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The relationship between one-hand overhead ball throw aimed at target area and maximal ball speed of flat serve in elite junior tennis players: a pilot study

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ABSTRACT

The aim of this study was to investigate the relationship between performance on the one-hand overhead throw speed (OHOTS) aimed at a target area and the post-impact ball speed of the flat serve (PIBS) to promote more effective performance enhancement, and to estimate PIBS using a regression model through this simple field test. The test involved 23 elite junior boy tennis players (14.87±2.47 years). To explore the relationship between performance on the OHOTS and PIBS, we applied Pearson correlation analysis. Furthermore, simple linear regression was used to analyse the effect of the predictor variable (OHOTS) on the dependent variable (PIBS). Performance on the OHOTS test aimed at a target area showed a significant, strong correlation ($r = 0.58$; $p<0.05$) with PIBS. Moreover, the reactive strength exertion on the OHOTS test aimed at a target area accounted for 34% of the variation in PIBS. The result suggests that the motor skill test, which includes a unilateral movement pattern, can be used to monitor reactive strength in tennis players and can also serve as a training tool in the preparation process.

Key words: field test, reactive strength, post-impact ball speed of the flat serve, tennis.

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INTRODUCTION

There is a clear consensus among sport professionals and scientists that serving is of extreme importance to the outcome of a match, for age-group tennis players, as well. The effectiveness of serving is influenced by a number of factors (Colomar et al., 2022), of which the post-impact ball speed is one of the most decisive components of performance (Fett, Ulbricht & Ferrauti, 2020).

When planning the athlete's training programs, optimizing effectiveness of training has of utmost importance. Therefore, it is advisable to use targeted training tools that result in measurable improvement in performance even in short term. This is a particularly sensitive issue for junior tennis players in this age group, whose development potential is determined by age-specific and individual characteristics as well as phases of biological maturation. That is why, it is necessary to use training tools that are aiming at the simultaneous development of specific motor skills (reactive strength) and the execution of a given technical element. This supports the improvement of service performance without jeopardizing the athlete's long-term development. Several studies (Dobos & Nagykáldi, 2017; Dobos, 2018; Dobos & Tóth, 2021; Fernandez-Fernandez et al., 2013, 2016; Ulbricht et al., 2013) have pointed to a large correlation between different overhead, unilateral (one-sided) and bilateral (two-sided) throws and serving speed. However, the throwing tests used in the studies were not directed at the target area typical for the serving, so they do not reflect the passing of the ball at a given target area (typical for serve).

It is important to note that serving is not merely a series of movement requiring exertion of reactive strength, but an extremely complex movement pattern, in which each part of the kinetic chain plays a decisive role, and the timing of their interlocking movements is critical in achieving its correct speed (Elliott, Reid & Crespo, 2009). In addition, the placement of the serve (the point of landing of the ball on the target area) also plays a decisive role in the performance of the serve (Colomar et al., 2022). Furthermore, the dynamic balance control and proprioceptive feedback, which are essential components of sport-specific movement

coordination, may be more prominent during the execution of movements directed toward a target surface. (Elliott, Reid & Crespo, 2009).

Based on the above, it would be reasonablőe to develop a modern training tool that takes into consideration the specific characteristics of passing the ball to the target area and also provides opportunities for the complex development of technical execution quality, as well as increasing the reactive strength exertion. Therefore, the aim of this study was to examine the relationship between the one-hand overhead target-oriented unilateral throwing form and the post-impact ball speed of the flat serve to promote a more effective performance development. A further aim was to use this simple field test to estimate the post-impact ball speed of the flat serve using a regression model.

METHODS AND PROCEDURES

The study included 23 elite junior boy tennis players with an average chronological age: 14.84 ± 2.47 years; body height: 170.47 ± 16.3 cm, body weight: 59.51 ± 13.83 kg (Table 1.). Subjects were selected through the professional sampling method to select those tennis players who possessed the correct serve technique at the highest level in their age categories. All players were among the top 30 on the Hungarian under 12, 14, 16, and 18 national ranking list in their age categories. As an extra, 26% of the players had a European Tennis Association (ETA) or International Tennis Federation (ITF) ranking.

During the testing sessions two simple field tests were applied. These were the following: a) one-hand overhead ball throw test —to measure the ball speed of the one hand overhead throw, and the unilateral reactive strength of the upper body; b) serve test—to measure the post-impact ball speed of the flat serve and the neuromuscular power ability of the total body. Both tests were performed to the target area (Figure 1.).

Testing sessions were conducted outdoors, in the main competition season. To avoid the effects of tiredness, testing sessions were carried out 48 hours after a heavy training or match. Before each testing the player's age, body height and body mass were recorded. Each testing sessions started with a standardized warm-up of aerobic-type running, general mobilizing, stabilizing exercises and 8 trials on each test. Then the 2 field tests were performed, during which the players had 3 one-hand overhead ball throws and 8 flat serves. Four-minute passive rests were provided after the warm-up and between the tests, and 30 seconds of rest were allowed in the one-hand overhead ball throw test among the trials. In the serve test the resting time was 25 seconds. The best results of the correct trials (the execution is correct and the ball bounces on the valid target area) were considered for later analysis.

The Stalker ATS II" radar instrument (within ±3 km/h of accuracy and operating frequency: 34,7 GHz [Ka-Band] ± 50 MHz) was used for measuring the speed of the ball of one-hand overhead throw and flat serve tests. Furthermore, new 53-56 gram and 6.5 diameter "Slazenger Ultra Vis" balls were used. Before each testing session, the "Stalker ATS II" radar gun was calibrated in accordance with the manufacturer's specifications.

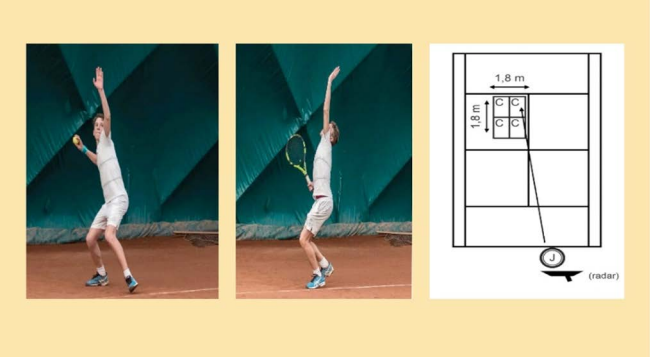

Figure 1. *The selected motor ability tests. C: target area, J: tennis player.*

First, normality of distributions was controlled with using the Shapiro–Wilk-W test. The distribution for each variable was normal (0.17-0.06; p>0.05), therefore the parametric Pearson correlation coefficients (r) were calculated to reveal correlation between the (predictor and dependent) variables. Finally, the simple regression model was used in order to calculate coefficient of determination (R2) and set up regression models. Significance was established at p<0.05 and data analyses were performed with the SPSS 21.0 software.

RESULTS

A significant positive correlation was found (r=0.58; p<0.05) between the ball speed of the one-hand overhead throw aimed at the target area and the post-impact ball speed of the flat serve (Figure 2.). Furthermore, the R2 values indicated that ball speed of the one-hand overhead throw aimed at the target area was 34% of the variance of the post-impact ball speed of the flat serve. Finally, based on simple linear regression analyses the following regression model (equation) was set up (Table 2.):

*PIBS (km/h) =(b0) 53.31+(b1) 1.23 *OHOTS (km/h)*

Where: PIBS=post-impact ball speed of the flat serve = b0: intercept + b1: slope* OHOTS: one-hand overhead throw speed aimed at the target area.

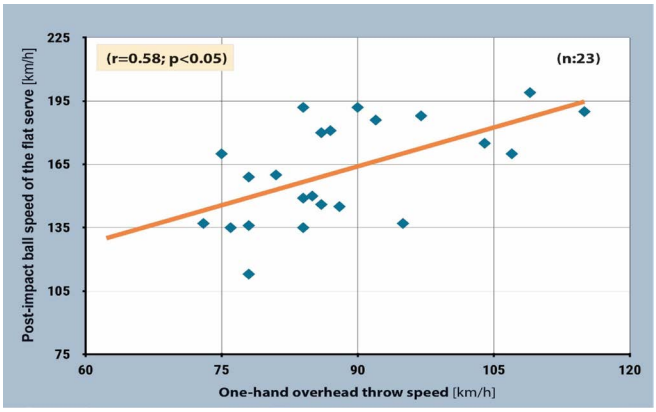

Figure 2. *Correlation between ball speed of the one-hand overhead throw aimed at the target area and the post-impact ball speed of the flat serve (n:23).*

Table 1
Individual characteristics and descriptive statistics of assessed variables in junior boy tennis players (n:23).

Descriptive statistics	Age	Body weight (kg)	Body height (cm)	One-hand overhead throw speed (km/h)	Post-impact ball speed of flat serve (km/h)
Mean±SD	14.87±2.47	59.51±13.83	170.47±16.30	88.34±11.45	161.95±24.16
Min-Max	11.12-18.39	40.0-81.10	145.0±193.40	73-115	113-199

Table 2
Simple linear regression analysis of junior tennis players (n:23)

Group		B	SEM	β	t	p
Junior boy tennis players	Intercept	53.31	33.29		1.60	
	One-hand overhead throw speed (km/h)	1.23	0.37	0.58	3.28	<.004

Dependent variables: the post-impact ball speed of the flat serve
R^2=0.34; adj R^2=0.30; F (1-22) =10.81; p<0.005

DISCUSSION

The fundamental question of the research was to what extent this unilateral movement aimed at the target area affects the post-impact speed of a flat serve and if it can be used to optimize serving performance. The results obtained showed that there is a significant positive correlation between the two variables in tennis players of this age group (r=0.58; p<0.05). Furthermore, the speed of the one-hand overhand throw to the target area explains 34% of the variance in the post-impact ball speed of the flat serve.

The results indicate that in age-group junior tennis players, the throwing motion to the target area may play a role in improving the post-impact ball speed of the flat serve. In other words, the speed of the serve is a complex, multi-component performance parameter that is not solely influenced by the magnitude of reactive strength (Roetert, Reid & Ellenbecker 2009). The level of development of the player's movement coordination, i.e., the precise and well-timed execution of the technical elements of the movement sequence, also plays a key role (Colomar et al., 2022). The integrated functioning of these factors fundamentally determines the dynamics of the entire movement chain and the post-impact speed achieved during the shot (Colomar et al., 2022). As mentioned previously several studies confirm the correlation between unilateral and bilateral throws and the launch speed of the serve (Dobos & Nagykáldi, 2017; Dobos & Tóth, 2021; Dobos, Tóth & Ökrös, 2022; Fernandez-Fernandez et al., 2013, 2016, Ulbricht et al., 2013). Research has revealed that the reactive strength manifested in these throwing movements—especially in the one-hand overhead throw—which collectively involve the lower limbs, torso, and upper body, can be effectively transferred to the serving motion with the right technical knowledge, thereby helping to increase the post-impact ball speed of the flat serve.

Furthermore, this research has highlighted that the throwing movement toward the target area used in the study, i.e., targeted unilateral ball throws, could significantly influence the post-impact ball speed of the flat serve. During the targeted ball transfer, the player throws the ball at a specific target area with conscious motor control. This exercise could help refine the technical movement pattern of the upper limbs and effectively transfer them into the serving motion. It could also support the development of movement coordination and ball control and contribute to increasing the tennis player's reactive strength (Dobos & Tóth, 2021; Fernandez-Fernandez et al., 2013, 2016). Therefore, based on these data, targeted unilateral throwing movements could be an integral part of tennis training, serving to effectively develop sport-specific movement patterns. It is important to mention that the research of Reid, Giblin & Whiteside (2015) and Wagner et al. (2014), which points out numerous mechanical similarities, observed significant mechanical differences between the two movement patterns. Nevertheless, it seems realistic to conclude that a one-hand throwing motion directed at the target area could provide a suitable basis for improving the post impact ball speed of the flat serve in junior boy tennis players.

As a limitation of this research, it would be justified to conduct the study on a larger sample and to expand it to female tennis players to obtain more comprehensive results.

In addition, it would be worth to analyse the correlations between one-hand overhead throws aimed at the target area executed from different starting positions and the post-impact ball speed of the flat serve. During tests performed from prone, seated, and half-kneeling positions, the conscious shortening of the kinetic chain and the exclusion of the lower extremities allow for the isolation of the reactive strength and coordination role of the dominant arm and shoulder girdle in the post-impact ball speed of the flat serve. This allows for more accurate information about individual contribution of each segment to the overall serve performance. In addition, these investigations may pave the way for the development of standardized field tests that enable the precise measurement of performance components of sport-specific movement patterns.

CONCLUSION

During the preparation period one of the most important aspects of training theory is efficiency. This means that training equipment used to prepare athletes must be capable of improving performance in the short term without jeopardizing the athlete's long-term development. Based on the collected data, we believe that unilateral throwing techniques aimed at this type of target area probably increase serving speed and improve movement coordination and ball control. Therefore, it would be worth for age-group junior tennis players to practice different throwing forms on target areas, as in case of tennis we are talking about ball transfer to target surfaces (Rigler, 2004). Furthermore, through the practical application of empirical results, more effective constructive teaching strategies could be developed that emphasize the understanding of tactical elements and the conscious application of specific technical elements (Kovács, 2024).

CONFLICTS OF INTEREST

The authors declared no conflict of interest regarding the publication of this manuscript.

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