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Original empirical article

THE CORRELATION OF MOTOR ABILITIES AND JAVELIN THROWING RESULTS DEPENDS ON THE THROWING TECHNIQUE

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Abstract. *This research was carried out to determine the correlation among the motor abilities and success of kinesiology freshmen in the javelin throw. The total number of participants (N=53) was divided into two groups. The first group (N=34) was a group of students who did not have sufficient knowledge of javelin throwing, while the second group (N=19) was a group of students who had proper knowledge of the javelin throw technique. Their motor abilities were determined by tests for the assessment of speed, explosive and maximum strength. A correlation among the motor abilities and results in the javelin event was determined by using a standard correlation analysis. According to the obtained results, we can make the conclusion that motor abilities (starting acceleration and explosive strength) have a significant impact on the results of the criterion variable only between the students whose knowledge of the javelin throws is at a high level.*

Key words: *students, athletics throwing skills, motor abilities, correlation analysis.*

INTRODUCTION

Athletic disciplines pertain to the group of monostructural movements of a cyclic, acyclic or complex type. Athletic throwing events have the characteristics of monostructural acyclic movements of a translatory or rotational type. The ynamic stereotype of movement in the glide-style shot put and javelin throw have the characteristics of translatory movements, and the dynamic stereotype of movement in the rotational shot put, discus throw and hammer throw have the characteristics of rotational movement (Mila-

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nović et al. 1986). In a kinesiological sense, throws are elementary types of movement in which a certain implement is passed into space. Also kinesiologically speaking, throws are defined as ballistic movements initiated by explosive agonist activation, after which follows a period of their relaxation, ending in de-acceleration due to the antagonist effect or passive extension of the connective tissue (Rasch and Burke, 1978; according to: Harasin, 2002). Athletic competitions take place in distinctly standardized conditions (weight of the throwing implements, the diameter of the throwing circle, run-up length, etc.) defined by the rules of the International Association of Athletics Federations. The athletes are ranked according to the results accurately measured with precise distance meters. Therefore, the results in throwing disciplines are somewhat more objective than the results in sports where they depend on the judge's evaluation (Harasin, 2002). The javelin throw is the athletic discipline in which the thrower tries to transfer the largest possible acceleration to the javelin at the moment of release through specific movement structures. From the point of coordination, the javelin throw is one of the more complex athletic disciplines (Silvester, 2003). The weight of the javelin is relatively small in comparison to other implements (600 grams for women, 800 grams for men), requiring from the javelin thrower the "feel for the implement" and special "explosive" activity at the moment of release. Loads occurring when the thrower suddenly stops running during the run-up and at the moment of the javelin release represent a difficult challenge for the physical and psychological abilities of the javelin thrower (in the 90-m throw, the javelin thrower gives the javelin a starting speed of 35 m/s). The majority of throwers specialized in the javelin throw have already achieved good results in throwing various implements: stones, balls, etc. in their childhood, which points to the innate movement speed at the moment of release. Along with strength and speed abilities, javelin throwers have excellent flexibility, coordination and the good "feel" of the javelin, i.e. the ability to "identify" with the javelin (Bošnjak, 2009). Regarding the competition results in javelin throwing, the highest importance is given to the ability which is under the influence of mechanism regulating excitation intensity – explosive strength, and the ability on which the size of the movement amplitude (flexibility) depends. Coordination factors also significantly affect the javelin throw results. Motor ability which enables the maximum additional acceleration of the throwing implement in the release phase is the speed of a single movement (Milanović, 1997). The efficiency of motor performances is defined through the relations between motor skills and the level of characteristics and abilities acting interactively and differently in various phases of progress (Miletić, 2003). Taking into consideration the level of skill in the javelin throw, the basic goal of this research was to determine the connection between motor abilities and results in this athletic discipline among first-year students of kinesiology.

METHOD

Sample of participants

The research was carried out on a sample of 53 first-year undergraduate students at the Faculty of Kinesiology in Split (academic year 2009/2010). The sample has been divided into two groups: the first experimental group (E1; N = 34) and the second experimental group (E2; N = 19). The participants had no previous experience with the javelin

throw technique. All of the students attended regular classes (6 lessons), two times a week for 90 minutes (2 classes).

Measurements

The sample of variables for the assessment of motor abilities consisted of four tests, namely: the standing long jump (cm), the 30-m run with a standing start (0.01 s), the bench press – 1RM (kg) and the counter movement jump (cm). The selection of motor tests was made according to the results of the previous research (Ivanovic, 2009; Milanovic, 1986; Enoksen et al., 2009). The javelin throw result (800 grams) was the criterion variable. The assessment of specific motor skills was performed through a standardized procedure with three examiners. Based on the Likert rating scale, students rated 1 to 2 were classified in the group with below-average throwing skills (E2), whereas the students rated 3 to 5 were classified in the group with above-average skills of the javelin throw (E1). The participants were supposed to demonstrate their javelin throwing skills through 7 steps of a straight run and 5 crossover strides. The major mistakes in the javelin throw were: the wrong hold on the javelin (the grabbing and holding of a javelin in the run-up), throwing the javelin on the wrong leg (same hand - same leg), hitting the floor with the tail of the javelin and stepping over / running over the line. The minor mistakes were: a smaller or larger distance between the javelin and the head, irregular running rhythm , uncontrolled movement of the javelin while running from straight ahead to a crossover, a bad release angle, irregular position of the javelin (bent arm) and bad velocity of the javelin at release (Žuvela et al., 2009).

The experimental program

At the beginning of the experimental program, the participants were introduced to the goal and the plan and the program of the experiment. Based on this, the participants were evaluated for their javelin throwing skills and four motor abilities. The assessment of their motor abilities and skills was performed after the experimental process. During the three-week period 6 lessons were performed. The complete volume included 6 topics, altogether comprising 20 frequencies (total repetition of all the topics). The experimental plan and program were carried out through the implementation of the following topics: learning how to hold the javelin (American, Finnish and fork grip), learning how to release the javelin, throwing the javelin from various positions, learning the specific javelin run, the javelin throw making crossover strides and the javelin throw from a full run-up. In this experimental procedure various learning and exercise modalities were often interchanged and supplemented, and the selection of the aforementioned modalities always depended on the present capabilities of the students, and on the speed of going through the planned topics. The most common teaching method used was the synthetic one, and if necessary, also the analytic method, especially in the cases where the planned technical elements were somewhat more complex. The methods described were implemented in the learning process and the improvement of individual technical elements (e.g. the standing javelin throw, the javelin throw from three crossover strides), but also when exercising the javelin throw from the full run-up.

Data analysis

After the measurement was carried out, the obtained data were entered into the Statistica program for "Windows Ver.5.0". Basic statistic parameters were analyzed, namely: arithmetic means (AM), standard deviation (SD), minimum (MIN) and maximum measurement results (MAX), skewness (SKE), kurtosis (KUR) and Kolmogorov-Smirnov test (D max). The independent sample t-test (t-value) was used to determine the differences between the two groups of students. According to the study aim, a linear correlation analysis was calculated to determine the relationship between motor abilities and success in the javelin throw among students with above- and below-average throwing skills.

RESULTS

Table 1 shows the descriptive statistic parameters of the variables for the assessment of motor abilities in the total sample of participants (N=53). The results of the Kolmogorov-Smirnov test (max D) show that there is no statistically significant deviation from the normal distribution of results with all the tests for the assessment of motor abilities: the standing long jump (max, D = 0.08, p <.20), the bench press – 1RM (max, D = 0.13, p <.20), the 30-m run from a standing start (max, D = 0.06, p <.20), the counter movement ***jump*** (max, D = 0.12, p <.20) and the javelin throw (max, D = 0.12, p <.20). With the total sample of participants, the value of the asymmetry coefficient in the MCMJ variable (SKE = 1.56) points to the most expressed result asymmetry towards the numerically lower values of the test. The peak coefficient value (KURT) defines a somewhat more pronounced grouping of results around the arithmetic means only in the MCMJ test (KURT = 5.61).

Table 1. Statistical parameters (means, standard deviation – SD; minimal result – MIN; maximal result - MAX; skewness - SKE; kurtosis – KURT; KS test – max D) of motor variables for first-year students of kinesiology.

Variables	Mean	SD	MIN	MAX	SKE	KUR	D max
MSLJ (cm)	252.53	13.24	220.00	287.00	0.20	0.44	0.08
MBP (kg)	82.55	15.46	50.00	125.00	0.44	0.22	0.13
M30M (sec)	4.40	0.13	4.13	4.73	0.25	-0.10	0.06
MCMJ (cm)	39.58	6.24	27.50	66.00	1.56	5.61	0.12
MJAV (m)	33.53	4.48	22.70	43.20	0.03	-0.19	0.08

Legend: *MSLJ – standing long jump; MBP – bench press-1RM; M30M – 30-m high start run; MCMJ - counter movement jump; MJAV – javelin throw and D max for N = 53, p < 0.188.*

The t-test results for independent samples (table 2) did not identify any significant differences between the two groups of participants in the 30-m run speed (t = 0.07; p = 0.945), explosive leg strength (MSLJ: t = - 0.71; p = 0.481; MCMJ: t = 0.33; p = 0.743) and the maximum strength or arm and the shoulder girdle (MBP: t = - 1.33; p = 0.107). Significant differences between the two groups of participants were confirmed only in the javelin throw variable (MJAV: t = - 6.01; p = 0.001). After the inspection of the arithmetic means for the two groups of participants (E1: AS = 31.38; E2: AS = 37.39), it can be

said that students with the above-average motor skills achieve significantly better javelin throw results.

Table 2. Basic and specific motor abilities for the two groups of students - mean values (AS), standard deviation (SD) and the t-test for independent samples (t – value).

Variables	E1 (N=34) Mean±SD	E2 (N=19) Mean±SD	t - value	p
MSLJ (cm)	251.56±12.34	254.26±14.91	-0.71	0.481
MBP (kg)	80.44±15.73	86.32±14.61	-1.33	0.107
M30M (sec)	4.40±0.13	4.40±0.13	0.07	0.945
MCMJ (cm)	39.79±7.08	39.19±4.52	0.33	0.743
MJAV (m)	31.38±3.42	37.39±3.47	-6.01	**0.001**

Legend: *MSLJ – standing long jump; MBP – bench press-1RM; M30M – 30-m high start run; MCMJ - counter movement jump and MJAV – javelin throw.*

The results of Pearson's correlation coefficient (r) indicated that with the E1 group of students (N=34) there is no statistically important correlation between motor abilities and the results of the javelin throw. However, with the E2 group of students (N=19), explosive strength (MSLJ: r = 0.58; p = 0.010) and speed (M30M: r = - 0.47; p = 0.041) have a significant correlation with the success in the javelin throw. Even though the partial correlation between a 30-m sprint from a standing start and the results of the javelin throw is a negative number, the correlation between the analyzed variables is positive because the measure for running speed assessment (M30M) is reversely scaled.

Table 3. Pearson correlation coefficients (r) between motor abilities and results in this athletic discipline – the javelin throw for the two groups of students.

Variables	Javelin throw - result (m)			
	E1 (N = 34)		E2 (N = 19)	
	r	p	r	p
MSLJ (cm)	-0.12	0.496	0.58	**0.010**
MBP (kg)	0.11	0.535	0.04	0.846
M30M (sec)	-0.28	0.114	-0.47	**0.041**
MCMJ (cm)	-0.12	0.503	0.35	0.147

Legend*: MSLJ – standing long jump; MBP – bench press-1RM; M30M – 30-m high start run and MCMJ - counter movement jump*.

DISCUSSION

This research analyzed the correlation between motor abilities and the results of the javelin throw on a sample of first-year kinesiology students. Given that the correlation between motor abilities (speed, explosive and maximum strength) and the level of success in the javelin throw was confirmed only for students with above-average throwing skills, it can be assumed that the level of success in the javelin throw is unavoidably caused by the efficiency of the body to perform a series of different movement structures

characteristic for the analyzed athletic discipline. Considering the total rate of learning and the repetition of javelin throw skills achieved during the three-week experimental program, it may be assumed that both groups of participants remained in the initial stage of motor learning. The idea of movement is generated in this stage of motor learning (Gentile, 1972), the goal is to understand the basic coordination "style" (Newell, 1985), i.e. to create initial conceptions and perform motor structures at the fundamental level (Neljak et al., 2008). The performance of motor activities during the initial learning stage demonstrates significant irregularity, slowness, inconsistency and uncertainty. It is obvious that the students from the E1 and E2 groups of participants did not have enough self-confidence so they were indecisive and insecure when they demonstrated their knowledge of throwing. To elaborate, regardless of the differences in particular learning theories, all authors agree with the fact that a high level of motor learning may only be achieved through a long-term practice process. Čoh (2004) states that it is necessary to make between 40,000 and 50,000 repetitions in order to achieve stability and automation of a single movement structure in sports, which corresponds to a multiannual time period. Even though the knowledge learning rate was equal in both groups of participants, it can be presumed that the given differences probably resulted from the impact of the transfer of knowledge of other specific kinesiological activities of students from the E2 group. The aforementioned is confirmed by the findings of former studies which assert that cognitive functions (Adams, 1971) and high-order motor factors (Metikoš and el., 2003), and especially the general coordination factor, are strongly involved in the initial stage of performance of a certain motor program. In accordance with the results of the correlation analysis, it is possible to confirm former findings (Silvester, 2003) which point to the fact that no movement in throwing activities can be performed without involving some form of muscle strength (primarily explosive), whereby the specific knowledge of the javelin throw has to be of a high degree in order to emphasize the abilities which are relevant for success in athletic throwing. This means that the explosive strength or, in other words, the ability to exert maximal energy in one movement during the shortest time interval, is particularly important in the phase of the greatest acceleration of the javelin delivery (Ivanović, 2009). The majority of studies on the relation between motor abilities and the results in athletic throwing disciplines corroborated the information on the cardinal influence of the explosive strength factor (Milanović et al., 1986; Harasin et al., 2003). This relationship arises from the kinematic and dynamic features of the throwing disciplines in which it is necessary to generate a great amount of energy in a short period of time if the person wants to achieve a noteworthy result (Katić et al., 2005). The results of this research correspond to the results of Bošnjak's research (2006) which claims that explosive leg strength has a significant impact on the throwing results and that the standing long jump test may be used as an extremely valid and reliable test for the selection of potential javelin throwers. Tešanović (2009) also states that the results of the standing long jump greatly affect the result achieved in vortex throwing. Ivanović (2009) stresses that the 20-m running start sprint, the standing triple jump, the standing long jump, standing on one leg on a balance bench with eyes open and mixed chin-ups have a significant impact on the javelin throw results of adolescents. It is important to note that the majority of authors (Silvester, 2003; Rogers, 2000; Bondarčuk et al., 1994) argue that even the slightest deviation from the correct technique may shorten the javelin flight considerably. This is corroborated by the results of this research which confirmed the non-existence of a statistically significant correlation between motor abilities and the results in the throwing

disciplines of students demonstrating under-average skills of the javelin throw. Contrary to popular belief which depicts the javelin throw as a simple throw with the hand, the results of this research show that the maximum potential of a javelin thrower may be reached only if the student also has above-average knowledge of throwing. This means that first-year kinesiology students must necessarily have a good sense of javelin throwing which includes the activity of the whole body, in addition to developed speed and explosive strength. However, we must not forget the fact that this research did not encompass coordination and flexibility on which, as it is well-known (Bompa, 1985), the results of the javelin throw greatly depend. Based on everything mentioned, we may say that this research offers partial insight into the relationship between certain motor abilities and javelin throw results. This suggests the application of a wider battery of motor tests in upcoming studies, which would surely contribute to a complete examination of this issue. Nevertheless, the results of this research may be applied in the process of planning the athletics course curriculum, and in the definition of training work methods which constitute an essential and integral part of the sport preparation system of athlete throwers. In addition, the authors believe that it is necessary to increase the total rate of learning and repetition of the javelin throw skills through the aforementioned topics and by implementing other concrete exercises. It is advised to throw various medicine balls (2 to 4 kilograms) with two hands from a standing position and after a few steps (e.g. the standing medicine ball throw, windup medicine ball throw, the three-step medicine ball throw). Since the best exercise for the javelin thrower is throwing, much of the technical work is geared toward improving the throwing skill and specific qualities of that skill. Overweight objects such as the javelin and weighted balls (100 to 400 grams) are used to improve power, to teach the "crack the whip" delivery rhythm, and to improve specific flexibility. It is also recommended to do specific flexibility exercises, such as elbow stretches with a javelin, partner chest and shoulder stretch, back arch and shoulder stretch with a javelin (Silvester, 2003).

CONCLUSION

The fundamental objective of this research was to determine the correlation between motor abilities and the results in the javelin throw of first-year students of kinesiology. A set of four motor tests and a single test for the assessment of the level of success in the athletic discipline, the javelin throw, were conducted on a sample of 53 first-year students of the undergraduate study program at the Faculty of Kinesiology of the University of Split in accordance with the fundamental objective of the research. The results of the research demonstrated that there is a statistically significant correlation between speed and explosive strength and the level of success in the javelin throw only for students with above-average knowledge of the javelin throw. Based on the given results, it may be generally concluded that the students have to first acquire various movement structures which will lead to the correct performance of the run-up stage, the correct throw which starts with a throw from the legs and hips, with an effective transfer of the centre of the body mass to the front, torsion with a maximum arm extension delay, blocking of the left side (for right-handers), and long-term acceleration of the throwing hand, if they want to achieve their maximum in the javelin throw. In addition, the authors believe that it is necessary to include the evaluation of coordination and flexibility in future studies in order to

get a clearer picture of the actual relation between motor abilities and the level of success in throwing disciplines. Also, the authors believe it is necessary to increase the overall scope of work which would be focused on the acquisition and repetition of throwing knowledge via the used topics and other kinesiological operators specific for the javelin throw.

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POVEZANOST MOTORIČKIH SPOSOBNOSTI I REZULTAT BACANJA KOPLJA U ZAVISNOSTI OD TEHNIKE BACANJA

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Istraživanje sprovedeno sa ciljem utvrđivanja povezanosti između motoričkih sposobnosti i uspeha u bacanju koplja kod studenata. Ukupan broj ispitanika bio je 53 koji su podeljeni u dve grupe. Prvu grupu N = 34 činili su studenti koji nisu imali dovoljno znanja o bacanju koplja, dok drugu grupu N = 19 činili su studenti koji su imali dobru demonstraciju tehnike bacanja koplja. Motoričke sposobnosti su određene testovima za procenu brzine, eksplozivne i maksimalne snage. Povezanost između motoričke sposobnosti i rezultata u bacanju koplja utvrđena je pomoću standardne korelacione analize. U odnosu na dobijene rezultate, moze se zaključiti da motoričke sposobnosti (startno ubrzanje i eksplozivna snaga) su imali značajan uticaj na rezultate kriterijumske varijable samo kod studenata čije je znanje tehnike bacanja koplja bilo na visokom nivou.

Ključne reči: *Studenti, tehnika bacanja, motoričke sposobnosti, korelaciona analiza.*