

Study on the profile of specific speed level among U20 long jumpers in Romania

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Abstract

The purpose of this study was twofold: first, to determine the physical characteristics of U20 (under 20) long jumpers to identify the level of speed parameters during the last 10 m of the run-up and the last three steps of the run-up, thus profiling the specific speed level of the research subjects; second, to ascertain whether the level of horizontal speed at takeoff influences the performance obtained in the competition, both as a group and as an individual tendency. The study involved eight female long jump athletes who were finalists of CN Outdoor U20 and were aged between 15 and 18 years ($M = 16.87$, $S = 0.75$). The results of the study allowed us to establish the profile of the specific speed level for all participating sportswomen. The specific speed level was found to be weak compared to the requirements of international long jump performance. Additionally, the study highlighted a significant correlation between horizontal speed during the run-up and the performance obtained in competition, $r = 0.748$, $n = 8$, and $p = 0.033$. There was also a significant correlation between the change in horizontal speed at takeoff and the performance obtained, $r = -0.978$, $n = 8$, and $p < 0.001$. Conclusion: The results of this study are consistent with the theoretical models in the specialized literature, revealing deficiencies in the subjects' speed levels specific to the long jump event. This study also opens opportunities for further research aimed at improving the methodology of force and speed development, as well as their combination, to enhance the explosive force of the lower limbs. This is recognized as an essential condition for achieving superior performance in competition.

Keywords: performance, long jump, speed, run-up

Introduction

The training program for long jumpers relies heavily on speed during the run-up, with an emphasis on perfecting the jumping technique based on the "correction-correction" principle (Dobbs, C. W. et al., 2015).

To develop a comprehensive profile of long jumpers, all aspects related to the expression of speed during the trial, the phases of the long jump, particularly the last part of the run-up, specifically the last five steps before and after takeoff from the board, have been examined.

One defining characteristic of the run-up is the necessity for the jumper to attain a high speed. This underscores the fact that long jumpers must be exceptional speed runners. Thus, their physical training is focused on enhancing horizontal speed through specific methods, including short-distance sprints of 30–50–80–100 m at 100% intensity, with a limited number of repetitions (4–6 repetitions), and relatively long breaks to allow for recovery. Concerning the combination of the two motor qualities, force and speed, in the long jump event, it can be asserted that speed, in all its forms of manifestation, plays a pivotal role in most motor actions. Speed is the key determinant in jumping events (these athletes must be exceptional speed runners). When combined with force, speed becomes decisively important in achieving high performance in the long jump event (Turner, A. N., 2021; Rapotan, A. et al., 2023).

Currently, it is widely acknowledged that several essential components significantly impact the length of the jump more than other mechanisms (Horatiu, C., & Mihailescu, L., 2023; Ortega, J., 2020). The most crucial factor appears to be the speed during the run-up and the horizontal speed generated by the athlete before and during takeoff. When studying the long jump, most researchers have focused on the run-up phase, demonstrating that athletes adjust their step lengths through perception-action coupling, where athletes' perceptions and movements continuously adapt. This self-regulation process implies that athletes create self-directed feedback loops oriented toward achieving performance objectives (Zimmerman, B. J. and Schunk, D. H., 2011). For instance, recent research analyzing long jump performance has suggested that athletes use their first jump in a competition to execute a "safe" jump (McCosker, C. et al., 2019) and make deliberate adjustments to their speed during the run-up to control the subsequent foot placement error on the takeoff board (Bradshaw, E., and Sparrow, W., 2000; Davids, K. et al., 2013; Araújo, D. et al., 2019).

Previous studies (Bridgett, L.A. et al., 2006; Wakai, M. et al. 2005; Graham-Smith, P. et al., 2005; Seyfarth, A. et al., 2000, Nemtsev, O., 2018) have asserted that the general long jump technique involves maximizing momentum speed while maintaining control (optimal speed), lowering the body's center of gravity during the last three steps, and placing the contact foot on the board before the G.C.G (general center of gravity).

In a recent report, Tucker, C.B. et al. (2019) demonstrated a strong correlation between horizontal speed during the run-up and performance. The primary objective for long jumpers is to develop and sustain horizontal speed as they approach the takeoff board. It has been consistently observed worldwide that the most successful long jumpers are exceptional sprinters with outstanding explosive force qualities (Selenica, R., & Quka, N. 2022). Correlations between variously calculated measures of run-up speed and performance are typically significant and have been well-documented by Hay, J.G. (1985) and Bayraktar, I., & Çilli, M. (2018). In their studies, Koh, T.J. and Hay, J.G. (1990) found a significant linear correlation of 0.44 between the takeoff speed and jump length, although Hay, J.G. and Nohara, H. (1990) found no such relationship. In a theoretical approach, Alexander, R. (1990) also suggested an optimal horizontal takeoff speed for long jumpers, closely approximating their maximal speed. Hay, J.G. and Nohara, H. (1990) identified positive linear correlations, such as the relationship between the distance of the center of gravity and the contact foot on the last step's threshold and jump length ($r = 0.51$). They argued that this relationship exists because the last step before detachment is the final running step where necessary adjustments occur, potentially reducing horizontal speed.

In addition to these aspects of run-up speed, previous studies have also examined speed characteristics in relation to the structure of steps near the takeoff board. In a similar study, Panoutsakopoulos, V. (2007) observed significant correlations between the horizontal speed at takeoff, the structure of the last three steps in a group of junior long jumpers, and the loss in horizontal velocity and foot contact on the takeoff board. The abovementioned study also revealed a significant correlation between the takeoff speed and takeoff angle.

A high horizontal speed shortens the ground contact time for athletes, thereby limiting the generation of vertical speed during takeoff. Generating vertical speed is essential in the takeoff preparation and takeoff phases to provide athletes with the necessary height and airtime to execute the technique. To increase ground contact and assist in generating vertical speed, athletes position their foot farther forward from the center of gravity during the phase of contacting the takeoff board, resulting in a shallow angle of foot placement. However, this adjustment reduces horizontal velocity (Jasminan, V., & Chandana, A. W. S. 2021), creating negative horizontal momentum. Consequently, vertical speed is required for jump height, and horizontal speed is crucial for jump distance. The trade-off between horizontal and vertical speeds is essential for a successful jump (Linthorne, N. 2008).

According to Idrizović K. (2010) and Pavlović R. (2016), Carl Lewis, during his 8.91-m jump in Tokyo in 1991, covered the last ten meters (11–1 m range) with a takeoff speed of 0.89 s, representing a speed of 11.26 m/s, which is equal to 95.3% of his maximum speed. Giovanni Evangelisti, during his 8.08-m jump, covered the same 10 m with a speed of 10.75 m/s and a takeoff speed of 0.93 s, which is 97.5% of his top running speed. The record holder, Mike Powell, who set the record of 8.95 m, traversed the same distance with a takeoff speed of 0.92 m/s and a horizontal speed of 10.87 m/s. These data indicate that speed is significant. However, more importantly, the ability to transition speed during the run-up affects jump length, as confirmed in this study. The average speed of the finalists at the World Championships in Berlin in 2009 in the 11–6 m section was 10.42 m/s (with a maximum of 11.06 m/s for D. Phillips) and 10.39 m/s in the range of 6–1 m (with a maximum of 10.93 m/s for D. Phillips). In this case, a decrease in speed is evident. Among the women finalists, speed increased from 9.31 m/s (11–6 m, with a maximum of 9.78 m/s for B. Reese) to 9.37 m/s (6–1 m, with a maximum of 9.76 m/s for B. Reese). These results support the findings published by Panoutsakopoulos, V. & Kollias, I. A. in 2007, confirming that speed decreases near the takeoff board owing to the increasing stride length (Hussain, I. et al. 2011b; Haridi, A. M. et al. 2012), which also plays an important role in facilitating the transition of horizontal velocity into the vertical component required in the takeoff phase.

Despite the importance of speed components when setting foot on the board and speed at takeoff, specifying speed profiles of long jumpers is surprisingly absent from the literature. Most authors of long jump articles attempt to calculate the average speed of the last stride and takeoff speed; however, none have reported speed profiles for the long jump. This gap in the literature led us to conduct this study.

Materials and methods

Participants

This study was conducted with a group of 8 athletes in the U20 age category, who were participants in the U20 National Outdoor Championship in Pitești, Romania in 2020. Before conducting the preliminary study, the subjects, coaches, and competition officials were informed about the research procedures, associated risks, and data confidentiality.

Table 1 Descriptive statistics of anthropometric data for the subjects

Gen		N	Min	Max	Mean	Std. Dev
Feminine	Weight (kg)	8	48	56	53.13	2.642
	Height (cm)	8	162	176	169.88	4.883
	Valid N (listwise)	8				

Their age and somatic characteristics are presented in Table 1. We note certain factors that limit the generalizability of the results in our study, including the small number of athletes who participated in the U20 CN final and the differences in ages, resulting in varying somatic indicators.

Procedure

In our research, we employed the measurement and assessment method operationalized through the use of the Optojump Next system and the WITTY timing system. This allowed us to measure horizontal speed during the last 10 m of the run-up, determine the speed on each of the last 5 steps, and record the maximum vertical and horizontal speeds on the last step. The processing, analysis, and quantitative measurement of these determined parameters were performed using the SPSS program.

The study was conducted in a single phase, with the speed values during the last 10 m of the run-up and the resulting performance being recorded during the competition.

Results

The results obtained by the participants in the U20 National Championship, 2021 edition, were documented. The best performance recorded was 6.10 m, while the worst was 4.94 m, with an average result of 5.56 m, as shown in Table 2.

Table 2 Results of competitors in the long jump event CN J1

PLACE	RESULT	1	2	3	4	5	6
S.I.	6.10 m	X	6.10 m	6.10 m	X	X	X
V.R.	6.00 m	X	5.86 m	6.00 m	X	X	X
D.A.	5.72 m	5.50 m	5.72 m	5.67 m	X	X	X
S.C.	5.62 m	X	5.58 m	X	5.59 m	X	5.62 m
B.A.	5.50 m	5.33 m	5.43 m	5.50 m	5.49 m	X	X
St.C.	5.37 m	5.15 m	5.20 m	5.34 m	5.30 m	X	5.37 m
A.A.	5.24	5.02 m	5.24 m	5.09 m	5.14 m	X	X
G.C.	4.94	4.76 m	4.90 m	4.94 m	X	X	X

Fig. 1 Long jump performance diagram

Table 3 shows the horizontal speeds for the last 5 steps of all finalists (F). The average maximum speed value was 8.8250 m/s, with a minimum of 7.7 m/s and a maximum of 9.81 m/s, and a standard deviation of ± 0.65440 m/s. The average horizontal speed values per step increased from 7.6825 m/s on the first step to 8.8250 m/s on the fifth step.

Table 3 Statistical description of horizontal speed over the last 10 m

	No.	Min	Max	Mean	Std. Dev
Step 1 speed (m/s)	8	6.76	8.28	7.6825	.50638
Step 2 speed (m/s)	8	7.23	8.23	7.8738	.37830
Step 3 speed (m/s)	8	7.26	8.85	8.1325	.53331
Step 4 speed (m/s)	8	7.43	8.36	8.0250	.33140
Step 5 speed (m/s)	8	7.70	9.81	8.8250	.65444
Maximum speed 10 m (m/s)	8	7.70	9.81	8.8313	.65440
Valid N (listwise)	8				



Fig. 2 Horizontal speed for each step in the long jump

Table 4 shows the components of velocity at takeoff, along with the horizontal velocity losses during contact with the takeoff board. The average horizontal takeoff velocity was 7.82 m/s, while the average vertical takeoff speed was 3.22 m/s. The average change in the horizontal takeoff velocity was -0.7250 m/s.

Table 4 Statistical description for the horizontal, vertical, and maximum speeds on the last step

	Min	Max	Mean	Std. Dev.
Horizontal takeoff speed (m/s)	7.27	8.44	7.8250	.40391
Vertical takeoff speed (m/s)	2.31	3.68	3.2250	.42547
Change in horizontal takeoff speed	-1.67	-.02	-.7250	.53455
TD-TO (m/s)				
Maximum speed 10 m (m/s)	7.70	9.81	8.8313	.65440

Linear correlations between the horizontal takeoff speed and the best performance were determined to examine the influence of the horizontal takeoff speed on athletic performance.

Table 5 Correlations between the horizontal velocity at takeoff and the best performance

		Best performance result	Horizontal takeoff speed
Best performance result	Pearson correlation	1	.748*
	Sig. (2-tailed)		.033
	N	8	8
Horizontal takeoff speed	Pearson correlation	.748*	1
	Sig. (2-tailed)	.033	
	N	8	8

The correlations between the horizontal takeoff speed and the best performance are significant, with $r = 0.748$, $n = 8$, and $p = 0.033$.

Table 6 Correlations between the step speed and the maximum speed over 10 m

		Step speed 5	Maximum speed 10 m
Step 1 speed	Pearson correlation	.872**	.879**
	Sig. (2-tailed)	.005	.004
	N	8	8
Step 2 speed	Pearson correlation	.567	.577
	Sig. (2-tailed)	.143	.134
	N	8	8
Step 3 speed	Pearson correlation	.741*	.756*
	Sig. (2-tailed)	.035	.030
	N	8	8
Step 4 speed	Pearson correlation	.475	.485
	Sig. (2-tailed)	.234	.224
	N	8	8
Step 5 speed	Pearson correlation	1	1.000**
	Sig. (2-tailed)		<.001
	N	8	8
Maximum speed 10 m	Pearson correlation	1.000**	1
	Sig. (2-tailed)	<.001	
	N	8	8

The correlation values indicate a positive relationship between step speed 1 and maximum run-up speed (Table 6): $r = 0.872$, $n = 8$, and $p = 0.004$. For step 3, $r = 0.741$, $n = 8$, and $p = 0.030$; and for step 5, $r = 1.000$, $n = 8$, and $p < 0.001$. However, for steps 2 and 4, the correlations are small and insignificant, $r = 0.485$ – 0.577 , $n = 8$, and $p = 0.224$.

Table 7 Correlations between the change in the horizontal velocity at takeoff and the best performance

		Change in horizontal velocity at takeoff	Best performance result
Change in horizontal velocity at takeoff	Pearson correlation	1	-.978**
	Sig. (2-tailed)		<.001
	N	8	8
Best performance result	Pearson correlation	-.978**	1
	Sig. (2-tailed)	<.001	

Correlations between the change in the horizontal velocity at takeoff and the best performance are strong and negative (Table 7), with $r = -0.978$, $n = 8$, and $p < 0.001$.

Table 8 Correlations between the maximum speed over 10 m and the best performance

		Maximum speed 10 m	Best performance result
Maximum speed 10 m	Pearson correlation	1	.305
	Sig. (2-tailed)		.463
	N	8	8
Best performance result	Pearson correlation	.305	1
	Sig. (2-tailed)	.463	
	N	8	8

The correlation values (Table 8) do not indicate a relationship between the maximum speed on the run-up and the best performance, with $r = 0.305$, $n = 8$, and $p = 0.463$.

Discussion

The results of our study confirm the findings of Herman, I., ET AL. (2020), showing that run-up speed strongly influences long jump performance. Despite the horizontal speed loss during the foot's contact phase with the takeoff board, the correlations between the run-up and takeoff speeds are very strong.

There was a consistent pattern of speed progression closely related to the structure of the last three steps: step three displayed an acceleration of speed (8.13 m/s), and step 4 (8.02 m/s) showed a slight deceleration followed by acceleration on the final step before takeoff (8.82 m/s).

All competitors demonstrated an increase in speed from steps 1 to 5, with a tendency to reach the maximum speed on the final step. This behavior included constant acceleration and slight deceleration on step 4, which is considered normal, given the structure of the last three steps. Notably, one athlete, S.I., exhibited speed fluctuations over the last 10 m, reaching the maximum speed on step 3 (8.85 m/s). This suggests an adjustment or self-regulation of optimal speed, resulting in step 5 (8.80 m/s) near the takeoff board. S.I. was the only athlete who displayed this behavior. A consistent pattern of speed progression closely related to the structure of the last three steps was evident: step three featured an acceleration of speed (8.13 m/s), step 4 (8.02 m/s) displayed a slight deceleration followed by acceleration on the last step before takeoff (8.82 m/s).

The study conducted by Panoutsakopoulos, V., & Kollias, I. (2007), during the European Cup 1st League-Group B Event held in Thessaloniki, Greece, on June 18, 2006, reported similar results for horizontal speed in competition. All competitors registered a change in horizontal speed at takeoff, with an average of -0.72 m/s. The smallest difference was observed for S.I., at -0.16 m/s, who achieved the best performance in the competition. Significant differences were noted between the maximum run-up speed and the horizontal takeoff speed, suggesting a substantial loss of horizontal takeoff velocity. Although horizontal takeoff speed values were similar to those recorded for the 1986 IAAF World Junior Championships long jump medalists (7.53 m/s), the trial results, except for the first and second place finishers, were significantly lower, despite a span of 35 years.

A smaller change in horizontal speed at takeoff correlated with better performance, with significant correlations between these variables ($r = -0.978$, $n = 8$, and $p < 0.001$). Horizontal takeoff speed influenced the performance obtained in the competition, with $r = 0.748$ and $p = 0.003$.

In contrast, correlations between the maximum speed over the last 10 m and the best performance were insignificant ($r = 0.305$). This demonstrates that reaching the optimal speed near the takeoff board is crucial, rather than achieving the maximum speed.

The correlation values between the horizontal takeoff speed and the best performance were significant ($r = 0.748$, $n = 8$, and $p = 0.033$), indicating that a higher horizontal speed at takeoff contributes to better performance.

Correlations between the step speed and the maximum speed over 10 m were significant for steps 1, 3, and 5 ($r = 1.000$, $n = 8$, and $p < 0.001$), suggesting that the maximum speed during the last part of the run-up remained constant.

Conclusion

Based on the analyzed data regarding the specific speed profile of the group of long jumpers in the U20 age category, we can conclude the following:

- The maximum speed on the run-up has no influence on performance, suggesting that the optimal speed before takeoff was not achieved.
- A higher horizontal speed at takeoff ensures better performance.
- The maximum speed on the last part of the run-up remained constant.
- A smaller change in horizontal velocity at takeoff is associated with better performance.
- Increased horizontal velocity at takeoff leads to better performance.

The descriptive data and the expected correlations between the analyzed variables in this study have helped us understand the speed behavior during the run-up and the speed transformations that occur at the moment of takeoff. Additionally, we have identified the impact of these variables on the performance achieved in competition. This information provides a foundation for developing specific physical training methods for jumpers to optimize their performance.

It is important to note that our study cannot be generalized owing to the small number of subjects. However, it does offer objective insights that warrant further research in this area.

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