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Morphological Characteristics of Female Handball Players and Their Influence on Ball Release Velocity in Relation to Playing Position

Características Morfológicas de Jugadoras de Balonmano y su Influencia en la Velocidad de Lanzamiento del Balón en Relación con la Posición de Juego

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SUMMARY: A substantial body of kinesiology research highlights the importance of morphological characteristics in female handball players as a determinant of elite athletic performance. The primary objective of this study was to identify positional differences in morphological attributes among female handball players and to examine the predictive influence of these variables on ball-release velocity. The sample consisted of 45 professional female handball players (mean age 18.0 ± 2.7 years), stratified into three positional groups: backcourt players, wings, and pivots. The measurement protocol included four anthropometric indicators and four tests assessing ball-release velocity. Descriptive statistics were computed for all variables. To determine potential differences in morphological characteristics between subgroups, a multivariate analysis of variance (MANOVA) was conducted, followed by univariate ANOVA models to examine individual effects. A regression analysis was subsequently performed to evaluate the predictive capacity of morphological variables for ball-release velocity. Significant differences were observed in morphological profiles across positions, with body height, body mass, arm length, and arm span contributing most notably to the variance. Wings were found to be shorter and lighter compared to backs and pivots, whereas backcourt players exhibited superior values for arm span and hand length. Regression results revealed that hand length, wrist diameter, and forearm length significantly predicted ball-release velocity among pivots. The findings suggest that positional demands shape optimal morphological attributes in female handball players, and that select anthropometric parameters may exert an indirect influence on throwing performance through anatomical and biomechanical mechanisms. Future investigations should incorporate a broader set of predictors, including biomotor capacities and technical execution parameters, to enable a more comprehensive understanding of the determinants of ball-release velocity in elite female handball.

KEY WORDS: Morphological characteristics; Ball-release velocity; Handball; Female athletes.

INTRODUCTION

Morphological characteristics represent a fundamental prerequisite for performance success in handball, owing to their well-established association with motor abilities and technical–tactical proficiency (Bala & Popmihajlov, 1988). Playing positions are defined by organizational-kinesthetic structures that reflect the rules and physical demands of the sport, thereby shaping the anthropological profile required for each role (Foretic, 2012). For instance, pivots are typically the most physically robust and powerful players (Zapartidis *et al*., 2009a; Vila *et al*., 2011), attributes that facilitate stability and effectiveness in continuous physical contact situations (Rogulj, 2003). Conversely, wings tend to be the lightest and fastest attackers (Zapartidis *et al*., 2009), while backcourt players frequently possess advantageous height and reach, enabling powerful long-range shooting and effective defensive capability (Cavala, 2012).

Throwing velocity is recognized as a decisive performance indicator distinguishing elite from average players (Zapartidis *et al*., 2009b). As a core technical skill, throwing constitutes the foundation of offensive play, where both maximal speed and accuracy are integral to success (Van den Tillaar & Ettema, 2004). The handball throw may be conceptualized within an open kinetic-chain model, beginning with ground reaction forces and transferring sequentially through the hips and trunk to the hand (Karisik *et al*., 2016). Prior research emphasizes the relevance of morphological characteristics to throwing efficiency; for example, larger hand size enhances control and precision (Ferragut *et al*.,

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2018), while height, body mass, and upper-limb dimensions are strong predictors of throwing velocity (Eliasz & Wit, 1996; Srhoj *et al*., 2002; Visnapuu & Jurimae, 2007).

The demands of specific playing roles suggest positional variability in morphological determinants of throwing performance, with dimensions such as hand size, limb length, and wrist breadth emerging as critical factors for successful execution (Ferragut *et al*., 2018). This is particularly relevant for pivots, who rely on superior upper-body strength, developed musculature, and the ability to shoot under physical pressure and imbalance (Bojic-Cacic, 2011). Throwing velocity is influenced not only by muscular strength but also by body dimensions, coordination, and technical proficiency. Previous findings indicate that longer longitudinal body dimensions facilitate greater ball velocity due to increased angular and resultant linear velocity (Fleisig *et al*., 1999).

Given these considerations, the aim of the present study was to determine positional differences in morphological characteristics among female handball players and to evaluate their predictive contribution to ball-release velocity. By attaining this objective, the study seeks to enrich theoretical knowledge relevant to training methodology and to enhance understanding of the positional specificity of morphological parameters and their relationship with throwing efficiency in women's handball.

MATERIAL AND METHOD

This study employed a cross-sectional design and consisted of a single measurement session aimed at assessing selected morphological characteristics and ball-throwing velocity in female handball players. The research sample comprised 45 athletes competing in the Montenegrin First League, with a mean age of 18.0 ± 2.7 years. Participants were stratified into three positional subgroups: backs (n = 20), wings (n = 15), and pivots (n = 10).

Morphological assessment was conducted through measurement, calculation, and analysis of the following anthropometric variables: body height, body mass, arm length, hand length, wrist diameter, arm span, upper-arm length, and forearm length. All anthropometric procedures were performed in accordance with the standardized protocols of the International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones *et al*., 2006).

Ball-throwing velocity was evaluated using four tests: throw velocity from 7 m, throw velocity from 9 m, throw velocity from 9 m following a three-step dribble, and throw velocity from 9 m following a three-step pass. Ball velocity was recorded using a Doppler radar system (StalkerPro Inc., Plano, TX, USA), operating at a frequency of 100 Hz with a measurement precision of 0.045 m/s. The radar device was positioned directly behind the goal, aligned with the ball-flight trajectory to minimize angular measurement error. This methodology has demonstrated high reliability, with ICC = 0.96 and CV = 2.4.

All raw results were coded and subsequently processed using SPSS version 20.0 (IBM Corp., Armonk, NY, USA). Descriptive statistical parameters, including minimum and maximum values and arithmetic means, were calculated for all morphological and throwing-performance variables. To examine potential differences in morphological characteristics between positional subgroups, multivariate analysis of variance (MANOVA) was applied. This was followed by univariate analysis of variance (ANOVA) to determine between-group differences at the level of individual variables. The predictive influence of morphological characteristics on ball-throwing velocity was assessed using linear regression analysis, with the following indicators calculated: B (regression coefficient), St. E (standard error), Beta (standardized coefficient), t (t-value), and Sig. (significance level). Statistical significance was set at $p \leq 0.05$.

RESULTS

Table I presents the basic descriptive statistical parameters of the morphological characteristics and ball throwing velocity.

By testing the significance of differences in morphological variables and variables related to ball release velocity between participant subsamples according to playing position, a statistically significant difference was identified, as the Wilks' Lambda value was 0.237, which, with an F approximation of 2.72, indicates significance at the $P<0.05$ level (Table II).

To determine the specific variables in which these differences occur, univariate analyses of variance (ANOVA) were calculated for each morphological variable (Table III).

The results presented in Table III indicate significant differences in body height, body mass, arm length, and arm span. Wing players were generally shorter and lighter, backcourt players were the tallest, and pivot players were the heaviest. Significant differences were also observed across all four ball throwing velocity variables. Backcourt players consistently achieved the highest throwing velocities, followed by pivot players, while wing players recorded the lowest values.

Table I. Central tendency and dispersion parameters of morphological characteristics and ball throwing velocity.

Subsample	**Backs**			**Wings**			**Pivots**		
Variables	**Min**	**Max**	**M**	**Min**	**Max**	**M**	**Min**	**Max**	**M**
Body height	165.5	183.0	173.6	160.7	172.0	166.9	64.40	85.75	172.1
Body weight	59.90	94.00	70.13	48.10	72.70	60.53	74.1	86.1	74.29
Arm length	70.0	87.4	78.39	60.0	81.1	74.18	73.0	85.0	80.31
Fist length	14.4	20.4	16.85	14.2	17.9	15.82	15.0	19.3	16.70
Wrist diameter	3.08	5.90	4.10	3.10	3.93	3.93	3.00	5.40	3.81
Arm span	160.0	187.0	175.3	156.0	177.0	167.9	165.0	186.0	174.3
Upper arm length	20.9	33.8	29.64	26.0	33.0	29.18	27.5	33.1	30.50
Forearm length	20.4	29.0	24.14	19.9	28.7	23.29	20.1	30.3	23.59
7 meter throw velocity	58	84	69.85	56	70	64.40	61	75	67.80
9 meter throw velocity	62	88	72.80	58	73	65.53	58	77	67.70
9 meter three-step dribble throw velocity	64	90	74.45	56	71	65.87	60	76	69.50
9 meter three/step pass throw velocity	64	93	75.65	60	72	67.13	63	79	72.70

Table II. Multivariate analysis of variance (MANOVA).

Wilks' Lambda test	**F value**	**p level of significance**
.237	2.72	.001

Table III. ANOVA of morphological characteristics and ball throwing velocity.

Variables	**F**	**p**
Body height	11.14	**0.00**
Body weight	10.38	**0.00**
Arm length	5.84	**0.00**
Fist length	2.58	0.08
Wrist diameter	0.43	0.65
Arm span	6.2	**0.00**
Upper arm length	0.78	0.45
Forearm length	0.49	0.60
7 meter throw velocity	3.44	**0.04**
9 meter throw velocity	6.59	**0.00**
9 meter three-step dribble throw velocity	11.33	**0.00**
9 meter three/step pass throw velocity	10.47	**0.00**

The following results (Tables IV to VI) present the regression analysis of morphological characteristics on ball throwing velocity according to specific playing positions.

No morphological variable was a significant predictor of ball throwing velocity in backcourt players.

No morphological variable was a significant predictor of ball throwing velocity in wing players.

The morphological measures of hand length, wrist diameter, and forearm length demonstrated statistical significance in predicting 9-meter throw velocity with a three-step dribble.

Table IV. Regression analysis of morphological variables on ball throwing velocity in backcourt players.

	9-meter throw velocity					**9-meter throw velocity**				
	B	St. E.	Beta	t	Sig.	B	St. E.	Beta	t	Sig.
Body height	-.446	.673	.268	-.662	.52	.176	.676	.109	.261	.799
Body weight	.139	.283	.156	.492	.63	.030	.284	.035	.107	.916
Arm length	.517	.603	.337	.857	.41	.408	.606	.275	.674	.514
Hand length	2.391	1.792	.500	1.334	.20	1.937	1.799	.418	1.077	.305
Wrist diameter	.347	3.384	.043	.103	.92	.152	3.399	.020	.045	.965
Arm span	.072	.399	.067	.180	.86	.010	.401	.009	.024	.981
Upper arm length	-.498	.678	.197	-.734	.47	-.817	.681	-.333	-1.20	.255
Forearm length	.522	.898	.173	.581	.57	-.457	.902	-.156	-.507	.622
	9-meter three-step dribble throw velocity					**9-meter three-step pass throw velocity not dribble**				
Body height	B	St. E.	Beta	t	Sig.	B	St. E.	Beta	t	Sig.
Body weight	-.262	.634	.186	-.414	.68	-.260	.613	-.186	-.425	.679
Arm length	.163	.266	.217	.614	.55	.326	.257	.436	1.269	.231
Hand length	-.606	.568	.467	-1.06	.30	.217	.549	.168	.396	.700
Wrist diameter	.270	1.686	.067	.160	.87	1.813	1.630	.452	1.113	.290
Arm span	-.824	3.185	.122	-.259	.80	-.107	3.078	-.016	-.035	.973
Upper arm length	.643	.376	.708	1.709	.11	.190	.363	.210	.522	.612
Forearm length	-.777	.638	.363	-1.21	.24	-.162	.617	-.076	-.263	.798
Body height	-.071	.845	.028	-.084	.93	-.877	.817	-.346	-1.07	.306

Legend: B – Unstandardized regression coefficient, St.E. – Standard error of the coefficient, Beta – Standardized regression coefficient, t – t-value (t-statistic), Sig. – Significance level (p-value)

Table V. Regression analysis of morphological variables on ball throwing velocity in wing players.

	9-meter throw velocity					**9-meter throw velocity**				
	B	St. E.	Beta	t	Sig.	B	St. E.	Beta	t	Sig.
Body height	.114	1.974	.076	.058	.95	-.451	1.343	-.325	-.336	.748
Body weight	.163	.345	.250	.473	.65	.135	.235	.224	.575	.586
Arm length	-.087	.535	-.097	-.162	.87	.417	.364	.506	1.146	.295
Hand length	1.523	8.048	-.342	-.189	.85	-.725	5.477	-.176	-.132	.899
Wrist diameter	2.813	12.554	.450	.224	.83	-.916	8.544	-.159	-.107	.918
Arm span	.033	.523	.040	.063	.95	-.030	.356	-.040	-.085	.935
Upper arm length	-.004	.985	-.002	-.004	.99	.900	.671	.503	1.343	.228
Forearm length	.492	1.222	.266	.402	.70	1.148	.832	.672	1.381	.217
	9-meter three-step dribble throw velocity					**9-meter three-step pass throw velocity**				
	B	St. E.	Beta	t	Sig.	B	St. E.	Beta	t	Sig.
Body height	.577	1.685	.431	.342	.74	-.901	1.822	-.657	-.495	.638
Body weight	-.090	.295	-.154	-.305	.77	-.002	.319	-.004	-.007	.995
Arm length	-.131	.457	-.164	-.286	.78	.047	.494	.057	.094	.928
Hand length	5.011	6.870	1.261	-.729	.49	2.082	7.429	.512	.280	.789
Wrist diameter	8.340	10.717	1.495	.778	.46	-3.34	11.588	-.585	-.288	.783
Arm span	.022	.446	.031	.050	.96	.310	.482	.419	.644	.544
Upper arm length	-.413	.841	-.239	-.491	.64	-.693	.910	-.392	-.761	.475
Forearm length	.307	1.043	.186	.294	.77	.582	1.128	.345	.516	.624

Table VI. Regression analysis of morphological variables on ball throwing velocity in pivot players.

	9-meter throw velocity					**9-meter throw velocity**				
	B	St. E.	Beta	t	Sig.	B	St. E.	Beta	t	Sig.
Body height	-.550	.471	-.596	-1.16	.45	-1.26	1.021	-1.155	-1.23	.432
Body weight	.235	.160	.402	1.471	.38	.298	.347	.429	.858	.548
Arm length	.401	.813	.274	.493	.70	-1.33	1.763	-.769	-.756	.588
Hand length	-5.58	2.639	1.608	-2.11	.28	-.711	5.726	-.172	-.124	.921
Wrist diameter	10.74	4.096	1.828	2.623	.23	3.05	8.888	.438	.344	.789
Arm span	1.477	.910	1.883	1.623	.35	2.67	1.975	2.869	1.352	.405
Upper arm length	-3.90	1.702	1.597	-2.29	.26	-5.00	3.692	-1.725	-1.35	.405
Forearm length	2.576	.769	1.457	3.351	.18	2.55	1.668	1.216	1.530	.369
	9-meter three-step dribble throw velocity					**9-meter three-step pass throw velocity**				
	B	St. E.	Beta	t	Sig.	B	St. E.	Beta	t	Sig.
Body height	-1.18	.103	-1.315	-11.5	.05	-1.02	.822	-1.004	-1.24	.430
Body weight	.309	.035	.539	8.800	.07	.330	.280	.508	1.179	.448
Arm length	.646	.178	.452	3.627	.17	1.13	1.420	.704	.802	.570
Hand length	-8.30	.579	2.442	-14.3	**.04***	-.713	4.612	-.185	-.155	.902
Wrist diameter	14.58	.899	2.535	16.22	**.03***	5.06	7.159	.777	.707	.608
Arm span	1.958	.200	2.548	9.803	.06	-.103	1.591	-.118	-.065	.959
Upper arm length	-2.84	.373	1.189	-7.62	.08	.799	2.974	.295	.269	.833
Forearm length	2.731	.169	1.577	16.19	**.03***	1.769	1.344	.903	1.317	.413

DISCUSSION

The observed differences in the morphological characteristics of players across distinct playing positions are consistent with previous research indicating that female handball athletes diverge in body dimensions and proportions depending on their tactical role within the team (Srhoj *et al*., 2002; Sibila *et al*., 2004; Cavala, 2012; Zapardiel Cortés *et al*., 2017). Furthermore, notable disparities were identified across all ball-throwing speed tests, with backcourt players demonstrating superior performance, followed sequentially by pivots and wings. This hierarchy reflects the biomechanical and functional demands inherent to each position: backcourt players tend to be taller with greater arm span, enabling them to shoot over defensive lines and generate powerful long-range throws (Zapartidis *et al*., 2009a,b; Wagner *et al*., 2010); wings are generally lighter and more explosive, providing an advantage in fast breaks and jump shots from acute angles (Bojic-Cacic, 2011; Michalsik *et al*., 2015); while pivots typically exhibit more robust somatotypes, offering superior

force production and stability in high-contact play near the six-meter line (Srhoj *et al*., 2002; Gorostiaga *et al*., 2005). Similar findings have been reported by Goranovic *et al*. (2023), who confirmed that morphological variables vary significantly across positions and partially influence shooting biomechanics. These patterns underscore the positional specificity of handball, wherein stature, upper-body strength, and arm span are pivotal determinants of throwing velocity (Wagner *et al*., 2010; Rivilla-García *et al*., 2011). Zapartidis *et al*. (2011), further emphasize that among youth female handball players, backcourt athletes achieve the highest throwing speeds, reinforcing the notion that positional demands substantially shape motor and biomechanical performance profiles. Ferragut *et al*. (2018), additionally note that under defensive pressure, technical stability and execution timing become decisive, highlighting the advantage of experienced backs and pivots.

The analysis of predictors of throwing velocity revealed that most morphological factors lacked statistical significance, suggesting that morphology alone does not determine performance outcomes. Nonetheless, hand length, wrist diameter, and forearm length emerged as significant predictors of throwing velocity from nine meters during a three-step dribble in pivots. This finding aligns with established biomechanical principles of throwing mechanics: in situations requiring reduced elevation and absent the need to shoot above defenders, force production relies more heavily on distal segments — namely the forearm, wrist, and hand. Greater forearm length and larger hand size extend the lever arm and enhance torque generation during terminal throwing phases, thereby increasing ball velocity (Jöris *et al*., 1985; Karisik *et al*., 2016). Moreover, the three-step dribble facilitates efficient kinetic energy transfer from the lower limbs and trunk through the kinetic chain to the upper limb (Winter, 2009; Wagner *et al*., 2010), a mechanism that may be particularly advantageous for pivots given their anthropometric structure and position-specific technical requirements. Prior work by van den Tillaar & Ettema (2004) and Visnapuu & Jürimäe (2007) similarly supports the influence of hand and forearm morphology on throwing speed, with comparable kinetic patterns documented in baseball (Takahashi *et al*., 2001). Although morphological traits constitute a biomechanical foundation for force generation, a substantial body of literature demonstrates that technical proficiency — including coordinated sequencing and efficient kinetic chain utilization — is the primary determinant of throwing speed (Wagner *et al*., 2010; Ferragut *et al*., 2018). While morphology may exert statistically significant effects, success in handball throwing is predominantly governed by technical skill and inter-segmental coordination (Goranovic *et al*., 2023). Accordingly, morphological parameters represent an important yet non-decisive factor, with technical-tactical mastery and motor abilities remaining paramount for elite throwing performance (Zapartidis *et al*., 2009a.b; Vila *et al*., 2012). In female athletes, such abilities frequently compensate for relatively lower absolute strength, manifesting in superior precision, timing, and efficiency of execution.

Taken together with findings from comparable studies, these results provide practical implications for optimizing training interventions in female handball. Coaches and performance staff may employ morphological information to guide player selection and position assignment — favoring taller athletes with greater upper-body strength and reach for backcourt roles, while selecting smaller, more explosive profiles for wing positions. Pivots, due to their more robust build, require targeted development of trunk stability and contact-strength capacities to maximize scoring efficiency from close range. Given that morphology alone does not guarantee high throwing velocity, training programs should prioritize enhancing biomechanical efficiency, particularly through optimizing kinetic chain transmission from the lower body through the trunk to the upper limb. Advanced biomechanical assessment and video-based performance diagnostics can aid in identifying technical deficiencies, refining motor execution, and mitigating injury risk. An interdisciplinary approach, integrating coaching expertise with contributions from kinesiology, biomechanics, and sports science, facilitates comprehensive training design that aligns morphological factors with motor and technical-tactical development, thus supporting long-term performance enhancement and injury prevention. Although the present findings provide valuable insight into morphological determinants of throwing performance in female handball, limitations include the modest sample size and absence of in-game situational assessment. Future research should incorporate larger cohorts and detailed biomechanical and kinematic analyses under competitive conditions to further elucidate the interaction between morphology and throwing technique.

MARTINOVIC, S.; BANJEVIC, B.; PETKOVIC, J. & NOKIC, A. Características morfológicas de jugadoras de balonmano y su influencia en la velocidad de lanzamiento del balón en relación con la posición de juego. *Int. J. Morphol., 44(2)*:431-436, 2026.

RESUMEN: Numerosas investigaciones en kinesiología destacan la importancia de las características morfológicas en jugadoras de balonmano como determinante del rendimiento deportivo de élite. El objetivo principal de este estudio fue identificar las diferencias posicionales en los atributos morfológicos entre jugadoras de balonmano y examinar la influencia predictiva de estas variables en la velocidad de lanzamiento del balón. La muestra estuvo compuesta por 45 jugadoras profesionales de balonmano (edad media: 18,0 ± 2,7 años), estratificadas en tres grupos posicionales: defensas, extremos y pivotes. El protocolo de medición incluyó cuatro indicadores antropométricos y cuatro pruebas para evaluar la velocidad de lanzamiento del balón. Se calcularon estadísticas descriptivas para todas las variables. Para determinar las posibles

diferencias en las características morfológicas entre subgrupos, se realizó un análisis multivariado de varianza (MANOVA), seguido de modelos ANOVA univariados para examinar los efectos individuales. Posteriormente, se llevó a cabo un análisis de regresión para evaluar la capacidad predictiva de las variables morfológicas sobre la velocidad de lanzamiento del balón. Se observaron diferencias significativas en los perfiles morfológicos entre las distintas posiciones, siendo la altura, la masa corporal, la longitud del brazo y la envergadura los factores que más contribuyeron a la varianza. Se encontró que las jugadoras de banda eran más bajas y ligeras que las de defensa y pivote, mientras que las jugadoras de defensa presentaban valores superiores de envergadura y longitud de la mano. Los resultados de la regresión revelaron que la longitud de la mano, el diámetro de la muñeca y la longitud del antebrazo predijeron significativamente la velocidad de lanzamiento del balón entre las pivotes. Los hallazgos sugieren que las exigencias de cada posición determinan los atributos morfológicos óptimos en las jugadoras de balonmano, y que ciertos parámetros antropométricos pueden ejercer una influencia indirecta en el rendimiento del lanzamiento a través de mecanismos anatómicos y biomecánicos. Las futuras investigaciones deberían incorporar un conjunto más amplio de predictores, incluyendo capacidades biomotoras y parámetros de ejecución técnica, para lograr una comprensión más completa de los determinantes de la velocidad de lanzamiento del balón en el balonmano femenino de élite.

PALABRAS CLAVE: Características morfológicas; Velocidad de lanzamiento del balón; Balonmano; Deportistas femeninas.

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