Turkish Journal of Sport and Exercise /Türk Spor ve Egzersiz Dergisi
http://dergipark.gov.tr/tsed
Year: 2021 - Volume: 23 - Issue: 2 - Pages: 73-79
DOI: 10.15314/tsed.948778

Turkish Journal of Sport and Exercise
Türk Spor ve Egzersiz Dergisi
ISSN: 2147-5652
https://dergipark.org.tr/tr/pub/tsed

Effects of Upper Body Anthropometrics and Handgrip Strength on Ball Velocity in Female Handball Players

Umut CANLI[1A], Cem KURT[2B], Ozan ATALAĞ[3C]

[1]Tekirdağ Namık Kemal University, School of Physical Education and Sport
[2]Trakya University, Faculty of Sport Sciences, Coaching Education Department
[3]University of Hawai'i at Hilo, Kinesiology and Exercise Sciences Department

(Received): 06/06/2021/ (Accepted): 30.08.2021

A:Orcid ID: 0000-0001-8603-3492 B:Orcid ID: 0000-0002-0254-5923 C:Orcid ID: 0000-0002-0254-5923

Abstract

The aim of this study is to analyze the relationship between ball velocity thrown from two different positions, parameters of upper body anthropometrics and hand grip strength as a marker of upper body strength. Twelve well-trained female handball players (age, 22.47±4.57 years; body mass, 66.70±11.05 kg; height, 167.33±7.41 cm; handball experience, 9.91±3.47 years), playing in a team that competes in the first division of the Handball League of Turkey joined this study. Body weight, height, body mass index (BMI), body fat percent and trunk muscle mass, hand length and breadth, sitting height, arm span index and dominant hand grip strength measured by using a stadiometer, bioelectric impedance device, anthropometric set, fiberglass measuring tape and hand grip dynamometer respectively. Ball velocity was measured with a speed radar for both throwing positions (throws are made from a sitting position either with a non-throwing hand on the floor (RP) or non-throwing arm free (RS). *According to hierarchical multiple regression analysis carried out; the original contribution of fat percentage, trunk muscle mass, BMI and handgrip strength included in the model in the first step is not significant within the model and both RP and RS were not able to predict ball velocity (p>0.05). It was also determined that hand length,* hand breadth, *sitting height and* arm span index which were *included in the model in the second step were not significant and did not predict the ball velocity for both RP and RS as well (p>0.05). However, there was a positive relationship between trunk muscle mass and ball velocity with RP* (r = 0.831; p<0.05). No relationship was found between other variables and ball velocity for both RP and RS. According to the results of the study, handball players and their coaches might consider designing resistance training programs that put an emphasis on increasing trunk muscle mass to increase the ball velocity during over arm throws.

Key words: Handball, Ball velocity, Anthropometry, Strength

INTRODUCTION

Handball is a dynamic sport characterized by intensive, intermittent physical exertion such as sprinting, change of direction, jumping, throwing, blocking and pushing (9,14). It is known that handball performance is affected by the anthropometric characteristics of the athletes for the skills of jumping, running, throwing or for the physical qualities of stamina power and strength (5,10,14).

Throwing is a crucial aspect of handball, since the main objective of this sport is to get the ball into the opponent's net (20). Ball velocity, together with throwing accuracy, are key factors in successful throwing performance (2). Efficiency of throwing depends on multiple factors such as throwing arm mechanics, coordination of sequential joint actions such as hip extension and rotation, shoulder rotation and elbow extension, as well as the strength and power of overall musculature (13).

Several previous studies (3, 20, 22-24) showed weak to moderately strong correlations of general anthropometric variables (body mass, stature, BMI) and ball-throwing velocity (r = 0.23 – 0.70). Zapartidis et al., also reported that ball velocity is positively correlated (r = 0.29–0.37) with anthropometric parameters with relevance to handball (e.g., hand size and arm span) (23). However, Shalfawi et al., argued that general anthropometric variables have almost no predictive value for athletes´ maximal throwing velocity (15). Therefore, the aim of this study is to analyze the relationship between upper body anthropometrics and handgrip strength on ball velocity with two different throwing positions (either from a sitting position with both arms free to move (RP) or non-throwing hand on the ground (RS) in female handball players.

We hypothesize that for both RP and RS: a) body fat , trunk muscle mass , BMI, handgrip strength variables combined together can predict the ball speed, b) hand length, hand breadth, sitting height and arm span index variables combined together can the predict ball velocity, c) common effect of all variables combined together can predict the ball velocity.

Table 1. Descriptive characteristics of the players

Variables	Mean ± SD (N=12)
Age (years)	22.47 ± 4.57
Body mass (kg)	66.70 ± 11.05
Height (cm)	167.33 ± 7.41
Handball experience (years)	9.91 ± 3.47
Training frequency (sessions/week)	7.75 ± 0.86
Training volume (h/week)	15.50 ± 1.73

Twelve well-trained female handball players, playing in a team that competes in the first division of the Handball League of Turkey joined this study. The Handball team finished third in previous year's competition, and they aim to be a part of Turkey's Women's Handball Super League next season. Players' characteristics are presented in table 1. The inclusion criteria were as follows: Subject should be: licensed as a professional player for at least 4 years (including the 2020–2021 handball season); age ≥18 years; apparently healthy (based on the medical examination for the 2020–2021 handball season); and have no chronic or musculoskeletal injuries in the last three months.

Procedures

All subjects underwent a set of anthropometric measurements, hand grip strength tests, and ball velocity evaluation assessment for both RS and RP. All tests were performed on the same day within the same time period (2.30–4.30 PM) at Tekirdag Namık Kemal University Sports Hall. Although the team and the players were in mid-season; they had a short break due to the COVID-19 pandemic thus allowing the tests and measurements to take place. All subjects were informed to rest well a day before the testing session and were instructed to continue their normal food consumption, fluid intake, and regular sleep patterns. However, caffeine and food intake were limited to 3 hours prior to the testing session. The order of the of tests and measurements were as follows: body mass, body composition (muscle mass and fat percentage), height measurement, sitting height measurement, arm span measurement, hand length and breadth measurement, grip strength, throws (ball velocity). To minimize the learning effect for ball throws, half of the subjects started the throws with RS, whereas other half with RP in a randomized fashion. There was a 2-min recovery period between throws and the subjects were not allowed to perform static stretching during this period. All of the subjects were instructed to wear sport shorts, short-sleeved t-shirts, and handball shoes prior to measurements. However, all anthropometric measurements were done barefoot.

Anthropometry

Body mass and body composition (muscle mass [in kg] and fat percentage %) were measured using a body composition monitor based on the bioelectric impedance method (BIA, Tanita BC 545N, Australia). Standing and sitting height were measured using a stadiometer (13539; Mesilife). Hand length and hand breadth were measured from the dominant side using an anthropometric set (HLT-100; Holtain Ltd. Crosswell, Crymych,UK). Arm span was measured using a fiberglass measuring tape. Body index (BMI) (kg/m2) and arm span index (%) were calculated as follows (12); BMI: weight (kg)/height (m2), arm span index (%): arm span/height.

Warm-up

All subjects started the testing session with a 15-min warm-up which included 10 min of self-paced jogging around the handball field (similar to what players do prior to training sessions or matches) and 5 min. dynamic stretching exercises, which consisted of front kicks with hand reach, walking lunges, high knee skipping and butt kicks. Each exercise was performed twice on a 20-m line.

Ball velocity

Ball velocity was measured with a speed radar (SpeedTrac X Sport Radar-5200, Canada), which was placed in between the target and the subject (4). Both RS and RP were performed twice with 20-s rest interval. Higher score was registered (in km/h) and used in the statistical analyses (14).

Throw with both arms free to move (RP)

This throw is performed with the subject in a sitting position (with hips flexed around 90 degrees and abducted at about 20 degrees) with the non-throwing shoulder flexed. A target was set at 4.5 m away from the subject (dimensions 50 x 50 cm, 75 cm above the ground). Each subject performed two throws to the target with the non-throwing arm free to move, allowing upper body rotation (4).

Throw with non-throwing hand on the ground (RS)

This throw is also performed with the subject in the same sitting position (with hips flexed around 90 degrees and abducted at about 20 degrees). However, hand of the non-throwing arm is placed on the ground, limiting the range of motion for the upper body. Each subject performed two throws to the target.

Figure 1. Throw with non-throwing hand free to move (RP)

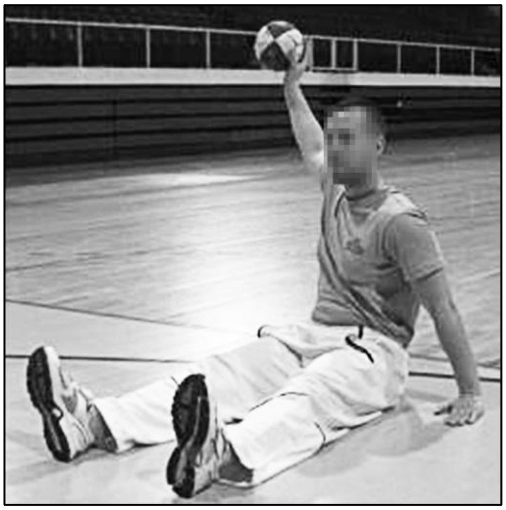

Figure 2. Throw with hand of the non-throwing arm on the ground (RS)

Grip strength

Hand grip strength on the dominant side was measured using a hand grip dynamometer (Takei Scientific Instruments Co., Ltd., Japan). During the test, shoulder joint was at anatomical position (9). Subjects were instructed to squeeze the dynamometer maximally, to hold the contraction for 5 s. with no ancillary body movements (8). Two trials were separated by a 45-s rest interval, and the higher score was registered for the statistical analysis.

Statistical Analysis

Descriptive statistics were defined as minimum, maximum, mean and standard deviation. Normality was tested with skewness and kurtosis, and the Levene test was used for homogeneity. Data was found to be normally distributed (-1.5, +1.5 for skewness and kurtosis respectively). Independent variables in the hierarchical linear regression that were added in the first step were: body fat, trunk muscle mass, BMI and handgrip, whereas dependent variables were throw with the hand of non-throwing arm on the floor (RP), throw with non-throwing arm free to move (RS). Hand length, hand breadth, sitting height, arm span index were added as independent variables in the 2nd step of the model. Alpha value of 0.05 was accepted as statistically significant and SPSS®18.0 program was used to conduct the statistical analysis.

RESULTS

The descriptive data for ball velocity, handgrip strength and anthropometric characteristics of the players are presented in table 2. *Hierarchical multiple regression analysis results for anthropometric characteristics, handgrip strength and* ball velocity for RS is shown in Table 3 whereas *hierarchical multiple regression analysis results with anthropometric characteristics, handgrip strength and* RP are shown in table 4.

Table 2. The descriptive data for ball velocity, handgrip strength and anthropometric characteristics of the players

Variables	Minimum	Maximum	Mean	Std. Deviation
Ball velocity in RP (km/h)	26.00	53.00	42.83	8.94
Ball velocity in RS (km/h)	22.00	58.00	44.75	10.82
Body fat (%)	16.50	33.60	24.56	5.71
Trunk muscle mass (kg)	12.20	32.10	21.25	6.44
BMI (kg/m²)	19.30	31.40	23.80	3.55
Handgrip strength (kg)	21.20	38.70	32.58	5.09
Hand length (cm)	6.60	9.20	8.40	0.89
Hand breadth (cm)	7.70	9.10	8.24	0.40
Sitting height (cm)	84.90	94.70	89.10	3.03
Arm span index (%)	0.97	1.04	1.00	0.02

RS: throw with the hand of non-throwing arm on the floor, RP: throw with non-throwing arm free to move, BMI: Body Mass Index

Table 3. Hierarchical multiple regression analysis results for explaining anthropometric characteristics, handgrip strength and ball velocity from throw with RP

	β	t	p	R	R^2	Adjusted R^2	F	p
Model 1								
Body fat (%)	0.231	0.464	0.657	0.785	0.616	0.397	2.808	0.111
Trunk muscle mass (kg)	0.831	2.643	0.033					
BMI (kg/m²)	-0.613	-1.207	0.266					
Handgrip (kg)	0.221	0.764	0.470					
Model 2								
Body fat (%)	0.123	0.132	0.903	0.791	0.626	-0.370	0.629	0.734
Trunk muscle mass (kg)	1.248	0.644	0.565					
BMI (kg/m²)	-0.721	-0.586	0.599					
Handgrip strength (kg)	0.495	0.452	0.682					
Hand length (cm)	-0.286	-0.235	0.830					
Hand breadth (cm)	-0.091	-0.143	0.895					
Sitting height (cm)	-0.255	-0.182	0.867					
Arm span index (%)	-0.044	-0.074	0.946					

BMI: Body Mass Index

Body fat percent, trunk muscle mass, BMI and hand grip strength which were included in the first step of the model did not predict the RP performance and found to be insignificant (p>0.05). However, there was a positive correlation between trunk muscle mass and ball velocity (r = 0.831; p<0.05). Hand length, hand width, sitting height and arm length which were included in the 2nd step of the model were also insignificant and did not predict RP performance (p>0.05). No relationship was found between the variables of the 2nd model and RP performance (p>0.05). Performance was also not predicted even when all of the variables combined from Model 1 and Model 2 (p>0.05).

Table 4. Hierarchical multiple regression analysis results for explaining anthropometric characteristics, handgrip strength and ball velocity with RS

	β	t	p	R	R^2	Adjusted R^2	F	p
Model 1								
Body fat (%)	0.029	0.051	0.961	0.719	0.517	0.242	1.876	0.220
Trunk muscle mass (kg)	0.635	1.801	0.115					
BMI (kg/m²)	-0.583	-1.024	0.340					
Handgrip strength (kg)	0.368	1.132	0.295					
Model 2								
Body fat (%)	-0.114	-0.112	0.918	0.747	0.557	-0.623	0.472	0.824
Trunk muscle mass (kg)	0.562	0.267	0.807					
BMI (kg/m²)	-0.260	-0.194	0.858					
Handgrip strength (kg)	0.480	0.402	0.715					
Hand length (cm)	0.138	0.104	0.924					
Hand breadth (cm)	-0.301	-0.432	0.695					
Sitting height (cm)	-0.024	-0.015	0.989					
Arm span index (%)	-0.154	-0.237	0.828					

BMI: Body Mass Index

Body fat percent, trunk muscle mass, BMI and hand grip strength which were included in the first step of the model did not predict ball velocity with RS and found to be insignificant (p>0.05). Furthermore, no relationship was found between RS performance and variables of Model 1 (p>0.05). Hand length, hand width, sitting height and arm length which were included in the 2nd step of the model were also insignificant and did not predict the ball velocity for RS (p>0.05). No relationship was found between the variables of 2nd model and RS performance (p>0.05) and performance was also not predicted even when all of the variables combined from Model 1 and Model 2 (p>0.05).

DISCUSSION

This study aimed to investigate the relationship between anthropometrics of female handball players such as body fat (%), trunk muscle mass (kg), BMI, handgrip strength, hand length, hand breadth, sitting height, and arm span index and the ball velocity. *Original contribution of body fat percentage, trunk muscle mass, BMI and handgrip strength included in the model in the first step was not significant within the model and the ball velocity (both for RP and RS) was failed to be predicted. Additionally, it was determined that hand length,* hand breadth, *sitting height and* arm span index *included in the model in the second step were not significant in the model as well and did not predict the ball velocity (as performance measure for both RP and RS). However, there was a positive relationship between trunk muscle mass and ball velocity with RP. According to the results of this study, all of our hypotheses were refuted.*

These results are contrary to some of the studies in the literature. For instance, Zapartidis et al., reported that ball throwing velocity of young male handball players which was measured from the penalty throw position was significantly correlated with body height, body mass, arm span and hand length but not BMI (24). Skoufas et al., (16), also found similar results with the study of Zapartidis et al., and reported that throwing velocity of novice handball players is correlated with body mass, lean body mass, arm span, arm span index, hand width and breadth (with the fingers abducted) (16).

Shalfawi et al., highlighted the importance of strength and power for both upper and lower extremities in order to achieve high throwing velocity (15). In this regard, van den Tillaar & Ettema further reported that ball velocity from a standing throw position was affected by fat free mass (FFM) and maximal isometric strength in well trained male and female handball players (18). In our study, strength level of the players was measured by using a hand dynamometer. According to Andrade et al., hand dynamometry is a simple and reliable test for evaluating male handball players' strength, whereas it has been shown to have high correlation with the isokinetic strength of shoulder rotator muscles in female players (1). Visnapuu & Jürimäe (21), also argued that a good grasp has a positive influence on the ball speed. The main finding of our study was that there is a positive relationship between trunk muscle mass and ball velocity for the RS position. Based on this, we concluded that the results of our study are partially similar with the study of Tillaar & Ettema (18).

However, it should also be noted that while increased FFM is correlated with greater strength and higher velocity for the ball with a throw (6,7,18), higher body fat percentage values show a negative correlation with throwing speed (11).

The difference between the findings in our study and those in the previous studies could be attributed to sex differences, age, anthropometric characteristics of the player, and playing experience (9,18,23,24). According to Foretić et al., throw with non-throwing arm free to move and non-throwing arm on the ground are valid and reliable positions to measure the ball velocity in sports such as handball, water polo, tennis, volleyball, basketball (4). In our study, we aimed to analyze the effects of various upper body anthropometric characteristics and handgrip strength on ball velocity with the throws done from either RP or RS in female handball players.

The rationale behind using standardized positions such as RS or RP was to minimize effects of anthropometrics and strength of other body parts on the ball velocity. When previous studies were examined, we noticed that majority of them used the penalty throw, 7-m standing throw and 9-m throw after three steps and a jump to measure ball velocity (13, 15, 18, 23, 24). Therefore, contradictory results between those and our study might be attributed to the differences in ball throwing technique of the subjects done from different positions.

It should also be noted that the most important limitation of the current study is the small sample size. A possible replication study with a larger sample size may lead to different results.

CONCLUSION

The results demonstrate that ball velocity in handball is independent from body fat (%), BMI, handgrip strength, hand length, hand breadth, sitting height and arm span index. Because there was a positive relationship found between trunk muscle mass and ball velocity from throwing with the hand of the non-throwing arm on the ground, we recommend to handball players and their coaches to consider designing resistance training programs that focus on improving trunk muscle mass to improve ball velocity for the over arm throws.

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