it can be said that the strength parameter has a positive effect on throwing velocity rather than throwing accuracy.

Studies investigating the relationship between body composition and throwing velocity and accuracy indicate that handball performance is associated with physical characteristics and that the heavier and taller athletes can increase their throwing velocity with the effect of their

mass (Van den Tillaar & Ettema, 2004; Wagner et al., 2010). Similarly, Saavedra et al., (2018) emphasized that factors such as height, body weight, arm length and palm width, which are important criteria in determining position for female handball players of different age categories, are effective in throwing velocity and are important for the development of the athlete (Taborskỳ, 2007). In a study conducted in the same direction, a moderate and positive correlation was found between throwing velocity and elbow width ($r=0.265$, $p<0.01$), calf width ($r=0.226$, $p<0.01$), waist circumference ($r=0.242$, $p<0.01$) and hip circumference (r= between 0.345, $p<0.01$); a low positive correlation was found between throwing rate and wrist (cm) ($r=0.191$, $p<0.05$); a moderate positive and significant correlation was found between throwing velocity and hand length ($r=0.358$, $p<0.01$); and a moderate positive correlation was found between biacromial width (cm) ($r=0.340$, $p<0.01$) and lean body weight (kg) ($r=0.252$, $p<0.01$). However, no significant relationship was found between throwing accuracy and anthropometric characteristics (Demirdizen, 2012). Similar studies in the literature do not show parallelism with the findings of our study.

It was concluded that static and dynamic balance can play a positive role in reducing the risk of injury, especially in rapidly developing sports such as handball, skiing, volleyball, and basketball (Dunsky et al., 2017). This result suggests that balance should be improved as an important way to improve the performance of athletes and minimize the risk of injury. During handball competitions, it is necessary to maintain balance and postural control, especially in defense and attack phases, as well as providing body stability during critical moments such as high basic throw and penalty during attack (Makaracı, 2019). Gomboş et al., (2017) further emphasized the need to develop balance ability in handball players in their study. Similarly, Sunawa et al., (2018) draws attention to the necessity of balance and stability during the fast and unexpected movements of handball competitions. However, in Makaracı's (2019) study, although there were more variables showing positive trends in the relationship between shot accuracy rate and jumping static balance performance, no statistical significance was found. These results show that balance exercises are not associated with all aspects of handball performance and the effect of certain factors may be more complex. At this point, further research and examination of different parameters are required.

As a result, the static and dynamic balance parameters of the handball players did not have an effect on the throwing velocity and accuracy. However, it can be said that while anthropometric characteristics such as body weight, body fat percentage and mass, and muscle

mass have an effect on throwing accuracy; hand grip strength, isokinetic shoulder internal and external rotation strength are effective on throwing velocity.

GENİŞLETİLMİŞ ÖZET

GİRİŞ

Hentbol, antrenman ve müsabaka esnasında şiddetli temaslara ve yüksek yoğunlukta gerçekleşen fiziksel aksiyonlara karşı koyabilecek fiziksel efor kapasitesine sahip hızlı tempolu bir temas sporudur (Gorostiaga ve ark., 2006; Bragazzi ve ark., 2020). Ayrıca yön değiştirme, hızlı-yavaş koşma, sıçrama, atmanın, isabetin ve ikili mücadelelerin ön planda olduğu bir takım sporudur (Ravier & Demouge, 2016). Hentbolda başarı için gerekli olan temel faktörler maksimal kuvvet, güç, denge, hız, dayanıklılık, atış hızı ve isabeti olarak gösterilebilir (Karcher & Buchheit, 2014; Saavedra ve ark., 2018). Oyun içinde temel atışlarda, başarılı bir atış için atış hızı ve isabetlilik önemli bir faktördür (Van den Tillaar & Ettema, 2003; Gorostiaga ve ark., 2006; Van den Tillaar & Ettema, 2007). Hentbol sporcularının fiziksel özellikleri atış isabeti ve hızı için önemli bir parametredir (Debanne & Laffaye, 2011). Sporcuların fiziksel profilleriyle ilişkili olduğu ve vücut ağırlığı fazla olan ve uzun sporcuların kütle etkisiyle daha hızlı atış yapabildikleri görülmüştür (Van den Tillaar & Ettama, 2004; Wagner ve ark., 2010). Oyuncular, oyun içinde savunma yaparken karşı takımın hücum oyuncularını engellemek ve dengelerini bozmak için devamlı olarak hem kendi vücutlarına hem de rakip oyuncuya kuvvet uygulamaktadırlar (Tokgöz & Aydın, 2022). Oyun esnasında dengenin korunması ve vücut postür yapısı hentbolda çok önemli rol oynamaktadır. Sporcunun statik ve dinamik denge kabiliyetinin iyi olması gereken hareketlerin düzgün ve koordineli bicimde yapılmasını sağlamaktadır (Kayacan & Makaracı, 2017). Hentbolda atış, hem mekanik hem de hareket yönlerini içeren motor becerileri içeren karmaşık bir beceridir (Fradet ve ark., 2004; Van den Tillaar & Ettema, 2007). Atış hızı ve isabeti için ise kuvvet önemli bir faktördür. Atış hareketi, her ne kadar ayağın yer ile temasında başlayıp topun elden çıkmasına kadar devam eden geniş bir kinetik zincir oluştursada, hareketi yönlendiren meydana gelen kuvveti topa aktaran, üst ekstremitedir. Bu nedenle kolun boşlukta aldığı pozisyonu belirleyen omuz, dirsek, el bileği eklemleri, kol, önkol ve el segmentlerinde kuvvet atışta isabetliliği sağlayan önemli faktörler gösterilmektedir (Hamill & Knutzen, 2003). Bu bağlamda bu çalışmanın amacı, hentbolcularda vücut kompozisyonu, izokinetik kuvvet, el kavrama kuvveti, statik ve dinamik denge parametrelerinin atış hızına ve isabetine etkisinin değerlendirilmesidir.

YÖNTEM

Çalışma ölçümleri 2 günde tamamlanmıştır. Sporcular iki günde de 10 dakikalık dinamik ve statik egzersizler içeren rutin ısınma protokolü uygulamışlardır. Sporcular 1. gün vücut kompozisyonu, statik ve dinamik denge, el kavrama kuvveti, omuz internal ve external rotasyon kuvvet testleri yapılarak veriler kaydedilmiştir. 2. gün sporcular hentbol sahasında belirlenen atış hızı ve isabet testlerinin ardından çalışma tamamlanmıştır. Çalışmaya haftada en az 3 gün düzenli antrenman yapan sporcular

dahil edilmiştir. Çalışmaya herhangi bir sağlık sorunu bulunmayan, yaş ortalaması 14,95±0,24, spor yaşı ortalama 4,15±0,44 (yıl) olan ve müsabık olan toplamda 20 erkek hentbol oyuncusu gönüllü olarak katılmıştır. Verilerin analizi IBM SPSS 27 paket ve Microsoft Excel 2019 programları kullanılarak yapıldı. Parametreler arasında anlamlı bir ilişkinin olup olmadığını tespit etmek için Spearman Rank Korelasyon uygulandı. İstatiksel olarak anlamlılık düzeyi $p<0,05$ olarak kabul edilmiştir.

BULGULAR

Çalışmanın bulguları doğrultusunda, statik ve dinamik denge parametrelerinin atış hızı ve isabeti üzerinde istatiksel açıdan anlamlılık bulunmamıştır. Vücut ağırlığı (r=-0,61), vücut kütle indeksi (r=-0,66), vücut kas kütlesi (r=-0,50), vücut yağ kütlesi (r=-0,58), vücut yağ % (r=0,61) gibi antropometrik özelliklerinin atış isabeti üzerinde anlamlılık bulunurken ($p<0,05$), baskın kol kası (r=-0,52), baskın kol omuz iç rotasyon kuvveti (r=0,59) atış hızında ise atış hızında istatiksel açıdan anlamlılık bulunmuştur ($p<0,05$).

SONUÇ

Sonuç olarak, hentbol oyuncularının statik ve dinamik denge parametrelerinin atış hızı ve isabeti üzerinde etkisi bulunmamıştır. Ancak, vücut ağırlığı, vücut yağ yüzde ve kütlesi, kas kütlesi gibi antropometrik özellikleri atış isabeti üzerinde etkiye sahipken, el kavrama kuvveti, izokinetik omuz internal ve external rotasyon kuvveti atış hızında etkili olduğu söylenebilir.

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KATKI ORANI ***CONTRIBUTION RATE***	**AÇIKLAMA** ***EXPLANATION***	**KATKIDA BULUNANLAR** ***CONTRIBUTORS***
Fikir ve Kavramsal Örgü *Idea or Notion*	Araştırma hipotezini veya fikrini oluşturmak *Form the research hypothesis or idea*	Neslihan AKÇAY Kerem Can YILDIZ Mustafa Şakir AKGÜL
Tasarım *Design*	Yöntem ve araştırma desenini tasarlamak *To design the method and research design.*	Kerem Cem YILDIZ Sezer TANRIÖVER
Literatür Tarama *Literature Review*	Çalışma için gerekli literatürü taramak *Review the literature required for the study*	Neslihan AKÇAY Sezer TANRIÖVER Mustafa Şakir AKGÜL
Veri Toplama ve İşleme *Data Collecting and Processing*	Verileri toplamak, düzenlemek ve raporlaştırmak *Collecting, organizing and reporting data*	Neslihan AKÇAY Kerem Cem YILDIZ Sezer TANRIÖVER Mustafa Şakir AKGÜL
Tartışma ve Yorum *Discussion and Commentary*	Elde edilen bulguların değerlendirilmesi *Evaluation of the obtained finding*	Mustafa Şakir AKGÜL Fatma Neşe ŞAHİN

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