

Analysis of the relationship between upper body speed capacity and lower body strength of elite handball players specialized in winger position

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim The physical demands of the winger position in elite handball require a unique combination of upper body speed and lower body strength. Therefore, identifying the optimal relationship between these two physical characteristics could improve performance for players in this role. This study aims to analyze the relationship between upper body speed capacity and lower body strength in elite handball players specializing in the winger position.

Material and Methods The study included 16 elite handball players specializing in the winger position from various teams in the National Handball League (Liga Zimbrilor). Four of these players were members of the Dinamo Bucharest team. Tests for evaluating the explosive strength of the lower limbs included the Squat Jump (SJ), Counter Movement Jump (CMJ), Counter Movement Jump with Free Arms (CMJb), and the maximum strength test (1RM) in squats. Specific technical training tests included triangular movement, a 30-meter sprint, and long-distance handball throws, focusing on speed and execution technique. Data analysis was conducted using KyPlot 6.0 software. Statistical indicators included median, standard deviation, coefficient of variation, and non-parametric Spearman correlation tests. Statistical significance was set at $p < 0.05$.

Results The results show no statistically significant differences in lower limb strength between high-performance handball players (HHP) and those specialized in the winger position (PSW) across various jump and squat tests ($p > 0.05$). The Countermovement Jump (CMJ) test approached statistical significance ($p = 0.084$), while the CMJ with free arms (CMJb) and squat strength test did not show significant differences ($p = 0.231$ and $p = 0.789$, respectively). In the specific fitness tests, no significant differences were observed in the Triangle Movement test ($p = 0.826$), the 30-meter sprint ($p = 0.404$), or the handball throw test ($p = 0.147$). Correlation analysis indicated that squats and CMJb had positive correlations with improved performance in speed and distance tests, while CMJ showed a negative correlation with technical performance in agility tests.

Conclusions The findings suggest that lower limb strength and technical fitness are similar between elite handball players, regardless of specialization. This supports a unified training approach across player roles. However, targeted exercises like squats and CMJb may enhance specific performance aspects. These exercises improve dynamic strength and stability, which can benefit wingers' technical execution and speed.

Keywords: elite athletes, speed, explosive strength, correlation analysis

Introduction

Elite handball performance relies on a combination of physical, technical, and tactical factors. Players in the winger position face unique challenges due to their specific role in the dynamics of the game. While upper body speed capacity and lower body strength are critical for wingers, the optimal balance between these attributes remains

unclear. Wingers must perform rapid actions, such as passing and shooting, while also requiring explosive strength for jumps and quick direction changes. This gap in understanding the relationship between these physical attributes creates a need for targeted research to optimize training and improve performance in this position.

In this context, the winger position in handball requires a combination of speed, agility, and strength. It is crucial for players to accelerate quickly and execute technical actions, such as shots on goal. These actions are significantly influenced

by the strength and speed of the upper body muscles, as well as by plyometric and resistance training. This type of training enhances reaction speed and the efficiency of dynamic movements [1, 2]. Given the physical demands of the winger role, understanding how different training approaches impact performance is essential.

Lower body strength enables wingers to perform effective jumps and change direction rapidly. These aspects can be developed through targeted plyometric exercises and strength training. The ability to transfer lower body strength to upper body actions, like jumping and shooting, is critical for on-court performance. Integrated training that combines these elements leads to improved efficiency and muscular coordination during game situations [3, 4, 5, 6]. These findings highlight the necessity of developing both lower body strength and its integration with upper body actions to maximize performance in handball wingers.

Lower body strength not only provides stability but also facilitates the transfer of kinetic energy to the upper body. This transfer helps achieve more powerful and precise executions. In handball, upper body speed and lower body strength work together to enhance performance in complex actions. Developing both capacities is essential for players specializing in the winger position. Lower body strength enables players to gain favorable positions through jumps and accelerations. Upper body speed is critical for converting these physical advantages into efficient technical actions, such as shooting on goal [7, 8]. Together, these elements underscore the need for balanced training programs that address both lower body strength and upper body speed to ensure optimal performance in game situations.

Other research highlights the importance of specific training methods in optimizing performance for elite handball players, emphasizing the role of game-based training and targeted recovery strategies [9, 10, 11]. In addition, studies have demonstrated a close relationship between upper and lower limb strength, power, and throwing speed, underscoring the value of resistance training for improving physical performance and accuracy [3, 12, 13, 14]. In this context, the physical and physiological demands of elite handball require advanced muscle strength and adaptation to high-intensity efforts, which are crucial for enhancing overall performance [5, 15, 16, 17]. Furthermore, variations in training needs based on playing position, such as wingers, suggest that tailored training approaches are essential for addressing the distinct movement profiles and physical capacities of different roles [14, 15]. These studies demonstrate the need for a targeted approach in training programs, taking into account the specific physical demands and requirements of different playing positions to optimize performance in elite handball.

Thus, the performance of handball wingers is determined by a complex interaction between upper body speed and lower body strength, which are crucial for success in executing dynamic movements and technical actions. Despite the recognized importance of these physical attributes, finding the optimal balance between them still requires exploring new, more sophisticated approaches.

This study aims to analyze the relationship between upper body speed capacity and lower body strength in elite handball players specializing in the winger position.

Materials and Methods

Participants

The study involved performance handball players specialized in the winger position (n=16) from several teams participating in the National Handball League (*Liga Zimbrilor*), Romania, out of which (n=4) are members of the *Dinamo Club Bucharest* team.

The consent of the subjects was required and signed before starting the research, according to the Declaration of Helsinki. It was approved by the Ethics Committee of the Doctoral School of Physical Education and Sports Science, the National University of Science and Technology *Politehnica Bucharest*, (ID: 17/24.07.2024), University Center Pitești.

Research Design

In the 2021/2022 competitive season, the senior men's handball team, *Dinamo Bucharest*, participated in the group stage of the Champions League. They won all the competitions they entered at national level (Romanian Cup, National Championship, Romanian Supercup). Most of the players specialized in winger position from the experimental group are or have been members of the national teams.

To conduct the fundamental research, we developed a strength training program together with the coaches and physical trainer of the *Dinamo Bucharest* handball team. The program is based on the periods and stages of the competitive system. It takes into account the participation of the team and players in domestic and international inter-club competitions. The involvement of the players in the national teams is also taken into consideration.

The action systems for developing strength capacity were applied during individualized training sessions. The training was based on playing positions, relative to the one-repetition maximum (1RM) of each athlete of the experimental group.

The strength development training sessions took place in the power gym of the club and on the playing court. The training was carried out according to the competitive system planning and included 2-3 specialized sessions. Also, training sessions of

shorter duration and lower intensity, conducted in the form of circuits, were carried out before official matches.

Tests to assess lower limbs strength:

Squat Jump (SJ) Test: starting from a semi-squat position with hands on hips, the participant performs a jump as high as possible, ensuring that the knees are fully extended during the flight. The landing is done on two feet, without any subsequent movement.

Counter Movement Jump (CMJ) Test: from a standing position with feet slightly apart and hands on hips, the participants flex their legs in a quick, continuous motion until reaching a semi-squat position, after which they perform a vertical jump. While in the air, the knees must be extended.

Counter Movement Jump Free Arms (CMJb) Test: from a standing position with arms free and feet slightly apart, the participants flex their legs in a quick, continuous motion until reaching a semi-squat position, after which they perform a vertical jump. While in the air, the knees must be extended.

Maximum Strength Test (1RM) - Squats: representing the maximum repetition that can be performed, the 1RM test (one-repetition maximum) has a high degree of reliability. It establishes the maximum strength level of a muscle or muscle chains. This test determines a more precise, individualized and differentiated periodization of the training process aimed at maximizing athletic performance. From a standing position with feet shoulder-width apart and toes slightly turned outward, the athletes keep a barbell on the back. Maintaining a straight back, they flex their legs so that the hips reach the level of the knees or even lower. Afterwards they return to the initial position.

Specific tests for technical training:

Test 1: Triangle Movement (seconds). This test

involves athletes moving between three cones arranged in the shape of an isosceles triangle, with a base and height of 3 meters. Athletes start from the left cone of the base and move in a defensive position with lateral step toward the right cone, then proceed to the apex of the triangle. After reaching the apex, they return to the starting point, following the same trajectory. The test consists of completing two full cycles at maximum speed, with athletes facing outward between the apex and the base of the triangle.

Test 2: 30-Meter Sprint (seconds). Two cones are placed 30 meters apart. From one of the cones, the athletes start a sprint until they pass the other cone, after which they slow down. The start is free and the sprint begins from a stationary standing position.

Test 3: Handball Throw for Distance (meters). After a run-up of three steps, the athlete executes a handball throw for distance from behind a marked line on the ground. Each athlete chooses the throwing technique and the sequence of steps for the run-up.

Statistical Analysis

The statistical indicators were calculated using the KyPlot 6.0 (©1997-2020, KyensLab Inc) program, in terms of Median, Standard Deviation (SD), Coefficient of Variation (CV%), Confidence Level of Mean (0.95) and Confidence Limit of Mean. parametric t-Test (Assuming Equal Variances) Unpaired Comparison for Means; The nonparametric Spearman's correlation coefficient was applied to evaluate the relationship between technical training and motor skills parameters in the elite handball goalkeepers. Statistical significance was set at $p < 0.05$.

Results

The results in Table 1 compare lower limbs strength between high-performance handball

Table 1. Results of the lower body strength in elite handball players specialized in the position of winger

Variables		Mean ± SD	CV (%)	Confidence Level of Mean (0.95)	Confidence Limit of Mean		t	P-value
					Lower	Upper		
Squat jumps	HHPH	34.41 ±3.61	10.48	1.92	32.49	36.33	1.31	0.205
	PSW	31.95 ±1.52	4.75	2.41	29.53	34.36		
CMJ	HHPH	40.3 ±4.88	12.10	2.59	37.70	42.89	1.83	0.084
	PSW	35.67 ±1.89	5.31	3.01	32.66	38.69		
CMJb	HHPH	43.01 ±3.81	8.87	2.03	40.97	45.04	1.24	0.231
	PSW	40.55 ±1.57	3.87	2.49	38.06	43.04		
Squats	HHPH	144.19 ±12.15	8.43	6.47	137.71	150.66	-0.27	0.789
	PSW	146.00 ±10.86	7.44	17.28	128.71	163.28		

Values are expressed as Mean ± Standard Deviations (SD), CV – coefficient of variation; parametric t-Test (Assuming Equal Variances) Unpaired Comparison for Means; HHPH(n=16) – high-performance handball players; PSW(n=4) - players specialized in the position of winger; df = 18; $t(0.05) = 2.101$

players (HHP) and those specialized in the winger position (PSW) through various jump and squat tests. The main interpretations are as follows: in the Squat Jump test, HHP achieved a difference of 2.46 cm greater than PSW ($p > 0.05$). In the CMJ (Countermovement Jump) test, HHP had a difference of 4.63 cm, close to statistical significance ($p = 0.084$). For the CMJb (jump with free arms), the difference is 2.46 cm but statistically insignificant ($p = 0.231$). In the squat test, PSW achieved a difference of 1.81 kg more, but without statistical significance ($p = 0.789$).

Table 2 presents the results of specific fitness tests for high-performance handball players (HHP) and those specialized in the winger position (PSW). The analysis of the results is based on the mean, standard deviation (SD), coefficient of variation (CV), confidence limits and p-values obtained from the t-test.

In Test 1 (Triangle Movement, seconds), HHP and PSW achieved very close average values, with a difference of only 0.08 seconds. The lower coefficient of variation for HHP indicates reduced variability. The difference between groups is not statistically significant ($p = 0.826$), suggesting similar performances between the two groups.

In Test 2 (30 m Sprint, seconds), HHP had a slightly better performance, with a difference of 0.07 seconds compared to PSW. However, the much lower coefficient of variation for PSW highlights greater consistency in the performances of this group. The difference between groups is not statistically significant ($p = 0.404$), showing that the results are similar.

In Test 3 (Handball Throwing for Distance, meters), PSW got a higher average value by 2.47 meters compared to HHP, but the difference is not statistically significant ($p = 0.147$). The higher coefficient of variation for PSW indicates greater variability in performances for this test.

In conclusion, the differences between high-performance handball players (HHP) and those specialized in the winger position (PSW) in the technical fitness tests are not statistically significant in any of the three tests. In Test 1 and Test 2, HHP showed slightly better performance and lower variability, while in Test 3, PSW had a higher average score, but without statistical significance.

Figure 1 demonstrates how strength levels in the lower limbs influence performance in various motor activities. Figure 2 presents the relationship between lower limb strength indices and specific motor tests in handball players specialized in the winger position. Test 1 highlights significant negative correlations for all strength exercises, with the most pronounced ones for CMJ (-0.927) and CMJb (-0.792). These values indicate that better performance in these strength exercises is associated with poorer results in Test 1. The values highlight a strong inverse relationship between explosive strength and technical performance in this test. Test 2 shows strongly positive correlations, especially for squats (0.870) and CMJb (0.378), while CMJ displays a moderate positive correlation (0.258). These results demonstrate that an increase in performance in these strength exercises is associated with improved performance in Test 2. Test 3 has very strong positive correlations, particularly for CMJb (0.923) and squats (0.895). This underlines a close relationship between the strength developed through these exercises and improved performance in Test 3.

In conclusion, squats and CMJb exhibit a more consistent positive correlation with performances in Tests 2 and 3. On the other hand, the CMJ and squat jumps show more pronounced negative correlations, especially in Test 1. These observations suggest that the type and nature of strength exercises can differentially influence the motor performances of handball players in the winger position.

Table 2. Results of specific fitness tests for technical training in elite handball players and the ones specialized in the position of winger

Variables	Mean ± SD	CV (%)	Confidence Level of Mean (0.95)	Confidence Limit of Mean		t	Pvalue	
				Lower	Upper			
Test 1	HHP	11.69 0.56	4.83	0.30	11.39	1.47	0.22	0.826
	PSW	11.61 0.85	7.35	1.36	10.25	12.97		
Test 2	HHP	4.51 0.16	3.65	0.09	4.42	4.60	0.85	0.404
	PSW	4.44 0.05	1.09	0.07	4.36	4.52		
Test 3	HHP	49.03 2.76	5.63	1.47	47.56	50.50	-1.52	0.147
	PSW	51.5 3.58	6.96	5.70	45.79	57.20		

Values are expressed as Mean ± Standard Deviations (SD), CV – coefficient of variation; parametric t-Test (Assuming Equal Variances) Unpaired Comparison for Means; HHP (n=16) – high-performance handball players; PSW(n=4) - players specialized in the position of winger; df = 18; t (0.05) = 2.101

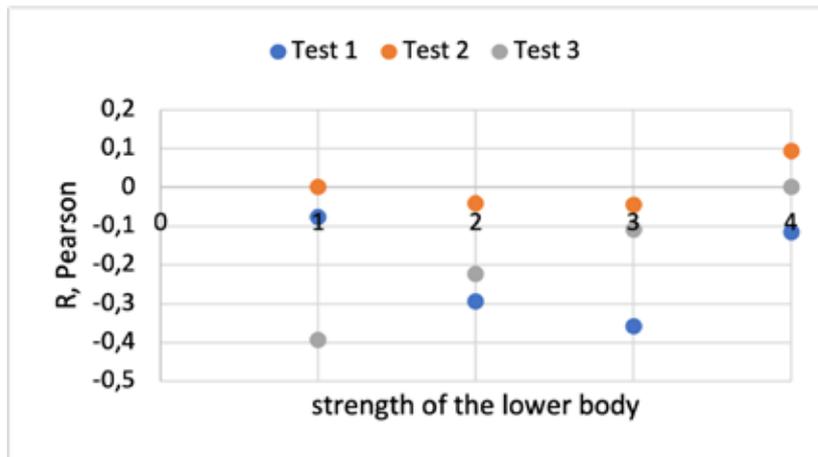


Figure 1. Relationship of lower limbs strength indices and specific motor tests in elite handball players

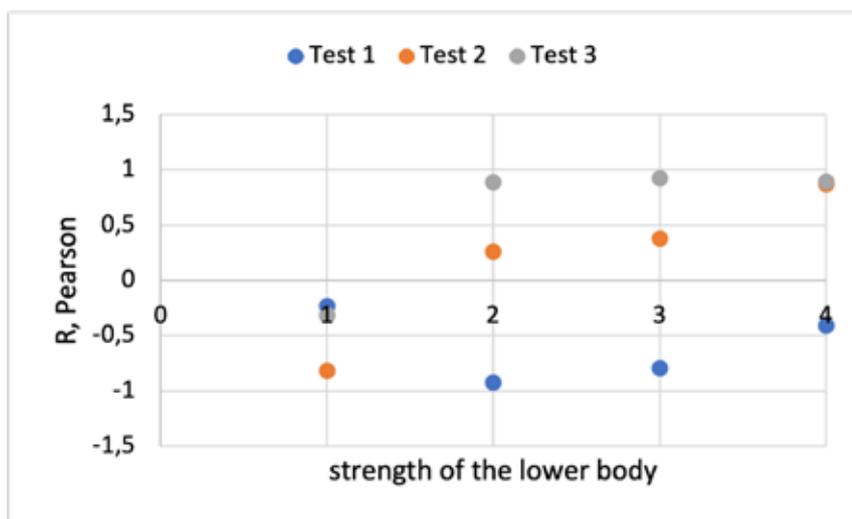


Figure 2. Relationship between lower limbs strength indices and specific motor tests in handball players specialized in the winger position

Discussion

The main objective of the study was to analyze the relationship between upper body speed capacity and lower body strength in elite handball players specialized in the winger position.

The results in Table 1 point out statistically insignificant differences between high-performance handball players (HHP) and those specialized in the winger position (PSW) concerning lower limb strength. This aligns with research in the specialized literature [1, 5, 18, 19, 20]. It was highlighted that wingers may have slightly different physical requirements, due to their specific playing position. Even so, the differences in explosive strength and jump capacity between positions are not always statistically significant. They prove a similar general physical training at the elite level.

The results in Table 2 indicate statistically insignificant differences between high-performance handball players (HHP) and those specialized in the winger position (PSW) in technical fitness tests. This fact confirms the specialized literature [13, 21,

22] that emphasizes that performance differences between positions in handball can be minimal in terms of basic training. However, variations in the consistency of results, highlighted by the coefficient of variation, may reflect specific differences in positional requirements and individual playing styles.

Comparative analysis of the results shows that most correlations are negative or insignificant in high-performance handball players in general (Figure 1). As for wingers (Figure 2), exercises like squats and CMJb have a significant positive influence on technical performances, especially in Tests 2 and 3. This suggests that wingers benefit more from training focused on dynamic strength and stability. The exercises focused on explosive strength, such as squat jumps and CMJ, contribute less to developing the technical skills necessary for this position.

The results of this study align with previous literature [23, 24, 25] highlighting the importance of specificity in the physical training of athletes. This specificity depends on the position on the playing field and the specific technical requirements

of each position. In particular, studies concerning wingers in team sports like handball have shown that they require a balance between speed, agility, and strength, with emphasis placed on quick lateral movements and short accelerations. Previous research indicates that explosive strength, measured through vertical jump tests such as CMJ and squat jumps, is less relevant for players requiring lateral agility and quick acceleration, such as wingers. Instead, isometric strength and exercises that develop stability and control of lateral movements, such as squats, are associated with better technical performance. In contrast, recent studies have highlighted the importance of monitoring internal and external physical loads in elite young handball players. The studies emphasized the role of game-based training and intermittent recovery tests in optimizing performance and assessing physiological and psychometric responses [9, 10, 11]. The specialists demonstrated a close relationship between the strength and power of upper and lower limbs and the throwing speed in elite handball players. They revealed the importance of specific resistance training in improving physical performance and throwing accuracy [3, 12, 13, 14]. Research indicates that the physical and physiological demands of elite handball involve advanced development of muscle strength and power and also specific adaptation to repeated high-intensity efforts. These are essential aspects for improving overall performance and throwing speed [5, 15, 16, 17]. The studies about athletic training in young athletes emphasize the importance of early development of fundamental physical qualities, like strength and speed. These ones directly influence performance in sports like handball, so a comprehensive and analytical approach is necessary to monitor and optimize their progress [26, 27, 28].

Studies demonstrate that maximal strength training and power-based training play an essential role in increasing throwing speed and muscle strength in handball players. However, there are significant variations depending on playing position and training method used [29, 30, 31]. Other specialists concluded too that the specific physiological and biomechanical demands in elite handball vary significantly depending on playing position and competitive level. The physical performance of players is directly influenced by these variations [21, 32]. Additionally, it has been observed that different team positions, such as the winger, require a distinct movement profile and physical capacity tailored to the specific demands of the game [14, 33]. Research suggests that individual and team performance in handball is considerably influenced by playing position and the level of specific physical training [34, 35, 36]. A similar conclusion is reached by other specialists: physiological characteristics and physical requirements, such as speed and throwing strength, vary according to playing position. For

example, wingers and players in other positions have distinct performance profiles [7, 15]. Analyzing movement time and heart rate in elite players of handball beach highlights differences between male and female performances. These are influenced by the specific demands of the game and the environment [37]. Physical fitness profiles in elite beach handball players, regardless of age category, reflect intense specific training, with variations according to age and playing position [38]. Studies conducted by Michalsiket al. [39] provide a detailed analysis of the physical and technical demands in elite handball, focusing on both male and female players. These studies deal with essential aspects such as locomotion characteristics, match-induced fatigue, physiological capacities and the influence of body composition on performance. Therefore, these studies too contribute to the optimization of training strategies and performance of elite handball players [39].

Despite the valuable insights provided by this study, several limitations should be considered. First, the sample size was relatively small, with only 16 elite handball players, which may limit the generalizability of the findings to the broader population of players. Additionally, the study focused specifically on wingers, which may not fully capture the variations in physical capacities and training needs across other playing positions. The cross-sectional design of the study also limits our ability to assess the long-term effects of different training approaches on performance. Future research with a larger sample size, including players from various positions and a longitudinal approach, would help to better understand the impact of tailored training programs on handball performance.

The results of our study indicate the need for tailored training approaches for elite handball players, particularly those in the winger position. The findings show that basic physical capacities, such as lower limb strength and technical fitness, do not significantly differ between wingers and other high-performance players. However, specific exercises like squats and CMJ provide clear benefits for wingers. These findings suggest that training should focus on dynamic strength and stability. Our study aligns with previous research that emphasizes the role of positional specificity in optimizing physical performance. This approach can help refine training programs and ensure that each player's unique demands are met.

Conclusions

The level of lower body strength among high-performance handball players, including those specialized in the winger position, does not present statistically significant differences. This indicates that overall physical conditioning is comparable at the elite level, regardless of positional specialization.

It highlights the role of fundamental training in developing similar strength capacities among players, emphasizing the importance of a solid physical training foundation for all elite athletes. The variations in the consistency of results likely reflect individual playing styles and the specific demands of each position, without significantly affecting overall strength levels.

The findings also suggest a meaningful correlation between training focused on dynamic strength and stability, such as squats and CMJb, and improved technical performance in the game. This improvement is particularly evident in aspects like speed and execution efficiency. These results demonstrate that targeted development of lower body strength can positively impact upper body speed capacity. Thus, the value of an integrated training

approach that aligns physical conditioning with the technical demands of handball is underscored. Conversely, exercises aimed at developing explosive strength, like squat jumps and CMJ, appear to play a smaller role in enhancing the technical skills necessary for wingers.

Acknowledgement

This study is part of the research theme within the Doctoral School of Physical Education and Sports Science, National University of Science and Technology *Politehnica* Bucharest, University Center Pitești. We express our gratitude to the athletes who participated in this research.

Conflict of interest

There are no conflicts of interest to declare.

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Cite this article as:

Mihaila I, Gavriloaia RA, Stancu M, Mihai I, Manole C, Acsinte A, Popescu D-C. Analysis of the relationship between upper body speed capacity and lower body strength of elite handball players specialized in winger position. *Pedagogy of Physical Culture and Sports*, 2024;28(5):440–448.
<https://doi.org/10.15561/26649837.2024.0512>

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Received: 12.09.2024

Accepted: 17.10.2024; Published: 30.10.2024