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## **Comparison of some kinematic variables of the triple jump between the two world championships (IAAF) (2017) and (2018)**

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**Abstract.** The study aimed to compare some of the kinematic variables and achievement between the competitions (2017) and (2018) in triple jump to find the percentages of the teams, which may indicate the reasons for the different level of the two championships. Statistical difference, although we may not find these differences in all variables, especially achievement, but at such global levels the differences of the few numerical parts make a difference in global achievements, numbers and medals. The researcher adopted the descriptive approach using the method of comparisons to extract the results of the study, and the research community consisted of (27) jumpers (12) competitors in the (2017) championship and (15) competitors in the (2018) championship, and the statistical bag (SPSS) was used to extract: (Mean ), (Std.Divition), (Independent-Sample.T.Test). This study found that the Hop angle and Length of speed Jump is the most influential interval in the best achievement. The researcher recommends following up on such international reports and comparisons because they may give solutions and orientation in training for the most influential factors at different levels of achievement.

**Keywords.** Hop, Step, approach speed

### **Introduction:**

The triple jump is one of the track and field events that requires the jumper to repeatedly generate maximum force to maintain horizontal speed throughout all phases of the jump. The jump consists of three phases where the athlete jumps on one foot, lands on the same foot, takes a step on the opposite foot, and finally jumps and lands in the sand pit (Miladinov, 2004). The distance of the triple jump depends on the ability of the jumps to apply the basic pathways during each phase, and in each phase of the jump, there is a change in the movement structure and rhythm occurs, which affects the timing of each central contraction. Therefore, each phase has its own dynamic requirements during support and propulsion, and it is important for the jumper to maintain the correct position when jumping so that their feet are flat on the ground because jumping on the heel or toe will negatively impact the jump. Therefore, the triple jump combines speed, strength, and agility to jump to the maximum extent possible (Liu, 2012).

In such performance cases, there are many factors that can contribute to the potential distance of the jump. Each athlete has their own unique configuration with a few different strengths and weaknesses, and there are individual technical adaptations for players to reduce energy loss in all parts of the skill, meaning that there is no single standard or variable responsible for success.

The men's triple jump finals were held in (2017), and upon reaching the final, there was strong competition between the Americans (Christian Taylor) and (Will Claye) due to their outstanding performance in the season. The final match was a battle between the two for the gold medal. (Taylor) jumped (17.68) meters in the third round after (Claye's) jump of (17.63) meters, which was enough for (Taylor) to win the gold medal. (Claye's) jump was enough to secure the silver medal, and the Portuguese (Nelson Évora) won the bronze medal with a jump of (17.19) meters in the third round (Catherine et al., 2018).

The men's triple jump finals were held in (2018), where the competition for the first place was intense. After the first round, Portuguese athlete (Nelson Évora) took the lead with a jump of (17.14) meters. However, Brazilian athlete (Almir Dos Santos) surpassed him with a jump of (17.22) meters. Then, (Évora) reclaimed the lead in the third round with a jump of (17.40) meters. Following this jump, (Will Claye's) from the United States, a previous winner in this event, exerted his influence and his fourth- round jump of (17.43) meters put him in the first place. (Dos Santos) secured the silver medal with a personal best jump of (17.41) meters in the fifth round. Neither (Évora) nor (Alexis Copello) were able to improve in the final rounds, thus settling for third and fourth place respectively (Catherine et al, 2018).

Based on the extensive research conducted on the internet sites dedicated to these championships, which issue reports for each competition and individual analysis for each player through a scientific biomechanical analysis team, the researcher noticed a difference in the achievement values between the two championships. The superior level was found in the championship held in (2017) by a margin of (0.272) meters. Therefore, it was deemed necessary to present this digital data in a comparative manner between the two championships in terms of the kinematic variables of the players to find the differences that may indicate the reasons for the difference in the level of the championships. Its usefulness is not limited to finding differences in these values alone, but it provides an indicator of the most important variables that statistically differ. Although these differences may not be found in all variables, especially in achievement, at such high international levels, slight numerical differences make a significant impact on achievements.

### **Material and methods:**

The researcher adopted the descriptive method with a comparative approach to extract the study results. The research community consisted of 27 jumpers, with 12 competitors in the 2017 championship and 15 competitors in the 2018 championship. The camera positions and measurements were determined as follows:

1. (2017) Competitions: Seven excellent camera positions were identified and secured along the track straight with the runway, and calibration was performed before and after each competition. A solid cubic calibration frame was placed in the running area several times over predetermined areas along the field to ensure accurate determination of the volume where athletes completed their last step before the take-off board and jump. Nine cameras were used to record the motion as follows:

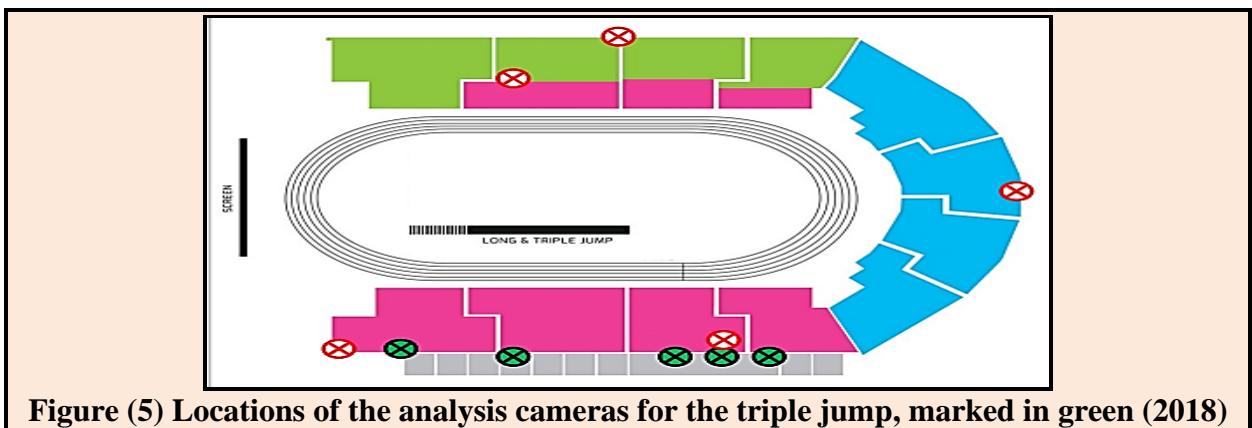
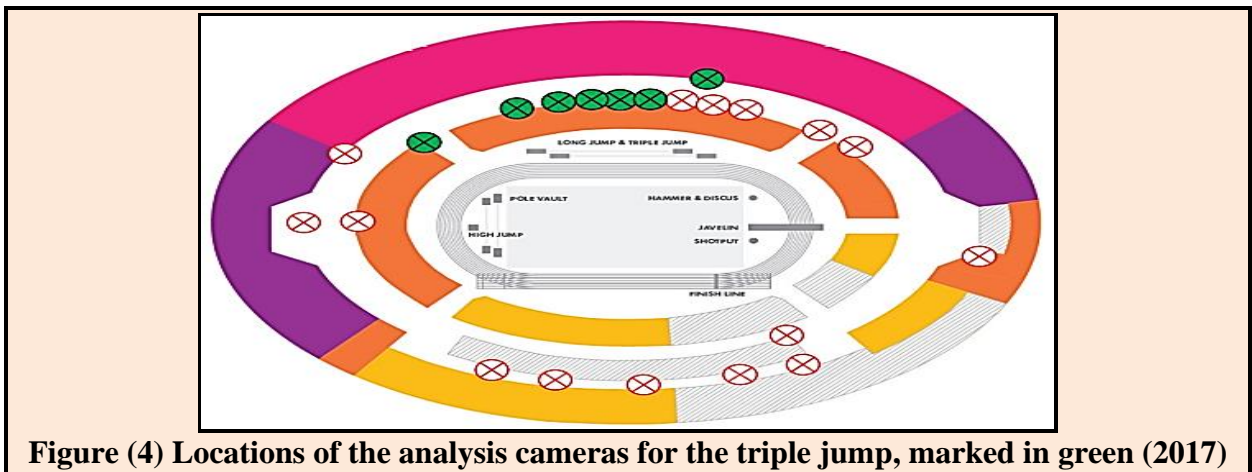
- ✓ Three (Sony-PXW.FS5) cameras operating at (200) Hz (shutter-speed: 1/1750; ISO: 2500; FHD: 1920x 1080px) captured player movement from the calibration area to the take-off board.
  - ✓ Six (EOS.700D-Canon) cameras operating at (60) Hz (shutter-speed: 1/1000; ISO: 1600; SHD: 1280x 720px) captured motion from the hurdles, step, and jump sections including the landing, with these cameras paired to capture these motion areas for athletes.
2. (2018) Competitions: Five distinguished camera positions were identified and secured along the field directly. Calibration was conducted before and after each competition, and a solid cubic calibration frame was placed on the running area multiple times over predetermined areas along the track to ensure accurate determination of the volume where athletes completed their last step before the take-off board, jump, and landing. Seven cameras were used to record motion as follows:
- ✓ Three (Sony-PXW.FS5) cameras operating at (200) Hz (shutter-speed: 1/1750; ISO: 2000-4000; FHD: 1920x 1080px) captured player movement from the calibration area to the take-off board.
  - ✓ Four (Sony.RX10.M3) cameras operating at (100) Hz (shutter-speed: 1/1000; ISO: 2000-3600; SHD: 1920x 1080px) were placed on the field line to capture the movements of the hurdles, step, and jump including the landing. These cameras also operated in pairs to capture these motion areas for athletes.



**Figure (1) (Sony-PXW.FS5)**

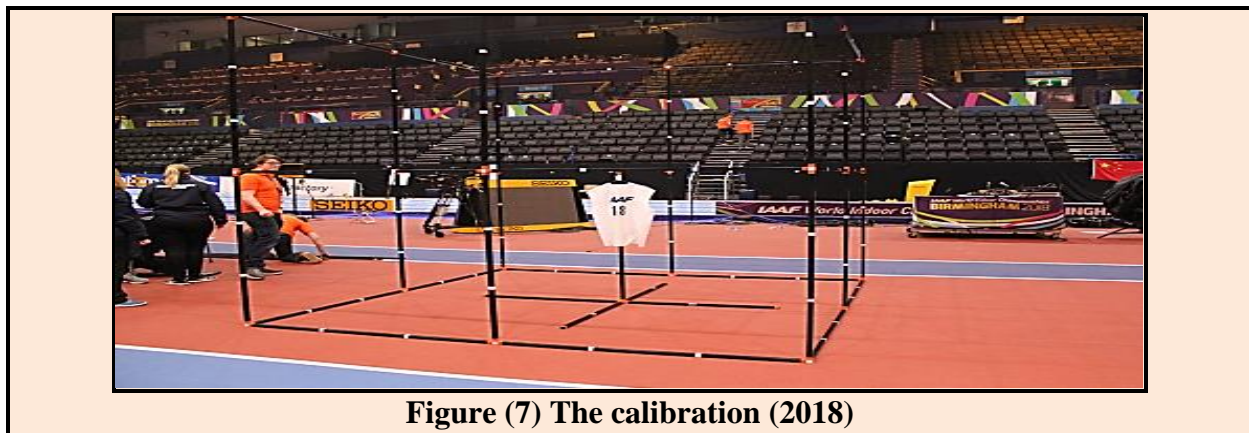


**Figure (2) (EOS.700D-Canon)**





**Figure (6) The calibration (2017)**

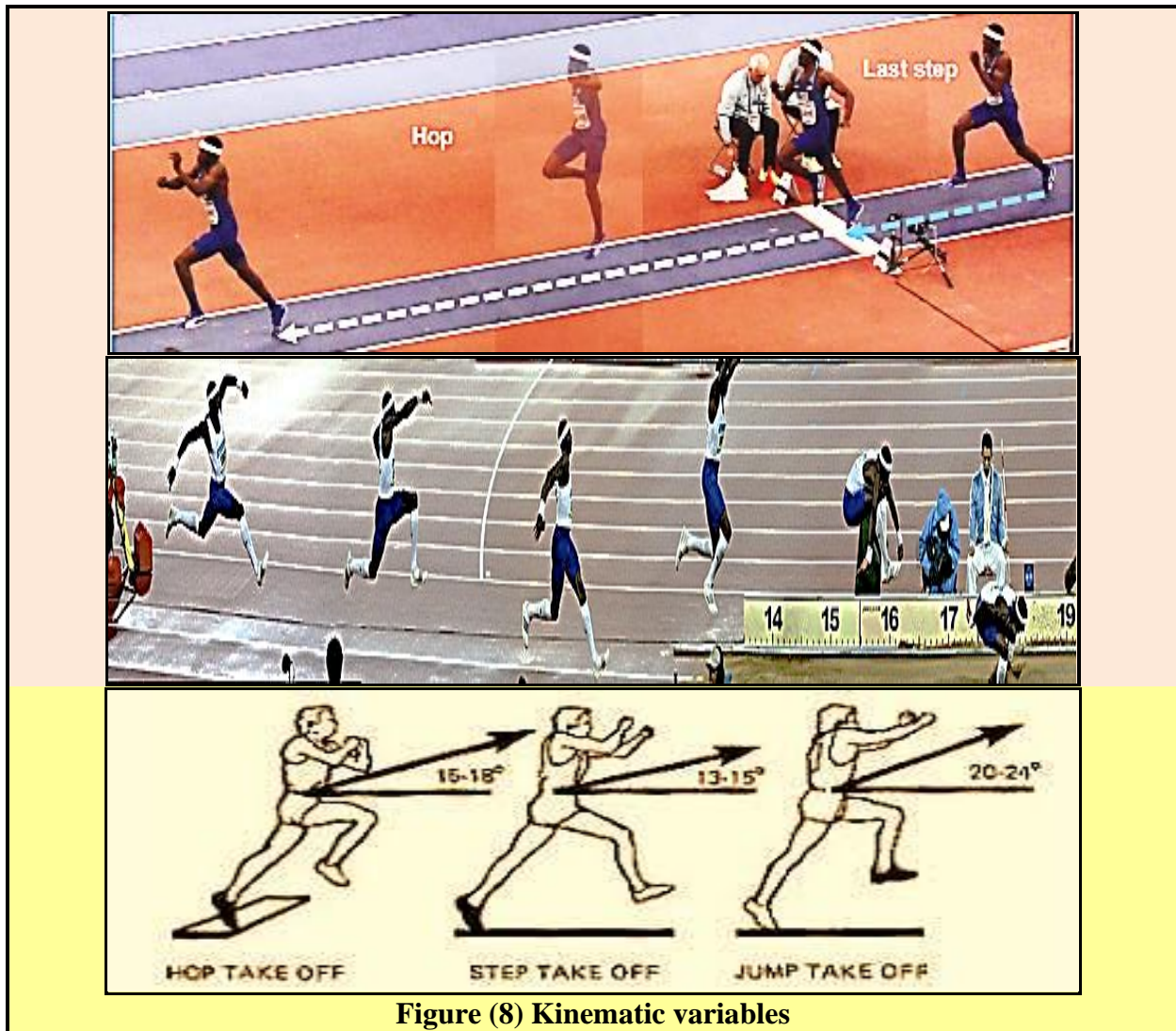


**Figure (7) The calibration (2018)**

The finals of (2017) were held on the night of August (10<sup>th</sup>) in warm and calm weather conditions, while the finals of (2018) were held on the evening of Saturday, March (3<sup>rd</sup>).

✓ The kinematic variables:

<i>s</i>	<i>Vairable</i>
1	<b><u>Official distance</u></b> ; <i>The Official distance published in the results.</i>
2	<b><u>Effective distance</u></b> ; <i>The distance measured from the tip of the foot at take-off to the take-off board plus the official distance.</i>
3	<b><u>Take-off loss</u></b> ; <i>The distance from the foot tip (take-off foot) to the front edge of the take-off board..</i>
4	<b><u>Step length</u></b> ; <i>last step before take-off board measured from the foot tip in each step to the next foot tip.</i>
5	<b><u>length (hop, step and jump)</u></b> ; <i>The length of the hop, step and jump as measured from the foot tip in each step to the next foot tip.</i>
6	<b><u>velocity (Last Step speed before board, hop, step and jump)</u></b> ;
7	<b><u>Take-off angle</u></b> ; <i>The angle of the athlete's (CM) at take-off relative to the horizontal of the hop, step and jump.</i>



**Figure (8) Kinematic variables**

✓ Statistical methods:

The statistical package (SPSS) was used to extract: (Mean), (Standard Deviation), (Independent-Sample T-Test).

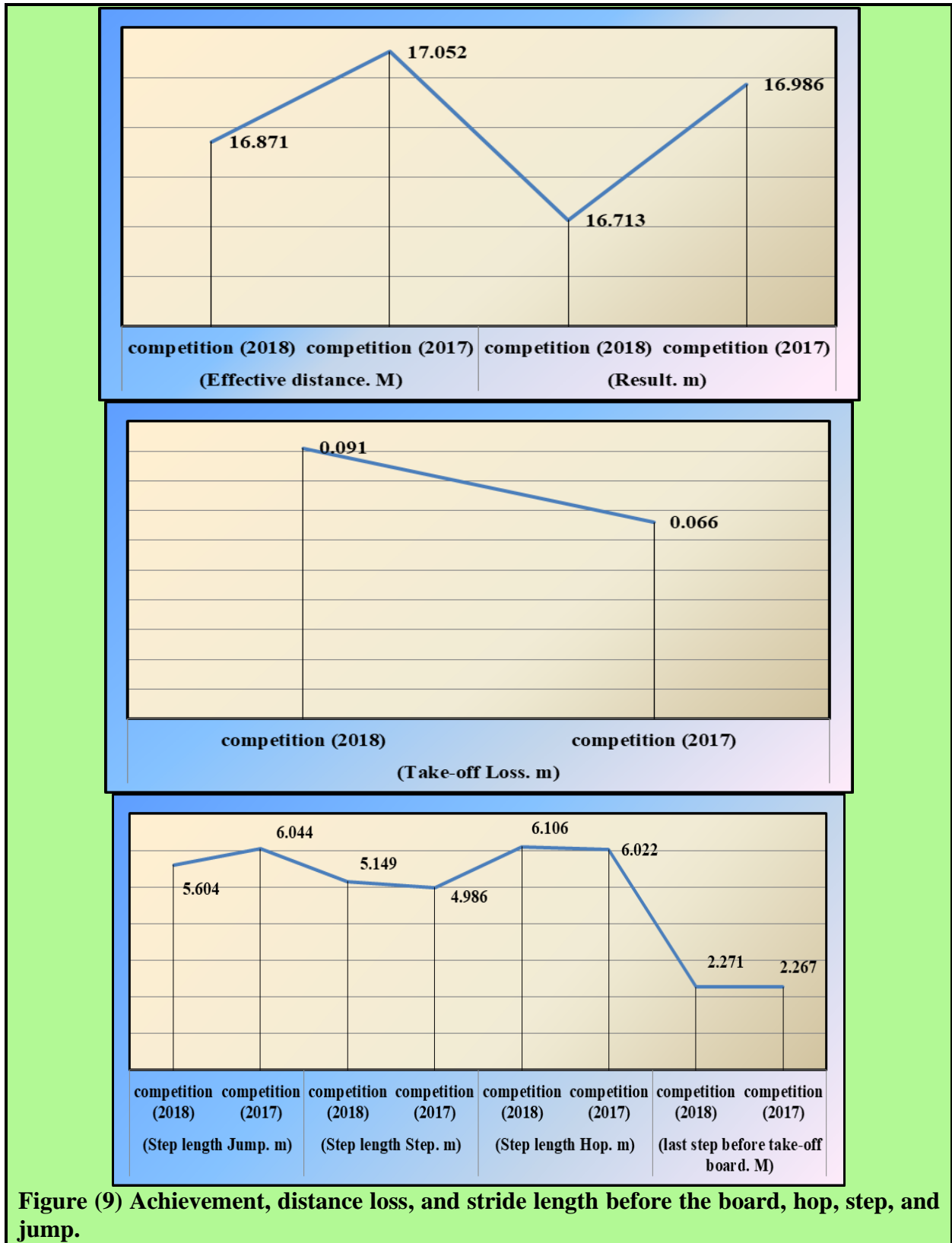
• **(Result):**

Table (1) Values of achievement differences and kinematic variables for triple jump players between the (2017) and (2018) championships

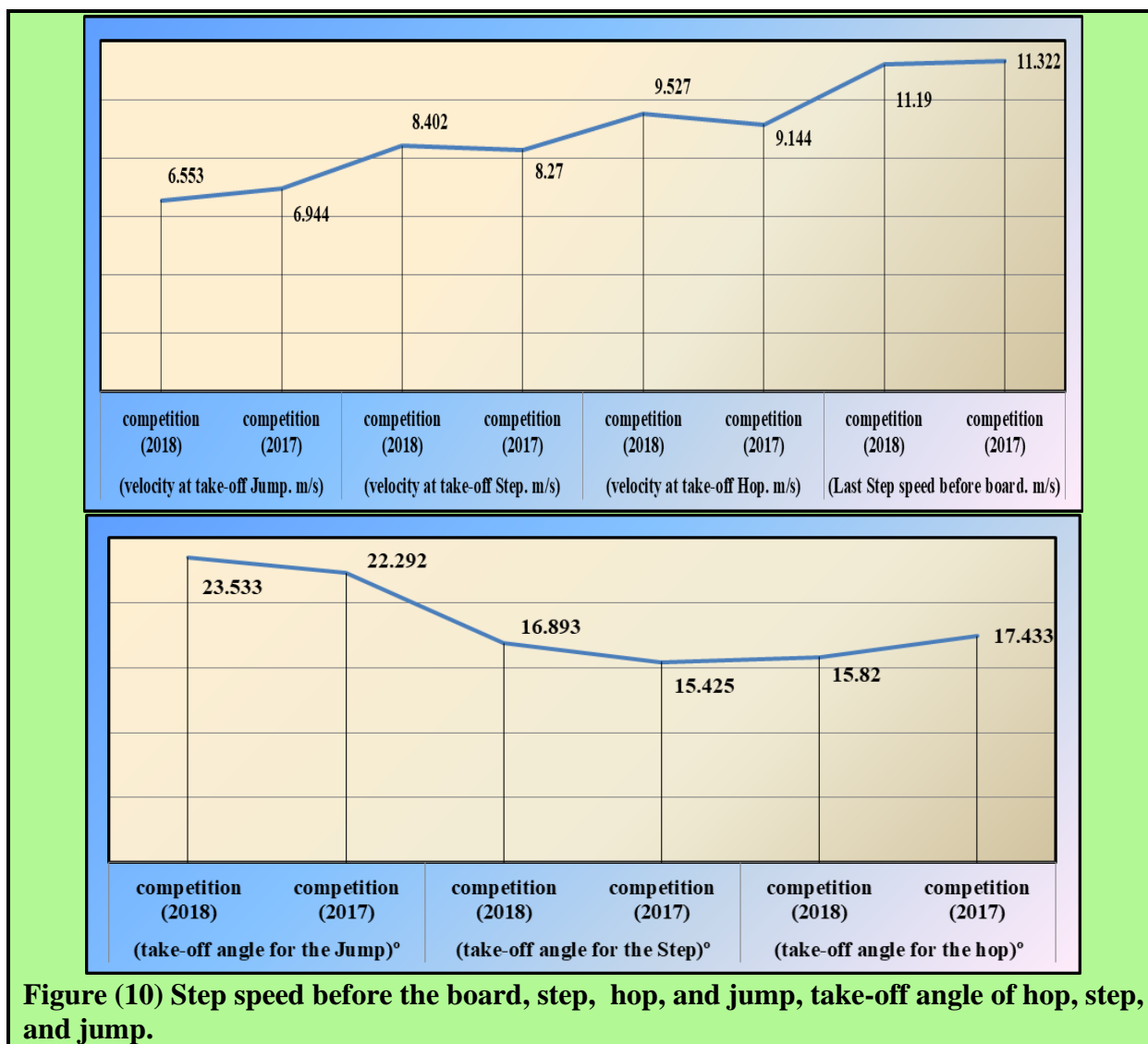
Variables	competition	Mean	Std.D	Mean. Diff	Std.Err Diff	T	Sig
Result. (m)	2017	16.986	.448	.272	.211	1.293	.208
	2018	16.713	.609				
Effective distance. (m)	2017	17.052	.445	.181	.182	.994	.330
	2018	16.871	.487				
Take-off Loss. (m)	2017	.066	.057	-.025	.030	.847	.405

	2018	.091	.089				
last step before take-off board. (m)	2017	2.267	.142	-.004	.047	.085	.933
	2018	2.271	.104				
Step length Hop. (m)	2017	6.022	.151	-.084	.083	1.017	.319
	2018	6.106	.253				
Step length Step. (m)	2017	4.986	.393	-.163	.136	1.197	.242
	2018	5.149	.316				
Step length Jump. (m)	2017	6.044	.308	.440	.139	3.177	.004
	2018	5.604	.393				
Last Step speed before board. (m/s)	2017	11.322	.417	.132	.198	.665	.512
	2018	11.190	.575				
velocity at take-off Hop. (m/s)	2017	9.144	.275	-.383	.189	2.024	.054
	2018	9.527	.605				
velocity at take-off Step. (m/s)	2017	8.270	.471	-.132	.266	.498	.623
	2018	8.402	.815				
velocity at take-off Jump. (m/s)	2017	6.944	.474	.391	.162	2.412	.024
	2018	6.553	.369				
take-off angle for the hop°	2017	17.433	1.728	1.613	.645	2.502	.019
	2018	15.820	1.613				
take-off angle for the Step°	2017	15.425	3.066	-1.468	1.074	1.368	.184
	2018	16.893	2.518				
take-off angle for the Jump°	2017	22.292	3.332	-1.242	1.644	.755	.457
	2018	23.533	4.842				

- Df = 25... significant at (Sig) ≤ (0.05).



**Figure (9) Achievement, distance loss, and stride length before the board, hop, step, and jump.**



**Figure (10) Step speed before the board, step, hop, and jump, take-off angle of hop, step, and jump.**

**Discussion:**

Through the results table, differences were observed in the values of kinematic variables and achievement between the two championships for the competitors. Some variables decreased while others increased, although they did not reach the level of statistical significance. As mentioned earlier, differences at such levels are very slight and may not show statistical significance, but they certainly affect achievement values. Achievement decreased in the (2018) competitions by (1.63%), and in the actual distance, it was higher in the (2017) competitions by (1.07%). The greatest increase in the missing distance was in the (2018) competitions by (37.87%), and in the length of the step before the board, it was higher for (2018) by (0.17%), as well as in the length of the hurdle by (1.39%), and also in the length of the step before the jump by (3.26%), except for the jump length, which was longest for the competitors in (2017) by (7.85%). As for the speed of the step before the board, it was fastest for the (2017) competitors by (1.17%), and in the speed of the hurdle, the (2018) competitors were faster by

(4.18%), and also in the speed of the step by (1.56%), while in the speed of the jump, the (2017) competitors were faster by (5.96%). In the angle of take-off of the hurdle, it was higher in (2017) by (10.19%), and in the angle of take-off of the step and jump, it was higher for the (2018) competitors by (9.51%) and (5.56%) respectively.

It is noted that the nature of the angle trajectory according to the phases indicates a decrease in the step phase after the hurdle and increases in the jump phase because an increase in the angle of the step would result in a loss of force exerted in the jump phase since the contact time for the jump phase would increase upon landing from the step phase. This was observed in the difference between the competitors in the rates of these angles.

It is worth mentioning that the take-off angle in the step phase is usually smaller than in the other flight phases (Čoh. M, 2011). This is because if the flight height in the step phase is much higher, the negative vertical speed upon landing in the jump phase will result in excessive loss of horizontal speed (Mohammed. Z, 2015). One study found a strong correlation between jump distance and take-off angle (Pavlović. R, 2018) and (Shabu. S. R, 2019).

Unlike other track and field events that require a single effort for maximum power during the final performance, the triple jump requires a series of efforts without maximum effort, and one maximum effort. The jumper must maintain horizontal speed while generating vertical speed in the hop, step, and jump phases. During the jump phases, athletes employ different techniques in distributing effort across the three phases.

The significant differences in the requirements of the jump in terms of its length and speed indicate the importance of this phase and its impact on the final achievement between competitors. However, there are certainly other factors contributing to this type of performance.

The jump distance is crucial, and the jumper must know how to increase it as it is an important means to improve overall performance. Additionally, the take-off angle is one of the factors influencing its increase or decrease (Jin. S, and Liu. F, 2014).

There are many variables that affect the performance of the triple jump: the lengths of the last two steps before take-off, flight distances, center of gravity (CG) height, angles of flight in the hop, step, and jump, missing distance. Each phase has an important role in determining performance, with the take-off phase of the hop being a critical stage for better performance in the subsequent steps. The phases are executed differently, but they must be done in a way that prevents loss of horizontal speed during them (V. Jasminan, and A.W.S. Chandana, 2021).

Athletes primarily focus on generating maximum controllable speed during approach to produce vertical speed upon take-off, and they make some adjustments in body position and focus on converting horizontal speed into vertical speed. Once the approach phase is executed, the flight phases will determine the jump distance. The kinetic variables affecting the performance of the flight phase here depend on the speed and angle of the CG during flight and the interaction of horizontal and vertical speeds upon touch and their changes during flight. The unnecessary decrease in horizontal speed due to excessive vertical speed that leads the athlete to spend more time in contact with the ground during the three flight phases is the critical factor limiting the performance of athletes (Eissa. A, 2014).

Therefore, the researcher sees from the results that the rates of take-off angles in the step and jump phases in the (2017) competitions were smaller than their rates in (2018), except for the take-off angle in the hop phase, which was greater in (2017) than in (2018), and this may be one of the reasons for the increase in achievement distance in (2017).

### Conclusions:

This study found that the take-off angle, jump distance, and speed are among the most influential factors and differences in achievement between competitors. Additionally, the level of adjustment in the approach run for jumpers in (2017) was faster than for jumpers in (2018). Furthermore, the performance in terms of the missing distance was better for the (2017) jumpers, with their ratio to the achievement difference reaching (9%). Moreover, smaller take-off angles in the step phase provide a significant advantage in motor coordination in terms of the force exerted by the jumper horizontally and vertically during the jump phase. The researcher recommends continuing to follow such international reports and comparisons as they may provide solutions and guidance in training for the most influential factors when achievement levels differ.

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