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The Relationship between Age and Selected Kinematic Parameters of Standing Long Jump Test*

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ABSTRACT The aim of this study is to determine the relationship between age and selected kinematic parameters of standing long jump. The sample consisted of 120 male respondents aged 4 to 18 years. The control group comprises of 20 students of Faculty of Kinesiology. The sample of variables consisted of 21 kinematic parameters. The relationship between age and selected kinematic parameters was determined by polynomial regression analysis. The results showed statistically significant relationship between age and six kinematic parameters in preparatory phase ($F = 15.66$; $F = 4.37$; $F = 5.62$; $F = 40.86$; $F = 6.30$; $F = 13.00$), six in take-off phase ($F = 16.78$; $F = 17.81$; $F = 12.98$; $F = 395.31$; $F = 5.62$; $F = 13.02$) and one in landing phase ($F = 22.37$). It can be concluded that standing long jump is a complex motor task, which is developing with the age of respondents.

INTRODUCTION

Standing long jump test is a multi-joint motor movement that is regularly used to evaluate explosive leg power. Although it is less reliable than other tests to assess the lower limbs explosive power, standing long jump is most frequently applied in practice and in scientific research because of its simple application. These applications include the fact that its performance does not require special equipment, time, and space. However, many factors can significantly affect the outcome of standing long jump test such as age and motor knowledge (Pasand et al. 2015), also maturation and morphological characteristics (Hraski et al. 2015).

One of the main limitations when using the standing long jump as a test for the evaluation of an individual explosive leg power is that standing long jump is a complex movement which involves a lot more abilities than just the explosive power (Aguado et al. 2000; Wakai and Linthorne 2005; Harrison and Keane 2007; Labiadh et al. 2010).

In many cases, especially if children are involved, the test evaluates false potential if the respondent does not use the best possible technique of performance (Roy et al. 1973; Horita et al. 1991; Wu et al. 2003; Zhouyi et al. 2010; Szerdiova et al. 2012). Specifically, to achieve the best performance of the standing long jump, the respondent must perform a complex movement to propel the body upward and outward (Wang et al. 2002; Knudson 2003; Fukashiro et al. 2005; Nagano et al. 2007; Lee and Cheng 2008).

Subsequently, the success of the jump depends on the coordination of the upper and lower body segments (Dapena 1999; Ashbby and Heegaard 2002; Cheng and Chen 2005; Ashby and Delp 2006; Bartlett 2007; Pišot et al. 2010; Mackala et al. 2012).

Furthermore, the performance of a standing long jump test is greatly influenced by the growth and maturity characteristics of the child (morphological, physiological, and neuromuscular). This is an exception for a complex movement that requires a high level of motor skills and coordination abilities (Butterfield et al. 2002; Malina et al. 2004; Caruso et al. 2012; Cliff et al. 2012).

Therefore, in this study, kinematic proficiency of the standing long jump test which was in previous researches was considered to be a task of great complexity and to be under the strong influence of growth and maturation. However, it is not appropriate for the younger population as a measuring instrument for the assessment of explosive leg power, which will be analysed for different age groups.

Objective of the Study

The aim of this study is to determine the relationship between age and selected kinematic parameters of standing long jump test technique. In accordance with the defined aim of this research, the researchers hypothesized that there would be a statistically significant influence of age on changes in selected kinematic parameters of standing long jump test performance.

METHODS

Participants

The research was conducted on 120 male respondents aged from 4 to 18 years, which was divided into five experimental groups with 20 subjects in each. Control group comprised 20 students of the second year of the Faculty of Kinesiology. The first experimental group includes children from 4 to 6 years (mean age 5.00 years, mean height 115.15 cm, mean weight 21.25 kg). Second experimental group includes children from 7 to 9 years (mean age 8.10 years, mean height 134.99 cm, mean weight 34.15 kg). The third experimental group includes children from 10 to 12 years (mean age 11.05 years, mean height 150.35 cm, mean weight 42.98 kg). The fourth experimental group includes children from 13 to 15 years (mean age 14.05 years, mean height 170.31 cm, mean weight 64.06 kg); and the fifth experimental group comprises of adolescents from 16 to 18 years (mean age 16.95 years, mean height 180.02 cm, mean weight 73.02 kg). Furthermore, the control group of subjects includes students from 20 to 22 years (mean age 20.35 years, mean height 182.99 cm, mean weight 82.43 kg).

Variables

The sample of variables consisted of 21 kinematic parameters which are relevant for the proficient performance of the standing long jump (Horita et al. 1991; Ashbby and Heegaard 2002; Wu et al. 2003; Fukashiro et al. 2005; Wakai and Linthorne 2005; Ashby and Delp 2006; Zhouyi et al. 2010) (Table 1). Selected variables are analysed through four basic phases of the jump. This phase include: 1. Preparatory phase, 2. Take-off phase, 3. Flight phase, and 4. Landing phase. Thus, this is concerning the geometry of the body, velocity of body segments and the centre of gravity, as well as the temporal and spatial parameters of the jump.

Table 1: Selected kinematic parameters of the standing long jump

Variable	*Mark*	*Unit*
Shoulder angle at the beginning of the preparatory phase	SABPP	°
Shoulder angle at the lowest point of the centre of gravity	SALCG	°
Hip angle at the lowest point of the centre of gravity	HALCG	°
Knee angle at the lowest point of the centre of gravity	KALCG	°
Peek velocity of shoulder before take-off	PVS	s
Peek velocity of hip before take-off	PVH	s
Peek velocity of knee before take-off	PVK	s
Peek velocity of ankle before take-off	PVA	s
Elbow angle at take-off	EATO	°
Shoulder angle at take-off	SATO	°
Hip angle at take-off	HATO	°
Knee angle at take-off	KATO	°
Take-off angle	TOA	°
Elbow angle at the highest point of the centre of gravity	EAHCG	°
Shoulder angle at the highest point of the centre of gravity	SAHCG	°
Lending angle	LA	°
Vertical velocity at take-off	VVTO	cm/s
Horizontal velocity at take-off	HVTO	cm/s
Take-off phase duration	TOPD	s
Flight phase duration	FPD	s
Jump length	JL	cm

Data Collection

The participants were randomly selected from kindergartens, schools, and faculty in city of Zagreb. All participants voluntarily participated in the study. Parental consent was obtained for participants under 18 years old. The study was conducted in adherence to the standards of Code of Ethics for research with children published by The Council for Children of the Croatian Government (Ajdukovic and Kolesaric 2003).

Collection of video data was made using two digital video cameras operating at the rate of 60 frames per second. All participants were on the sports footwear and clothing. The test was performed on standing long jump track with marked start line and a measuring scale in centimetres. Respondents had three test trials, followed by the three executions of the standing long jump test. The longest jump of each respondent was subjected to further analysis. Therefore, the collected videos were processed by *Ariel Performance Analysis System* (Apas 2007).

The influence of age on changes in selected kinematic parameters of standing long jump test performance was examined by Polynomial Regression Analysis.

RESULTS

In accordance with the aim of this research to determine the relationship between age and changes in selected kinematic parameters of standing long jump test techniques, polynomial regression analysis was conducted. From the result obtained, it can be seen that there is a statistically significant influence of age on the changes in most of the measured kinematic parameters (Table 2).

After excluding parameters that are expected to be changed by the age of the respondents (length of the jump, duration of the flight, etc.), according to the results of this research, it can be observed that there is a statistically significant relationship between age and many other analysed kinematic parameters which determines the proficient performance of the standing long jump test.

From a total of twenty-one kinematic parameters, statistically significant influence of age was obtained in fifteen of the measured parameters.

In the preparatory phase of the jump, two parameters are related to the geometry of the body (HALCG - F = 15.66 and KALCG - F = 4.37) and four to the segments velocities (PVS - F = 5.62; PVH - F = 40.86; PVK - F = 6.30; and PVA - F = 13.00). In the take-off phase, three parameters are related to the geometry of the body (SATO - F = 16.78; HATO - F = 17.81; and KATO - F = 12.98), two on segments velocities (HVTO - F = 395.31 and VVTO - F = 5.62), and one on the duration of the take-off phase (TOPD - F = 13.02). In the flight phase, a statistically significant influence of age on the time duration of the flight phase was obtained (FPD – F = 47.65). Also, in the landing phase, there is one more parameter related to the geometry of the body during the jump (LA - F = 22.37) and one with the spatial parameter of the jump (JL – F = 846. 98).

DISCUSSION

In accordance with the results of polynomial regression analysis, it can be confirmed that the standing long jump is a motor task whose technical performance is affected by changes influenced by the age. However, these changes include many of kinematic parameters (Table 2) which is selected as parameters responsible for proficient performance of standing long jump. Pasand et al. (2015) also examined age differences in the quality of the acquired motor knowledge of the standing long jump assessed by its performance. They concluded that evaluation of performance enables higher quality organization of kinesiological activities intended for children at certain age.

In addition, the obtained changes in selected kinematics parameters are influenced by the growth and maturation which was also recogn-

Table 2: Polynomial regression analysis of kinematic parameters of standing long jump test

Variable	*Regression Beta coefficient*	*t-value*	*F-value*	*p-level*
Age / SABPP	0.13	1.41	(1.118) = 1.9896	0.16
Age / SALCG	-0.17	-1.89	(1.118) = 3.5784	0.06
Age / HALCG	0.34	3.96	(1.118) = 15.663	0.00*
Age / KALCG	0.19	2.09	(1.118) = 4.3732	0.04*
Age / PVS	0.21	2.37	(1.118) = 5.6275	0.02*
Age / PVH	0.51	6.39	(1.118) = 40.864	0.00*
Age / PVK	0.23	2.51	(1.118) = 6.3047	0.01*
Age / PVA	-0.41	-4.89	(1.118) = 23.909	0.00*
Age / EATO	-0.03	-0.37	(1.118) = .13482	0.71
Age / SATO	0.35	4.1	(1.118) = 16.789	0.00*
Age / HATO	0.36	4.22	(1.118) = 17.816	0.00*
Age / KATO	0.31	3.6	(1.118) = 12.985	0.00*
Age / TOA	-0.11	-1.25	(1.118) = 1.5816	0.21
Age / EAHCG	-0.08	-0.9	(1.118) = .80603	0.37
Age / SAHCG	-0.16	-1.81	(1.118) = 3.2924	0.07
Age / LA	-0.4	-4.73	(1.118) = 22.378	0.00*
Age / VVTO	0.72	11.17	(1.118) = 124.88	0.00*
Age / HVTO	0.87	19.88	(1.118) = 395.31	0.00*
Age / TOPD	-0.32	-3.61	(1.118) = 13.020	0.00*
Age / FPD	0.54	6.9	(1.118) = 47.659	0.00*
Age / JL	0.94	29.1	(1.118) = 846.98	0.00*

*marked p-levels are significant at p<0.05

ised in previous studies (Horita et al. 1991; Decker et al. 2003; Wu et al. 2003; Wakai and Linthorne 2005; Mackala et al. 2012; Szerdiova et al. 2012).

After excluding parameters that are expected to be changed by the age of the respondents (length of the jump, duration of the flight, velocities of segments, etc.), there are many other analysed kinematic parameters that have a significant relationship with growing and maturation. For example, the relationship between kinematic parameter SATO (shoulder angle at take-off) and age (Table 2). It is clear that young respondents reach different values in shoulder angle at take-off when compared to students. In youngest group of boys, achieved results extremely varied from -90° to 200°. These founding's points include insufficient maturation of the movement at that age, the immaturity of the respondents to perform a movement, and the fact that a finalisation of motor development and the adoption process of movement structure are still ongoing. This can also refer to all other selected kinematic parameters in this study that have a statistically significant relationship with age.

Similar conclusions are achieved by Zhouyi et al. (2010) who conducted a detailed kinematic analysis of the standing long jump on boys from sixth to the eleventh year. Also, they compared their performance with the performance of young athletes. From the data obtained, they found that during the arm swing, the shoulder angle significantly increases with age, while the angles of the hip and knee before the take-off significantly reduces up to eighth years of age. Statistically significant differences were not obtained for a group of eleven years of age. Based on the results, the authors concluded that a coordinated arm swing is very important during the performance of the standing long jump. Also, in children under school age, the proper actions of the arms, hip, and knee in the preparatory phase before the take-off are still not developed. Generally, they found that the motor stereotype of standing long jump is almost matured in the third grade of primary school, although they obtained significant differences in some parameters at 10 years of age.

The results obtained in this study is also consistent with the results of previous studies of Kanoha et al. (1987), Gabbard (1999), and Haywood and Getchell (2009) where the authors established that successful performance of standing long jump is not recorded until 6 years of age. Also, a similar result continues in adolescence and later in adulthood, usually in the form of insufficient arms swing and lack of knee extensions at take-off. Dissimilar tempo of motor development of standing long jump is explained by Clark et al. (1989). They investigated the developmental stages of standing long jump in children aged 3, 5, 7 and 9 years, and twenty year old athletes. They concluded that 30 percent of children aged 3-7 years have not coordinated the work of lower and upper segments of the body.

Based on the researchers' findings, the hypothesis that there is a statistically significant influence of age on changes in selected kinematic parameters, of standing long jump test performance was confirmed.

CONCLUSION

From the results of this study, it can be concluded that there is a statistically significant relationship between the age of the respondents and the selected kinematic parameters of standing long jump test in most of the measured variables. After excluding parameters that are expected to be changed by the age of the respondents (length of the jump, duration of the flight, etc.), it can be seen that there is a statistically significant relationship between age and many other analysed kinematic parameters. In the preparatory phase of the jump, two parameters are related to the geometry of the body ($F = 15.66$; $F = 4.37$) and four on segments velocities ($F = 5.62$; $F = 40.86$; $F = 6.30$; $F = 13.00$). In the take-off phase, three parameters are related to the geometry of the body ($F = 16.78$; $F = 17.81$; $F = 12.98$), two on segments velocities ($F = 395.31$; $F = 5.62$), and one on the duration of take-off phase ($F = 13.02$). In the landing phase, there is one more parameter related to the geometry of the body during the jump ($F = 22.37$).

Furthermore, it can be seen that there is no statistically significant relationship between age and kinematic parameters that refer to arm swing in the preparation phase (SABPP, SALCG, and EATO) and flight phase (SAHCG and EAHCG), as well as with the geometry of the body in the take-off phase (TOA). Attained deviations and large variation of the results of respondents can be explained by different level of motor skills, familiarization with the test, and the coordination of each respondent.

In accordance with the results of polynomial regression analysis, it can be concluded that standing long jump is a complex motor task that requires a high level of coordination abilities which according to the results of this study, are developing with the age of the respondents.

RECOMMENDATIONS

A standing long jump is a common test for the evaluation of explosive strength in young children, students, athletes etc. In the direction of the outcomes attained in this study, that the standing long jump is a motor task whose technical performance is affected by changes influenced by the age, it is reasonably to say that the standing long jump test has not the same object of measurement in respondents of different age, especially for younger subjects.

NOTE

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