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Study of the level of correlations between performance and force/velocity parameters in the long jump event women u16-u18

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Abstract

Background. Long jump is an athletic event that requires strength and speed abilities, both alone and in combination, and the way they condition each other has effects on athletic performance. The explosive force is decisive in this event and the speed on the run up, as well as obtaining the optimal speed near the takeoff board, creates optimal conditions to perform a successful jump.

Aims. The aim of this study was to identify whether and to what extent correlations exist between force speed parameters and competition performance in under 16-18 years old women long jumpers.

Methods. The research took place in two stages under similar conditions for all sub jects; the first stage at the Romanian National Indoor Athletic Championship 2023 and the second stage at the Romanian National Outdoor Women's Athletic Championship 2023. 15 subjects were chosen for this study all long jumpers participating in the National Athletic Championships of Romania aged 16-18 years (x=13.87, SD=0.75). The measurements took place at both competitions under the same conditions and with the same measuring devices and the following parameters were investigated: speed on the last 10 m of momentum, 1 maximal repetition, verti.cal jump and afferent flight time, performance obtained in the competition.

Results. The study identified significant correlations in both indoor and outdoor testing between test performance and speed over the last 10 m of the run up, $r = -0.547$, $n = 15$, $p = 0.035$ and $r = -0.547$, $n = 15$, $p = 0.035$, between vertical jump and flight time, $r = 1$, $n = 15$, $p < 0.001$. The correlations between the performance obtained in competition and the other variables are statistically insignificant for both tests, for indoor testing: $r = 0.151$, $p = 0.591$ for flight time of the vertical jump, $r = 0.209$, $p = 0.455$ for one maximal repetition, $r = 0.165$, $p = 0.556$ for vertical jump and for outdoor testing: $r = 0.151$, $p = 0.591$ for the flight time of the vertical jump, $r = 0.209$, $p = 0.455$ for 1 maximal repetition, $r = 0.165$, $p = 0.556$ for vertical jump.

Conclusions. Based on the results recorded in this study, strong negative linear correlations were determined between the speed on the last 10 m of the run-up and the performance obtained in the event, reinforcing the claim that a high speed on the run-up can lead to better performance in the long jump event. The lack of correlations between force parameters and long jump performance suggests that physical training at the level of the researched group is precarious and confirms the need to intervene on how to develop its specific strength.

Keywords: long jump, performance, speed, specific force.

Introduction

Long jump is an athletic event characterized by two motor skills: strength and speed. Performance in the long jump is determined by the athlete's ability to develop a high horizontal speed on the run-up and perform an explosive takeoff from the jump board. All phases of long jump are decisive in obtaining high performances, these being conditioned by the physical training of each athlete (Nadzalan et al., 2016; Nadzalan et al., 2018; Abd Razak & Hashim 2017). The possibilities of strength and speed, as well as the combination of these two abilities of the athlete, are considered in the literature to be an important aspect in achieving high performance. Several studies have shown relationships between dominant abilities of the event and the performance (Kons et al., 2018; Veeger et al., 2018; Osman et al., 2019; Mahfudz et al., 2019).

The ability to develop increased speed and explosive force indices in the long jump event is necessary to achieve outstanding performance. An important role in this test is played by the horizontal speed on the run-up and, more specifically, the speed on the last steps of the run-up before takeoff. Although achieving optimal run-up speed

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before takeoff is a determining factor of the long jump, it is also imperative to measure and interpret (Brown et al., 2004) kinetic determinants of sprint performance, such as rate of force development, force generation, and correct application of forces, since the ability to accelerate and reach the highest possible speed in the shortest time depends on the correct application of the impulse force to the ground (Hicks et al., 2020; Morin et al., 2011). In determining the profile of the sprinter, Hicks et al. (2020) conclude that an athlete to achieve high mechanical power during acceleration requires improvement of maximum force with optimal loads, and the correlations identified in this study between force/speed parameters were significant.

In addition to data on the speed of the run-up, the development of muscle strength of the lower limbs is of particular interest for long jumpers, especially the development of explosive force in the lower limbs.

In the literature, lower limb strength has been assessed by measuring vertical jump and depth performance (Kale et al., 2009; Lockie et al., 2014; Lockie et al., 2016), finding strong correlations between performance in the long jump event and force-speed parameters. In addition, long jump performance was associated with the speed on the last 10m of the run-up before takeoff (Hudgins et al., 2013; Kale et al., 2009; Loturco et al., 2015), as well as acceleration speed and horizontal speed on the run-up (Peterson et al., 2006). This association can be explained by the explosive nature of both the long jump and the sprint, as well as the rapid hip extension required for both events.

Although the performance obtained in the long jump event is linearly correlated with the horizontal speed on the run-up, there is little information on the relationship between the specific force of the long jumper and the speed parameters recorded on the run-up (Muraki et al., 2008). The literature has indicated that better performance is correlated with better lap times on the run-up, but it is necessary to observe whether there is a relationship between maximum force, explosive force and performance in competition (Di Prampero et al., 2015; Mackala et al., 2015). A higher explosive force produced at the moment of takeoff leads to better performance (Refiater, 2012; Augustsson, 2013; El-Ashker et al., 2019; Muhamad, 2010). Similarly, higher horizontal ground reaction forces produced during the sprint would result in greater propulsion and obviously better speed times on the run-up.

Hypothesis

If we determine the nature and value of linear correlations that are established between performance in long jump and speed on the last 10 m of the run-up, vertical jump, flight time and 1RM, we shall be able to objectively identify the causes of poor results recorded by U16-U18 long jumpers in Romania.

Material and methods

Given that some measurements were made in competition, with the agreement of the Romanian Athletic Federation (RAF), we mention that the subjects, coaches and competition officials were informed about the way the research was conducted, the risks to which the athletes are subjected and we ensured to keep the confidentiality of the recorded data. The parents of the study subjects consented to the participation of underage athletes in our research.

Research protocol

a) Period and place of the research

The present study was conducted on a number of 15 athletes age category under 16-18 years (U16-U18), long jumpers participating in the National Athletic Championships of Romania (NC) on indoor and outdoor grounds between February and July 2023. The research consists of two tests, an initial one (IT) at the indoor competition and a final one (FT) at the outdoor competition. The initial testing took place at the Bucharest Athletics Hall in February, and the final outdoor testing took place in July, also in Bucharest, at the Lia Manoliu Stadium of RAF. All subjects voluntarily participated in this study.

b) Subjects and groups

Table I presents somato-anthropometric data of experimental group (E), aged 16-18 years, weighing between 43-59 kg with mean weight value of 52.67 kg, standard deviation ±4.402 kg with variability coefficient of 0.08%, waist between 161-176 cm with mean waist value of 167.47 cm, standard deviation ± 4.470 cm with variability coefficient of 0.02%, with the foot plant range from size 36-41 with the mean foot plant value of 39, the standard deviation ±1.558 with the variability coefficient of 0.03%.

Table I

Anthropometric characteristics of subjects.

E	N	Min.	Max.	Mean	SD
Weight (kg)	15	43	59	52.67	4.402
Hight (cm)	15	161	176	167.47	4.470
Foot plant (cm)	15	36	41	39.00	1.558

Values are expressed as means ± standard deviations

According to anthropometric indicators, the experimental group is a homogeneous group with values grouped around the average, and the values of anthropometric indicators fit the group into the standards of the long jump event respecting the requirements of the event.

Because the anthropometric parameters do not change essentially within 5 months, they were not registered at the Outdoor competition.

c) Applied tests

Specific motor measurements were performed at both competitions, Indoor and Outdoor, using specialized equipment Opto-jump Next, GykoRePower Sistem and the Witty Timing System to investigate the level of parameters subject to research. The data was collected two weeks before the goal competition.

The parameters investigated for this study were the speed on the last 10 meters of the run-up recorded during competition with the Witty timing system, vertical jump (VJ) and related flight time (FT) tested with the OptoJump Next sports performance rating system, a maximum repetition (1RM) measured with the GykoRePower system. The performance in competition (P) was obtained from the official web site of FRA.

d) Statistical processing

Statistical analyses were performed with SPSS software (Version 20.0; IBM SPSS, Inc., Chicago, IL, USA) with which Pearson correlations between investigated parameters were determined. The arithmetic mean (mean), variability coefficient and standard deviation (SD) were calculated for all variables. The use of the statistical-mathematical method in our research aimed at analyzing and interpreting quantitative data for measuring parameters determined with the help of identified recording and measuring devices and equipment.

Results

The following table (Table II) presents the results recorded in the competition and the values of the parameters investigated for this study for all subjects both at the Indoor and Outdoor NC U16-U18 women.

The average speed value over the last 10 m (Table III) in indoor testing was 8.4320 m/s with a minimum of 7.43 m/s and a maximum of 9.81 m/s with a standard deviation of ± 0.67162 m/s, and in outdoor testing the average speed value over the last 10 m was 8.4227 m/s with a minimum of 7.28 m/s and a maximum of 9.77 m/s with a standard deviation ± 0.62844 m/s.

The vertical jump and flight time in indoor testing recorded an average height value of 37.3733 cm and a standard deviation of ± 5.63693 cm and a flight time with an average value of 0.55080 s and a standard deviation of ±0.040534 s. The minimum value of the vertical jump was 31.4 cm, and the maximum 48 cm., and the minimum flight time value of 0.506 s and maximum of 0.626 s, and in outdoor testing the vertical jump value and flight time at group E had an average height value of 37.3800 cm and a standard deviation of ± 5.62751 cm and a flight time with an average value of 0.5507 s and a standard deviation of ± 0.04028 s. The minimum vertical jump value was 31.6 cm, and the maximum 48 cm., while the minimum flight time value of 0.51 s and maximum 0.63 s.

Muscle profile in indoor testing with average 1RM value of 68.133 kg with a standard deviation of ±17.77585.

Table II

Measured physical parameters, Indoor and Outdoor testing, group E.

Athlete	V 10 M TI (m/s)	V 10 M TO (m/s)	V J TI (cm)	V JTO (cm)	F T TI (s)	F T TO (s)	1RM TI (kg)	1RM TO (kg)	P TI (cm)	P TO (cm)
CN1	9.81	9.77	31.4	31.6	0.506	0.508	75	78	382	387
CN2	9.08	8.92	41.4	41.6	0.581	0.583	62	64	488	356
CN3	8.12	8.32	42.4	42.4	0.588	0.585	93	88	530	518
CN4	9.25	9.18	48	47.7	0.626	0.623	81	85	575	573
CN5	7.70	8.03	34.2	34	0.528	0.526	49	54	530	510
CN6	8.90	8.72	43	43.3	0.592	0.595	89	91	510	502
CN7	8.94	8.88	36	35.8	0.542	0.540	35	34	506	476
CN8	8.36	8.35	47.9	48	0.625	0.626	70	72	583	542
CN9	8.33	8.33	35.2	35.4	0.536	0.538	68	74	458	458
CN10	8.04	8.11	34	33.2	0.527	0.520	92	93	564	558
CN11	8.06	8.01	33.4	33.4	0.522	0.522	48	47	503	474
CN12	7.68	7.66	35.2	34.7	0.536	0.531	77	77	514	525
CN13	7.98	8.03	32.6	32.5	0.516	0.515	44	48	539	542
CN14	7.43	7.28	32	32.8	0.511	0.518	67	69	565	557
CN15	8.80	8.75	33.9	34.3	0.526	0.530	72	71	501	487

CN-subjects of research, V 10 m - speed on the last 10 m of the run-up, V J – vertical jump, TF-flight time, 1RM - a maximum repetition for a squat, P - performance obtained in the event, TI - indoor testing, TO: - outdoor testing.

Table III

Descriptive statistics with analysis of differences of physical parameters group E.

Indicators evaluated	N	Min.	Max.	Mean	SD.
V 10 m-T I(s)	15	7.43	9.81	8.4320	.67162
V 10 m T O (s)	15	7.28	9.77	8.4227	.62844
F T-T I (s)	15	.506	.626	.55080	.040534
V J-T I (cm)	15	31.40	48.00	37.3733	5.63693
F T-TO (s)	15	.51	.63	.5507	.04028
V J-TO (cm)	15	31.60	48.00	37.3800	5.62751
1RM-TI (kg)	15	35.00	93.00	68.1333	17.77585
1RM-TO (kg)	15	34	93	69.67	17.430
P-TI (cm)	15	382	583	516.53	50.871
P-TO (cm)	15	356	573	497.67	61.604

E - subjects of research, V 10 m - speed on the last 10 m of the run-up, VJ - vertical jump, FT-flight time, 1RM - a maximum repetition for a squat, P - performance obtained in the event, TI - indoor testing, TO: - outdoor testing.

The maximum value of 1RM was 93 kg with the minimum of 35 kg. Muscle profile in outdoor testing with average 1RM value of 69.67 kg with a standard deviation of ±17.430. The maximum value of 1RM was 93 kg with the minimum of 34 kg.

The performances obtained in the competition were recorded for the E group both in the Indoor and Outdoor competition, for the indoor one with the average performance value of 516.53 cm (±50.871 cm), and for the outdoor one with the average performance value of 497.67 cm (±61.604 cm). The maximum value for indoor performance testing for group E was 583 cm with a minimum of 382 cm, and for outdoor testing the maximum performance value was 573 cm with a minimum of 356 cm.

The comparative analysis between the TI and TO results at group E shows no significant differences between the two tests. Thus, the difference in averages in the performance recorded in the sample between TI and TO shows a regress of -18.8663 cm, the difference of the averages 1 RM between TI and TO registers a progress of 1.53367 kg, the difference in the averages at vertical jump registers a progress of 0.007 cm, the difference in the averages of flight time is 0.000133 s insignificant progress. The difference in average velocity over the last 10m is -0.4587 s and in this case, there is a regression.

We identified linear correlations that manifest between the parameters of the specific motor capacity measured and the performance in the sample. In Table IV statistical results indicate that at the level of group E indoor testing there are correlations between performance in the test and speed on the last 10 m of the run-up, $r = -0.530$, $n = 15$, $p = 0.042$, between vertical jump and flight time, $r = 1$, $n = 15$, $p < 0.001$. The correlations between performance and the other variables are statistically insignificant, $r = 0.420$, $p = 0.112$ (FT), $r = 0.091$, $p = 0.747$ (1RM), $r = 0.430$, $p = 0.110$ (VJ).

In Table V statistical results indicate that at the level of group E outdoor testing there are correlations between test performance and speed on the last 10m of the run-up, $r = -0.547$, $n = 15$, $p = 0.035$, between vertical jump and flight time, $r = 1$, $n = 15$, $p < 0.001$. Among the performance and the other variables, the correlations are statistically insignificant, $r = 0.151$, $p = 0.591$ (FT), $r = 0.209$, $p = 0.455$ (1RM), $r = 0.165$, $p = 0.556$ (VJ).

The analysis performed with the t-Student test between TI and TO for group E does not record statistically significant differences for any of the investigated parameter's p>0.001.

Table IV

Correlations between parameters investigated in research group E indoor testing.

Indicators evaluated		P (cm)	V 10 m	F T (sec)	1RM (kg)	V J(cm)
P (cm)	Pearson Correlation	1	-.530*	.428	.091	.430
	Sig. (2-tailed)	–	.042	.112	.747	.110
V 10 m (m/sec)	Pearson Correlation	-.530*	1	.297	.120	.300
	Sig. (2-tailed)	.042	–	.283	.671	.277
F T (sec)	Pearson Correlation	.428	.297	1	.376	1,000**
	Sig. (2-tailed)	.112	.283	–	.167	<,001
V J (cm)	Pearson Correlation	.430	.300	1,000**	.376	1
	Sig. (2-tailed)	.110	.277	<,001	.167	–
1RM (kg)	Pearson Correlation	.091	.120	.376	1	.376
	Sig. (2-tailed)	.747	.671	.167	–	.167

Sig-significance, V 10 m - speed on the last 10 m of the run-up, V J – vertical jump, FT- flight time, 1RM - a maximum repetition for a squat, P - performance obtained in the event, TI - indoor testing, TO: - outdoor testing.

Table V

Correlations between investigated parameters group E outdoor testing.

Indicators evaluated		V 10 m	F T (sec)	V J (cm)	P (cm)	1RM (kg)
V10m (m/sec)	Pearson Correlation	1	.295	.293	-.547*	.130
	Sig. (2-tailed)	–	.286	.289	.035	.644
F T (sec)	Pearson Correlation	.295	1	1,000**	.151	.365
	Sig. (2-tailed)	.286	–	<,001	.591	.181
V J (cm)	Pearson Correlation	.293	1,000**	1	.165	.370
	Sig. (2-tailed)	.289	<,001	–	.556	.175
1RM (kg)	Pearson Correlation	.130	.365	.370	.209	1
	Sig. (2-tailed)	.644	.181	.175	.455	–
P(cm)	Pearson Correlation	-.547*	.151	.165	1	.209
	Sig. (2-tailed)	.035	.591	.556	–	.455

Sig-significance, V 10 m - speed on the last 10 m of the run-up, V J – vertical jump, FT- flight time, 1RM - a maximum repetition for a squat, P - performance obtained in the event, TI - indoor testing, TO: - outdoor testing.

Discussion

This study aims to determine the relationship between force/speed components on long jump performance. Significant negative linear correlations were determined between the speed over the last 10 m of the run-up and the performance obtained in the event, r = -0.530, p = 0.04 at TI and r = -0.547, p = 0.035 at TO. Positive linear correlations were determined in both indoor and outdoor testing between vertical jump and afferent flight time (r = 1, n = 15, p < 0.001). As expected, the speed on the run-up in the last 10m has an influence on the performance obtained in the competition, and the vertical jump is closely related to the flight time directly proportional. These findings were in line with the study of Mackala et al. (2015), which found a significant correlation between speed over 100 meters and performance achieved in the event. Also, the study conducted by Lockie et al. (2016) reported strong negative correlations between competition performance and speed on 30 m (r = -0.70, p<0.01) and Loturco et al. (2015), reporting a significant negative correlation between speed over 100m and performance in the long jump event (r = -0.81 p<0.01).

The correlations determined for 1RM, vertical jump and flight time with performance in the long jump event were not statistically significant. This finding is not consistent with the notion that lower limb muscle strength is an important factor for long jumpers. Lower limb muscle strength as an aspect of performance contribution is determinant in this event, as noted in the study of Refiater (2012), which have concluded that there is a significant relationship between jumping leg strength and performance in the long jump. The study by Augustsson (2013) found that there was a strong linear correlation between 1RM and jump performance, meaning that peak power was a major predictor of jump length. Based on previous research, it has been proven that muscle strength in the lower limbs can help the athlete produce a higher speed on the run-up followed by an explosive takeoff that positively influences the length/height of the jump (El-Ashker et al., 2019). The results also showed that there is a significant relationship between vertical jump and long jump performance.

The findings of Muhamad (2010) have shown that there are significant linear correlations between vertical jump and the performance. Muraki et al. (2008) stated that in order to achieve the longest possible jump in this event, the long jumper must transfer horizontal velocity to vertical velocity during the takeoff phase. Therefore, maximum power in vertical and horizontal jumps can help maximize takeoff speed to produce longer jumps.

The performance achieved in the long jump was significantly positively correlated with the theoretical maximum horizontal force, maximum power and maximum force ratio. It has previously been reported that superior performance is achieved by applying increased forces in the horizontal direction (Peterson et al., 2006). Similarly, speed on the run-up also requires increased application of horizontal force for optimal performance, since greater horizontal force results in a higher force ratio, hence greater propulsion during the sprint (Singh & Singh, 2012; Hunter et al., 2005; Morin et al., 2011).

Conclusions

1. A high speed on the run up leads to better performance in the long jump event and also determines the involvement of greater forces at the moment of takeoff, and in this case, we can discuss the optimal speed on the run up to the detriment of the maximum one.
2. The specific strength training program of long jumpers should be focused on the development of explosive force of the lower limbs and maximum power.
3. It is recommended that future research be conducted on determining the best or optimal way to improve the specific strength/speed training of long jumpers.

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