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KINEMATIC ANALYSIS OF THE REVERSE DIVE (B) 5M PLATFORM

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Abstract:

This study aims to calculate the kinematic variables by performing a two-dimensional video analysis of the preparation before the jump of the reverse dive movement (B) and the open movement before entering the water and present the basic data on the basis of the analyzed kinematic data in order to increase the completeness of technical expressions and perform difficult elements safely. This study depicted the reverse diving movement (B) of five athletes representing the Saudi diving team and a two-dimensional analysis of the movement was carried out in order to achieve the purpose of this study. This study concluded that the reverse dive requires a rapid vertical lift of the center of mass and an increase in the angles of the joints when getting up, in addition to tightening the ankle and knee joints and rapid bending of the hip joint upon rising. Correcting these positions and techniques through repetitive training on the ground will help athletes improve performance in 5-meter ladder dives

Keywords: Kinematic analysis; reverse dive.

1. INTRODUCTION:

Diving requires physical strength factors such as strength, agility, and flexibility to perform high-level skills in aerobic movements. It is an event that requires strong mental strength to overcome fear of heights along with technical factors. Includes diving competitions. Diving from the escalator and stationary ladder. The escalator dive is an event that is performed using the flexibility of a ladder and is 1m by 3m high. It has the property of producing elegant and flexible movements. The fixed ladder is performed using a diving platform fixed at a height (5, 7.5, and 10 meters) from the surface of the water. The movements must be made in a short moment with the capabilities of the person without the reaction force of the ladder. Diving competitions consist of six sets indicating the direction of rotation of the dive. Group) 1) Forward and group (2) Stand back, Group (3) Stand forward and jump (reverse), Group (4) Stand back and jump forward (inward), Group (5) Twist, Group (6) (handstand). In addition, four pneumatic positions (straight (A), (semi-curved type (B), (full-curved type (C)), (freestyle (D)) must be performed with high-level and perfect movements and finished with precision ([FINA, 2015).

The curved inverted dive is one of the inverted dives group and leads to the effect of the back dive from the front rise, and these dives are of great difficulty not only because they are blind dives, but also for the head rotation in them back towards the diving ladder, and one of the most important success of learning reverse dives from the fixed dive ladder at a height 10 meters is a necessity for both the coach and the teacher to understand the mechanics of upgrading and to be able to communicate it to his players with confidence, clarity and power (Jamal, 1980). In diving competitions into the water, the diving score consists of two parts: the judges' score and the dive's difficulty score. The height of the dive is taken into account when judging the dive, and a greater height allows more time to turn and prepare to enter. The diver must strive to the maximum dive height with sufficient angular momentum to allow expansion before entry while maintaining a safe distance from the ladder in flight. The degree of difficulty of the dive increases with the rotation of the flip, so it is beneficial to use a dive with high rotation requirements. The amount of flip rotation that can be achieved depends on time of flight, angular momentum, and body composition. Rotation potential, defined as the product of angular momentum and time of flight (Hiley &Yeadon, 2008).

While rising from the diving ladder, maximum reaction force is applied to the ladder, but the force at this time is nearly constant regardless of the level of difficulty (Hamill & Golde: 1986). Individuality, and provides a foot-wide margin to sufficiently raise the center of mass in the air. The strength and flexion of the knee have a significant impact on the performance of diving movements (Sander: 1998). It consists of three movements: jumping in place, moving in the air, and entering the movement. None of the three movements is considered unimportant, but at the time of the jump, the

angular variables of the upper and lower extremities, height and distance to the center of the body, and the velocity factor are very important. Looking at previous studies on ladder diving, it was found (Miller & Munro, 1994) that in order to perform the perfect movement on the ladder, it is necessary to have a sufficient moment of rotation in the air which is required by sport, and necessary to secure the time and height required for such rotation. In addition, (Golden, 1981) indicated that the vertical velocity decreases with the increase of rotation in the aerodynamic movement of diving, and mentioned (Hamill & Golden, 1986) the upper part of the body during jumping and confirmed (Mookerjee: 1990) that the horizontal velocity contributed to moving the body away from the diving ladder And that the movement of the two legs represents the first importance in achieving the amount of angular movement. (Gambral: 1998) indicated that there is a similarity in the movement of the joints during the two operations of pressing the escalator and performing the dive with skilled gloves, as well as the presence of a significant contribution from the moving diving ladder related to the vertical distance resulting from its movement.

2. METHOD

2.1 Sample

The study sample was 5 players from the Saudi national diving team on the fixed ladder 5 meters for the age of 11-12 years.

Table (1) physical and personality characteristics of athletes.

Sample	Age (year)	Height (cm)	Weight (kg)	Training age
Player 1	12	137	34	2
Player 2	12	136	34	2
Player 3	11	127	27	2
Player 4	12	138	35	2
Player 5	12	135	28	3
M±SD	0.447±11.8	4.393±134.6	3.782±31.6	0.447±2.2

2.2 Stages and events

In this study, a total of 4 events were assigned to the analysis section from the moment of jumping to preparing for acquisition, and the analysis stage was divided into 3 stages and analyzed as in Figure (1).

Figure (1) Stages of movement and events

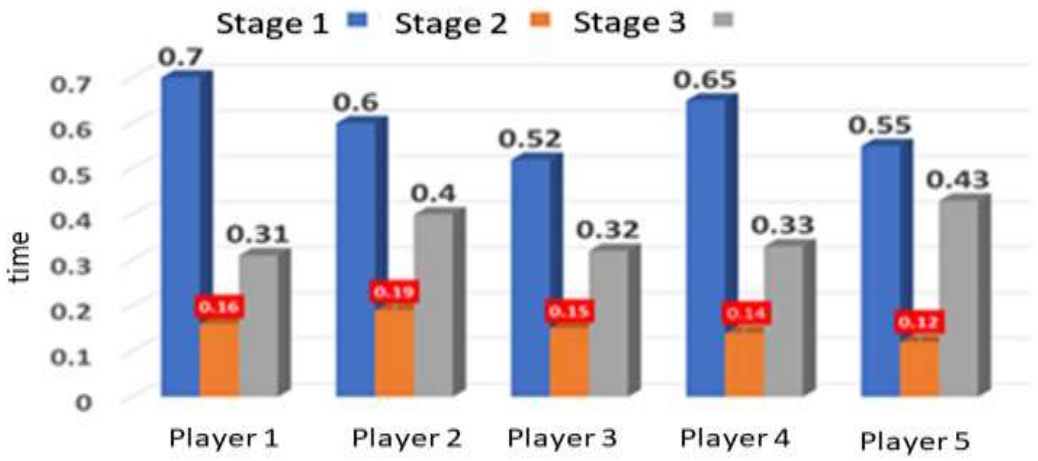

Figure 2 Time for each stage

2.3Experiment Procedures

The study sample for each player was filmed with a video camera with a speed of 60 frames per second within the activities of the Gulf Championship 2019. The camera was vertical on the sagittal plane. Then the recorded video was downloaded to the computer hard for the purpose of pickling it using the program (kinovea version 9.3). The data was extracted to Excel for the purpose of placing it in tables and discussed.

3. PRESENTATION AND DISCUSSION OF THE RESULTS

Time, horizontal distance, center of mass height, horizontal and vertical velocity, and angular movement variables for the upper and lower extremities were analyzed, and the results of the analysis were as follows.

1. Time according to the movement stage

Table (2) values of time variables for reverse dive (B) (unit: seconds)

	stages			
sample	**Stage 1**	**Stage 1**	**Stage 1**	**Total**
Player 1	**0.70**	**0.16**	**0.31**	**1.17**
Player 2	**0.60**	**0.19**	**0.40**	**1.19**
Player 3	**0.52**	**0.15**	**0.32**	**0.99**
Player 4	**0.65**	**0.14**	**0.33**	**1.12**
Player 5	**0.55**	**0.12**	**0.43**	**1.1**
M±SD	**0.073±0.604**	**0.026±0.152**	**0.054±0.358**	**0.078±1.11**

From Table (2) and Figure (2) for the values of the time variables for the inverse dive by comparing the time required for each stage, in stage (1) the longest time for player (1) was (0.70 seconds), which is the longest time than the rest of the players, and in stage, Player (2) took the longest (0.19 seconds), and players (3 and 5) took the shortest (0.15, 0.14 seconds). In Stage 2, Player 5 took the longest time and was 0.43 seconds. In stage 3. Player (1 and 3) showed the shortest time required, which was (0.31 seconds, 0.32 seconds). Average time required for (5) players (1.11±0.078 seconds). In stage 1 (0.073±0.604 sec), which is 54% of the total time required. In stage (2), 0.16 ± 0.03 s (14%) of the total time required, and finally, in stage (3), 0.38 ± 0.05 s (represented 32% of the total time required. The visible region appeared as stage 1, Followed by stage 3 and stage 2. These results agree with the results of which indicated that during the performance of the two curved front and half courses of the escalator at a height of one meter, the flight time is the largest, followed by the time of ascent and then the time of entry into the water. These results are with what was indicated by (Adel Abdul Baseer :2009) that the flight time should be the largest time during performing acrobatic movements in gymnastics and diving, followed by the time of ascent and then the time of landing.

1. Horizontal distance according to each event

Table (3) the horizontal distance to the center of mass for the reverse dive (B) (unit: cm).

	Events			
sample	**Event 1**	**Event 2**	**Event 3**	**Event 4**
Player 1	**177.9**	**202.5**	**228.9**	**269.9**
Player 2	**179.8**	**203.3**	**231.8**	**278.1**
Player 3	**178.7**	**198.7**	**223.2**	**261.1**

Player 4	**177**	**209.8**	**238.5**	**294.8**
Player 5	**174.5**	**205.7**	**228.7**	**289.5**
M±SD	**2.007±177.58**	**4.104±204**	**5.576±230.22**	**13.815±278.68**

From table (3) for the values of the horizontal distance variables to the center of mass for the reverse dive. When comparing the distance of mass movement by event, for player (4) it was (294.8 cm) the farthest distance for the movement of the center of mass from the ladder, and it was (261.1 cm) for player (3), which indicates that it is the closest distance to the movement of the center of mass from the ladder. The average horizontal movement distance for the center of mass was (177.58 ± 2.007 cm), which shows a difference between the variables, and the value of player (4) was (294.8 cm) in event (4), which is the longest distance on the ladder than the average horizontal movement distance. It is judged that a long distance is moved to increase safety due to the characteristics of the object, but if the horizontal movement distance is increased, the height of the center of mass decreases, making it impossible to secure the height required for the acquisition. If the horizontal distance becomes too far, the parabolic path becomes larger, making it difficult to obtain and manipulate. Therefore, it is necessary to maintain an appropriate distance from the ladder. These results are in agreement with the results of (Miller & et al: 1990). It was reported that during the backward rise on the ladder (10 m), the vertical velocity of the center of body mass decreased with the increase in the number of turns, and that the posterior curve required a greater horizontal distance from the back stoop.

2. The height of the center of mass

Table (4) Height of the center of mass of the reverse dive (B) (unit: cm).

	Events			
sample	**Event 1**	**Event 1**	**Event 1**	**Event 1**
Player 1	**77.69**	**83.72**	**107.09**	**81.36**
Player 2	**84.68**	**89.57**	**117.02**	**48.96**
Player 3	**72.41**	**79.69**	**105.46**	**81.12**
Player 4	**83.77**	**85.1**	**104.86**	**76.57**
Player 5	**76.26**	**84.56**	**100.6**	**34.71**
M±SD	**5.19±78.96**	**3.53±84.53**	**6.09±107.01**	**21.42±64.54**

From Table (4) for the values of the center-of-mass height variables for the reverse dive. When comparing the height of the center of mass for each event, player (2) showed the highest center of mass height on the ladder at (117.02 cm) in event (3), and player (5) showed the lowest center of mass height on the ladder at (100.6 cm). The change in body center height showed a difference between the players whose average center of mass height (6.09±107.01 cm) in event (3), the moment they jumped to the highest height, was found by player (2) to be the highest among the players (117.02 cm). In event (4), he was (48.96 cm), fourth among the players. He has attained a high jumping position, but due to weak abdominal and back strength, the upper and lower folds slowly, and the parabola is small. So the change in height is judged to be the largest. Also, in event (3), it can be seen that the moment the player (4,5) jumped to the maximum height (104.86cm, 100.6cm) is the lowest among the two players presumably because of their weakness. The rising moment is when the athletes achieve sufficient height and rotational speed to perform the dive, by rapidly extending the bent joints of the lower extremities. This is a critical point in diving because the stretching position and speed have an effect on the rise and spin speed (; Lee: 2008; Kang & Nam, 2010; Hue & Nam:2012).

3. Horizontal and vertical speed

Table (5) the horizontal velocity of the center of mass of the reverse dive (B) (unit: cm/sec).

	Events			
sample	**Event 1**	**Event 1**	**Event 1**	**Event 1**
Player 1	**5.8**	**114.45**	**167.07**	**114.56**
Player 2	**21.86**	**105.48**	**148.59**	**86.69**
Player 3	**3.1**	**106.77**	**151.73**	**107.59**
Player 4	**15.46**	**150.95**	**209.22**	**142.63**
Player 5	**15.01**	**136.09**	**193.69**	**122.58**
M±SD	**7.67±12.246**	**19.97±122.75**	**26.54±174.06**	**20.48±114.81**

Table (6) the Vertical velocity of the center of mass of the reverse dive (B) (unit: cm/s).

	Events			
sample	**Event 1**	**Event 1**	**Event 1**	**Event 1**
Player 1	**44.68**	**199.8**	**74.91**	**-259.65**

Player 2	**59.05**	**228**	**52.47**	**-385.8**
Player 3	**14.29**	**224.6**	**91.21**	**-244.84**
Player 4	**37.63**	**202.51**	**74.3**	**-258.63**
Player 5	**-16.76**	**176.1**	**67.29**	**-385.42**
M ±SD	**29.69±27.78**	**21.06±206.20**	**14.02±72.04**	**72.12±(-306.87)**

From table (5) (6) for the values of the horizontal and vertical velocity variables of the center of mass for the reverse dive, when comparing the change in the velocity of the center of mass by event, player (4) showed the fastest horizontal velocity of the center of mass at (209.22 cm/sec) in the event (3), and player (2) showed the slowest horizontal velocity of the center of mass at (148.59 cm/sec). When comparing the vertical velocity of the center of mass by event, player (2) showed the fastest vertical velocity of the center of mass at (228 cm/sec) in event (2), and player (5) showed the slowest vertical velocity of the center of mass at (176.1 cm/sec). For the change in the vertical velocity of the center of mass, given event (2), the moment when both feet fall off the ladder, the average vertical velocity of the center of mass was (21.06±206.20 cm/sec), which shows a difference between players, and player (2) between Players was 228 cm / sec. It was found to be the fastest. This event was judged to be executed by increasing the vertical speed and securing a high jump position. The change in the horizontal velocity of the center of mass is the average horizontal velocity of the center of mass of (19.97±122.75 cm/sec) in event (2), the moment both feet fall off the ladder. The average horizontal velocity of the center of mass was (26.54±174.06 cm/sec) in event (3), the moment when he was jumping to the highest height. Among the players, when player (4) was in event (2) (150.95 cm/s), event (3), he displayed a fast horizontal velocity of (209.22 cm/s). Because of the high horizontal speed, a high vertical jump position could not be secured, so the parabola trajectory became large, and the completeness of the reverse dive movement (B) is judged to be inferior. Changes in the velocity of the center of mass are considered to have an effect on the change in the center of mass. These results are consistent with what was indicated by each (Hay, D, A: 1985) It is imperative that the force thrusts and rotational thrusts are directed during the rise phase in the vertical and horizontal directions and take off at an angle greater than 75° and less than 90° to obtain a suitable flight curve to achieve the kinetic duty in aerobic movements in gymnastics and diving.

UPPER LIMB ANGLES

1- Elbow angle

Table (7) Reverse Dive Elbow Angle (B) (Unit: Degree)

	Events			
sample	**Event 1**	**Event 1**	**Event 1**	**Event 1**
Player 1	**171**	**141.28**	**160.47**	**158.45**
Player 2	**167.65**	**149.84**	**152.78**	**155.46**
Player 3	**174.98**	**121.44**	**129.13**	**142.59**
Player 4	**176.25**	**161.7**	**111.25**	**153.77**
Player 5	**176.25**	**123.17**	**111.25**	**153.77**
M ±SD	**3.79±173.23**	**16.85±139.83**	**22.95±132.98**	**6.02±152.81**

2- Shoulder angle

Table (8) Reverse dive shoulder angle (B) (unit: degrees)

	Events			
sample	**Event 1**	**Event 1**	**Event 1**	**Event 1**
Player 1	**130.31**	**161.54**	**152.14**	**95.4**
Player 2	**136.37**	**151.1**	**160.93**	**99.95**
Player 3	**94.12**	**141.95**	**162.52**	**97.83**
Player 4	**111.93**	**161.44**	**167.02**	**100.83**
Player 5	**141.73**	**166.63**	**162.67**	**97.61**
M ±SD	**19.62±122.89**	**9.92±156.53**	**5.47±161.06**	**2.13±98.32**

When comparing the elbow angle for each event, it was found that player (4) had the largest elbow angle (161.7.°), and player 3 had the smallest elbow angle with (121.44.°) in event (2), when the forefoot fell off the ladder. When comparing the shoulder angle by event, in event (3), in which the body rises to the highest height, player (4) showed the largest shoulder angle with (167.02 degrees), and player (1) showed the smallest shoulder angle with (152.14 degrees). The change in the angle of the upper extremity is the change in the angle of the elbow and shoulder parts. In event 2, where the elbow joint is and in the jump stage where both feet fall off the ladder, the mean elbow angle was (143.61 ± 16.34 degrees), which showed a difference between players, and the moment they jumped to the highest height. It can be seen that the angle increases from the event section (2) to the event section (3). Player (4), was (111.25 degrees) in

the event section (3), which is the moment of jumping to the highest height, which was less than (123.17 degrees) in the event section (2). This is consistent with what was indicated by (Kim , Y , J: 2003), where he indicated that the completeness of the technique can be improved by increasing the elbow angle and raising it vertically because rotation of the arm is not required due to the nature of the reflection (B) relative to the angle, the average angle of the shoulder joint was (161.06 ± 5.47°) in event section (3), which is the moment of jumping to the highest altitude, and (98.32 ± 2.13 degrees) in event section (4), which is prepared for entry. Looking at it, it can be seen that the angle has decreased sharply, due to the reduced angle of the shoulder section in order to reduce the rotational speed and make a stable jump gain, due to the angle has been increased to speed up the acquisition process.

Lower limb angles

1- Hip angle

Table (9) reverse dive hip angle (B) (unit: degrees)

	Events			
sample	Event 1	Event 1	Event 1	Event 1
Player 1	168.01	153.23	115.25	48.87
Player 2	169.49	156.25	107.95	38.55
Player 3	163.44	166.15	113.22	45.68
Player 4	166.62	158.65	132.13	50.26
Player 5	168.36	166.72	135.06	50.84
M ±SD	2.33±167.184	6.01±160.2	12.09±120.722	5.05±46.84

Table (10) Reverse dive ankle angle (B) (unit: degrees)

	Events			
sample	Event 1	Event 1	Event 1	Event 1
Player 1	111.8	138.57	147.03	144.98
Player 2	130.65	147.13	161.77	165.19
Player 3	127.19	134.32	149.12	162.68
Player 4	134.79	145.8	156.83	167.33
Player 5	104.19	143.73	154.8	160.94
M ±SD	13.10±121.72	5.35±141.91	5.95±153.91	8.86± 160.22

When comparing the hip angle by event, in event 3, in which the player rose to the highest height, player (5) showed the largest hip angle at (135.06 degrees), and player (2) showed the lowest hip angle at (107.95 degrees). When comparing the knee joint angle by event, it was found that player (3) had the largest knee joint angle of (154.49 degrees) and player (4) showed the smallest knee joint angle of (139.13 degrees) in event (2), the moment the foot fell from the ladder. When comparing the ankle joint angle for each event, in event (2), at the moment the foot falls off the ladder, player (2) had an angle (147.13 degrees), showing the largest angle of the ankle joint, and player (3) had (134.32). Degrees), which indicates the smallest angle of the ankle joint.

The change in lower limb angles was the change in the angle of the hip and knee joints, and there was no significant difference between the players. However, the average hip angle was (12.09±120.722°) in the event section (3), which is the moment of jumping to the highest height, showing the difference between the players, player (2) showed the smallest angle (107.95°), and among the players, Player (5) showed the largest angle at (135.06°). Player (2) was able to secure a sufficient reach distance by raising the jump height, in order to secure a safe distance from the ladder. It is judged that the center of the upper body has been moved forward and, conversely, because player (5) did not provide sufficient height to jump, so the angle of the hip joint was large with the center of the upper body so needs to improve the accuracy of possession. The average knee joint angle was (5.78±144.92°) in event (2), the moment both feet fell off the ladder board, and there was a difference between the two players. The highest angle was found among the two players, with player (4) having the smallest angle at (139.13°), and average ankle joint angle (141.91±5.35°), indicating a difference between the two players. Player (3) showed the smallest ankle angle (134.32°) among the players. As for the knee joint, it was judged that player (3) made the knee joint angle as large as possible to jump up at the moment of jumping. So the knee joint angle could not be increased because the momentary thigh muscle strength was weak. Conversely, player (3), who increased the knee joint angle, showed the lowest ankle joint angle, and player (4), who had the smallest knee joint angle, was among the cases, and secondly, it was found that the player's ankle joint angle (2) It has increased (147.13 degrees). This is because the strength of the thigh muscle of player (2) is weak and cannot jump high, so it is considered that the jump was made using the ankle joint.

4. CONCLUSION:

1. The time scores showed a difference between players, and stage 1 took 54% more time.
2. When the horizontal distance is too long, the height of the center of mass decreases, and the player fails to secure the required height for the movement to enter the water. When the player only jumps vertically, the parabola becomes smaller and the changes in height are greater from event 3 to event 4. When the player's vertical velocity is faster in the event section 2, the action is in a high-altitude jump, and when the horizontal velocity is Faster, the action of the movement is at the lowest height among the players.
3. The player who performed the movement at the height of the jump, which was the lowest among the players, made a shoulder angle in order to make the movement of entering the water fast. The ankle angle of the jumper by making the knee joint angle greater was the smallest.
4. On the basis of the above results of this study, we can see that in order to perform the reverse dive movement (B) well the athlete must make a parabolic trajectory by making the horizontal distance to the center of the body a little longer than 100 cm and jump by making the knee joint angle and ankle angle large. In addition, the player has to secure the height of the high jump by making the angle of the shoulder joint small.
5. A reverse dive requires a rapid vertical lift of the center of mass, an increase in the angle of the joint when getting up, as well as stretching of the ankle and knee joints, and rapid bending of the hip joint upon rising. Correcting these postures and techniques through repetitive training on the ground will help athletes improve performance in 10m ladder dives.

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