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Preliminary kinematic analysis of the serve in 10 and under players

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ABSTRACT

The serve is a fundamental stroke to win a match at a high level. From a long-term player development perspective, it is necessary to know the biomechanical learning stages of this stroke. However, the scientific data concerning the biomechanics of the serve have focused on the 12&U, 14&U, 16&U, 18&U and +18 categories. The objective of this study is to propose a preliminary kinematic analysis of the serve in children aged 10 and under (10&U) to provide benchmarks for coaches regarding the teaching of the serve in younger players.

Key words: service, performance, biomechanics .

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INTRODUCTION

At a high level, the serve is the most important shot of the game, as it allows the player to dominate the opponent and win the rally quickly (Whiteside et al., 2013). Its effectiveness can influence the player's performance, the outcome of the point and the result of the match. Players who win the match, make fewer double faults and outperform their opponents in 1er serve percentage (Hizan et al., 2011). The percentage of total points won and points won after the first serve are determining factors in the junior game (Kovalchik & Reid, 2017). If a player expects to have success at a high level on the junior and then the professional tour, learning to serve from the first years of practice (7&U, 9&U, 10&U) is very important. However, the serve is a complex shot whose execution can pose real problems to young players. For example, research has shown that in the 10&U category on green court the success rate is the lowest for the serve (Fitzpatrick et al., 2018). Therefore, when training these young players, the knowledge related to the technical execution of this stroke is paramount to provide guidance to coaches. However, data in the scientific literature regarding the biomechanics of the serve have focused on the 12&U, 14&U, 16&U, 18&U and +18 categories (Fett et al., 2021; Fleisig et al., 2003; Hernández-Davó et al., 2019; Touzard et al., 2019; Whiteside et al., 2013). Data for the 10&U category are very limited (Durovic et al., 2008). Therefore, the aim of this study is to describe different kinematic parameters of the 10&U serve.

METHOD

Six departmental level players, two girls and four boys, participated in this study (age: 9.3 ± 0.8 years; height: 136.0 ± 5.8 cm; mass: 27.8 ± 3.8 kg). The study took place on a "green" court (24 m x 8.23 m) equipped by a motion capture system comprising 23 optoelectronic cameras (Oqus 7+, Qualisys System, Gothenburg, Sweden). The players were asked to serve 3 first flat serves in the serve box. The players and their rackets were equipped with reflective body markers (Figure 1). The ball speed was measured with a radar (Stalker Pro II+, USA). 16 kinematic parameters were calculated to describe the biomechanics of the serve (Table 1).

Figure 1. *Position of front and back markers.*

RESULTS

The players hit the serves with a ball speed of 94 ± 10 km/h and a maximum racquet head speed of 93 ± 9 km/h. The 10&Us showed a maximum rear knee flexion angle of 134 ± 10 ° and a front knee flexion angle of 121 ± 12 °. The internal angles of maximum flexion were 83 ± 5° for the rear ankle and 82 ± 9° for the front ankle. The speed of maximum extension was 508 ± 108 °/s for the rear ankle and 478 ± 100 °/s for the front ankle. The speed of maximum extension of the rear knee was 366 ± 153 °/s and 489 ± 160 °/s for the front knee. The maximum rear hip velocity was 1.3 ± 0.2 m/s, and 0.9 ± 0.3 m/s

at the front hip. The maximum longitudinal hip rotation speed was 493 ± 154 °/s. The children flexed their trunk at a maximum speed of 286 ± 45 °/s. At the level of the dominant upper limb, 10&U year olds reached maximum elbow extension velocities of 1003 ± 403 °/s, wrist flexion of 1472 ± 155 °/s and shoulder internal rotation of 1668 ± 668 °/s.

DISCUSSION

Ball speed is an indicator used in training to characterise the level of expertise of players and to evaluate the efficiency of their serves (Fleisig et al., 2003). Our results showed that the serve of 10&U players is about 60 km/h slower than that of 16&U players (Fett et al., 2021) and about 90 km/h slower than that of +18 professional players (Fleisig et al., 2003). Although these differences are largely related to the maturation of physical abilities from childhood to adulthood (Kovalchik & Reid, 2017), there are kinematic parameters that may account for the lower ball speed observed in 10&Us.

The serve follows a proximo-distal sequence during which the movement starts with the proximal segments. At the start of the kinematic chain, our results showed that 10&Us flex the front knee more than the back knee (121 ± 12 ° vs. 134 + 10 °). The maximum extension speed of the front knee was greater than that of the back knee (489 ± 160 °/s vs 366 ± 153 °/s). For older age categories (12&U to adult), players do the opposite by increasing the flexion and then the extension speed of the back knee (Fett et al., 2021; Whiteside et al., 2013). Our results therefore demonstrated a still immature rear knee thrust in 10&U departmental level players. It can be hypothesized that this immature thrust is associated with an overly long stretch-shortening cycle of the lower limb resulting in dissipation of stored elastic energy having the effect of limiting the extension velocity produced by the lower limbs (Whiteside et al., 2013). Conversely, our results showed a more mature action at the ankles in 10&U as the maximum extension velocity of the rear ankle was approximately 30 °/s higher than that of the front ankle.

At the trunk level, the maximum longitudinal hip rotation speed of 10&Us was similar to that of older players (Fett et al., 2021; Fleisig et al., 2003). In contrast, the maximum trunk flexion speed of 10&Us was lower than that of 16&Us (Fett et al., 2021). This result suggests that 10&Us favour longitudinal rotation of the trunk to create speed instead of the lateral trunk or shoulder over shoulder rotation, which is still not very effective because the leg thrust is still immature at that age. These two actions of the trunk (flexion and lateral tilt) thus constitute axes of progress to be considered during adolescence.

Table 1

Comparative table of the different parameters measured according to the age categories 10&U, 12&U, 16&U and +18.

Parameters	Our results	Fett et al, (2021)	Whiteside et al, (2013)			Fleisig et al, (2003)
	10&U	16&U	12&U	16&U	+18	+18
Ball speed (km/h)	94 ± 10	151 ± 20	/	/	/	Men: 183 ± 14 Women: 149 ± 14
Maximum racquet head speed (km/h)	93 ± 9	/	108 ± 11	148 ± 11	155 ± 11	/
Internal angle of maximum rear knee flexion (°)	134 ± 10	102 ± 10	93 ± 10	93 ± 8	92 ± 8	/
Maximum internal angle of flexion of the front knee (°)	121 ± 12	108 ± 16	105 ± 10	115 ± 7	111 ± 8	/
Maximum rear knee extension speed (°/s)	366 ± 153	518 ± 102	/	/	/	/
Maximum front knee extension speed (°/s)	489 ± 160	447 ± 99	/	/	/	800 ± 400
Maximum internal angle of flexion of the rear ankle (°)	83 ± 5	/	/	/	/	/
Maximum internal ankle flexion angle (°)	82 ± 9	/	/	/	/	/
Maximum rear ankle extension speed (°/s)	508 ± 108	/	/	/	/	/
Maximum front ankle extension speed (°/s)	478 ± 100	/	/	/	/	/
Maximum rear hip speed (m/s)	1,3 ± 0,2	/	1,8 ± 0,2	1,9 ± 0,1	2,3 ± 0,1	/
Maximum speed of the front hip (m/s)	0,9 ± 0,3	/	1,4 ± 0,2	1,5 ± 0,1	1,7 ± 0,1	/
Maximum longitudinal hip rotation speed (°/s)	493 ± 154	424 ± 96	/	/	/	440 ± 90
Maximum trunk bending speed (°/s)	286 ± 45	493 ± 71	/	/	/	/
Maximum elbow extension speed (°/s)	1003 ± 403	1564 ± 327	1147 ± 185	1592 ± 191	1524 ± 144	1510 ± 310
Maximum wrist flexion speed (°/s)	1472 ± 155	1071 ± 299	1164 ± 189	1581 ± 184	1911 ± 264	1950 ± 510
Maximum shoulder internal rotation speed (°/s)	1668 ± 668	2029 ± 332	1288 ± 365	2165 ± 373	2000 ± 297	Men: 2420 ± 590 Women: 1370 ± 730
Maximum longitudinal shoulder rotation speed (°/s)	585 ± 144	/	/	/	/	870 ± 120

The dominant arm joints contribute strongly to speed production (Tanabe & Ito, 2007). The maximum elbow extension speed of 10&Us is comparable to that of 12&Us (Whiteside et al., 2013). In contrast, there is a significant deficit between the 10&Us and 16&Us, indicating minimized elbow involvement at younger ages. Thus, our results support the hypothesis of (Whiteside et al., 2013) that younger players employ a less ascending pre-impact racket trajectory than that used by older players, potentially explaining the differences in ball speed between these age categories.

The internal shoulder rotation velocity of the 10&Us is higher than that of the 12&Us obtained by Whiteside et al., (2013) but is significantly lower than those obtained by the 16&Us, 18&Us and +18s (Table 1). The same is true for the maximum wrist flexion speed. These results provide a better understanding of the reduced ball speed in 10&Us insofar as it has been shown that shoulder internal rotation and wrist flexion speeds are the main contributors to linear racquet head speed (Tanabe & Ito, 2007).

PRACTICAL APPLICATIONS

The results of this study provide some practical recommendations for coaches of young players. After the age of 10 (12&U and 14&U categories), biomechanical work to improve the serve technique can be oriented on the action of the back knee. The aim is to progressively bring the young players to bend the back knee more to store a certain amount of elastic energy in the quadriceps and then to produce an explosive extension of the back knee that will allow them to efficiently engage the upward projection of the back hip and the rotation actions of the trunk (trunk flexion and shoulder over shoulder rotation) and the upper limb (elbow projection and internal rotation of the shoulder). Thereafter, targeted and adapted muscle strengthening work during adolescence (16&U, 18&U and +18) will allow to optimize segmental and joint rotation speeds such as rear knee extension, shoulder internal rotation, elbow extension or trunk flexion.

CONCLUSIONS AND WAY FORWARD:

This study shows that the 10&Us perform immature actions of the back knee, elbow and shoulder during the serve compared to older age groups, which helps to explain their reduced ball speed performance. In contrast, the ankle and longitudinal hip rotation actions were found to be biomechanically already in place. Future work is needed to determine whether scaling the environment (court size, net height) to the morphology of the 10&Us would facilitate serve learning, improve their performance, and result in biomechanical parameters closer to those measured for older age groups.

CONFLICT OF INTERESTS AND FUNDING

The authors declare that they do not have any conflict of interest and that they did not receive any funding to conduct the research.

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