Journal of Applied Sports Science
December 2021, Volume 11, No. 2
www.jass.alexu.edu.eg

Studying the Bio-kinematic Factors Affecting the Pushing Off Velocity from the Starting Block

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Abstract

The purpose of this study identifies the most important bio-kinematic variables affecting the velocity of the swimmer's pushing off from the starting block, and the researcher used the descriptive method. The research sample included 12 swimmers from the National Bank Club in Alexandria. The performance of the swimmers was recorded and analyzed to extract the bio-kinematic variables, Conclusions the significance of the horizontal velocity and the resultant velocity at the flight off moment. The horizontal acceleration reached its maximum acceleration rate at the horizontal level at the relative stillness moment, reaction from stillness moment and maximum flexion of the front knee joint moment, while the vertical acceleration reached its maximum acceleration rate at the vertical level at the pushing off moment and the beginning of flight moment, the horizontal Acceleration greatly affected the acceleration Resultant at the pushing off moment, the weakness in the ankle angle affecting the swimmer's pushing off velocity. The shoulder and elbow angle help guide the swimmer's body and adjust the path of the center of gravity during flight. The full extension of the hip joint increases the acceleration angular and the quick and smooth entry into the water. The angular acceleration increases at the beginning of flight moment for the elbow and wrist joints.

Keywords : *(the Bio kinematic Factors. Starting Block.)*

Introduction:

Pushing off is one of the most important and effective phases in competitive swimming competitions since it affects the final time of the swimmer. (2:12)

Time is the main indicator of sports achievement in all types of swimming, where all the factors affecting this time are required, and they are pushing off and rotation until the difference between the swimmers reaches a fraction of a second. Therefore, we should concern developing the technical performance of swimmers. (15:1)

Pushing from the four swimming types enables the swimmer to push off at a high velocity to obtain the largest horizontal distance before entering the water in the shortest possible time. A good push off leads to an improvement in the first 50m between 2:1 sec. compared to the same record for the same swimmer without pushing off.

(139:10) (280:7)

Pushing off the track is a type of quick start, where the swimmer gains the fastest velocity to enter the water and saves a lot of time, because the change in the position and weight mass of the swimmer is transferred from the back leg, which is at (90°) knee angle, to the front leg at (120°) knee angle when hearing the start signal which allows a quick reaction. (72:16)

Based on the above, the researcher believes that pushing off is one of the most important phases affecting the swimming competitions since it enables the swimmer to push off at a high velocity to obtain the largest horizontal distance before entering the water in the shortest possible time.

Kinetic analysis helps us to identify the fine details of performance method, which reveals the points of strength and weakness, in order to develop alternatives and different methods that suit the nature of performance to compensate for the weaknesses in the technique used to raise the level of the players. Since the abilities and capabilities are not 49 enough, a trainer should be aware of the kinematic factors affecting the pushing off velocity from the starting block, as the study provides numerical data that contribute positively to improving the achievement time for the swimmers.

study aims:

Identifying the most important bio-kinematic variables affecting the swimmer's pushing off velocity from the starting block.

study Hypotheses:

1- There is a statistically significant positive correlation between the horizontal velocity, the resultant velocity, the horizontal acceleration, the resultant acceleration, and the resultant velocity of the center of gravity during pushing off.
2- There is a statistically significant positive correlation between the elbow and shoulder angle and the resultant velocity of the center of gravity during pushing off.
3- There is a positive correlation between the angular acceleration of the thigh, elbow and wrist joints, and the resultant velocity of the center of gravity during pushing off.

study Procedures:

study Methodology: The researcher used the descriptive method.

study Sample: The researcher used a purposively selected sample consisting of 12 swimmers aged16-20 years from the National Bank Club in Alexandria.

Table (1)
shows the statistical description of the basic variables under study (n = 12)

Variables		the middle	Mediator	standard deviation	skew modulus	Flatness coefficient	less value	The largest value
Basic variables	length	169.86	172.50	8.81	0.00	-1.79	158.00	181.00
	weight	63.93	64.10	9.54	0.10	-1.17	51.00	78.00
	shoulder width	40.55	40.00	2.62	0.28	-1.51	37.00	44.00
	pelvic width	30.82	31.00	3.49	-0.90	1.63	23.00	36.00
	foot space	26.09	25.00	2.39	0.57	-1.48	24.00	30.00
	palm space	17.91	18.00	1.45	0.19	-1.24	16.00	20.00

Table (1) shows that the data of the total research sample are moderate, not scattered, and characterized by the normal distribution of the sample, where the skewness coefficient values are close to zero, and they lie in the moderation curve between (±3), which confirms the moderation of the sample in the general variables under study.

Devices and tools used in the study:

- A rasta-meter for measuring height, measuring tape, medical scale, phosphorous marks, white (medical) plaster to determine the points of the joints of the body.
- GoPro Hero 6 camera.
- Kinetic analyzer device.
- Wires to connect the electrical current to the shooting location.
- Registration form .
- statistical analysis software (SPSS v. 20، Microsoft Excel 2010) .

Survey Study: The pilot study was conducted by video capturing the male and female players at the National Bank Club in Alexandria on 15/8/2021.

Study aims:

– ensure that the equipment is safe and ready.
– determine the location and height of the cameras and their distance from the players, as well as adjusting the parameters of the shooting process.
– ensure how the indicative signs are fixed on the centers of the body joints of the study sample, as well as their clarity level.

Main Study:

Video capturing and Analytical Procedures:

The pushing off phases for the top-level players were video captured on 20/8/2021, through the following procedures:

1- Conducting two-dimensional video capturing using a GoPro Hero 6 camera, where the camera is set at a frequency of 120 frames/sec and is placed on a tripod, 1.20 meters high from the ground and about 4 meters away from the starting place for freestyle swimming, covering 9 meters from the starting block to the gliding moment under
2- biomechanical general variables Table (1) and the biomechanical variables for the most important performance moments Table (2)

Table (2)
General biomechanical variables

	general biomechanical variables		measuring unit
1	temporal analysis	break-time	S
2		push-time	S
3		flight time	S
4	support phase	Center of gravity Horizontal breaking distance	M
5		Center of gravity vertical breaking distance	M
6		Center of gravity resultant breaking distance	M
7		Center of gravity horizontal pushing distance	M
8		Center of gravity vertical pushing distance	M
9		Center of gravity resultant pushing distance	M
10	flight phase	Center of gravity horizontal flight distance	M
11		Center of gravity vertical flight distance	M
12		Center of gravity resultant flight distance	M

Table (3)
Biomechanical variables for the performance moments

	biomechanical variables	measuring unit
1	The horizontal velocity of the center of gravity of the body	(M/S)
2	The vertical velocity of the center of gravity of the body	(M/S)
3	The resultant velocity of the center of gravity of the body	(M/S)
4	The horizontal acceleration of the center of gravity of the body	$(M/S)^2$
5	The vertical acceleration of the center of gravity of the body	$(M/S)^2$
6	The resultant acceleration of the body's center of gravity	$(M/S)^2$
7	Ankle joint angle of the rear leg	(DEG)
8	Back leg knee joint angle	(DEG)
9	front leg hip joint angle	(DEG)
10	Right shoulder joint angle	(DEG)
11	Right elbow joint angle	(DEG)
12	Right wrist joint angle	(DEG)
13	Ankle joint angle for the front leg	(DEG)
14	front leg knee joint angle	(DEG)
15	front leg hip angle	(DEG)
16	left shoulder joint angle	(DEG)
17	left elbow joint angle	(DEG)
18	left wrist joint angle	(DEG)
19	The angular velocity of the ankle joint of the front leg	(DEG/S)
20	The angular velocity of the knee joint of the front leg	(DEG/S)
21	the Angular velocity of the hip joint of the front leg	(DEG/S)
22	The Angular velocity of the right shoulder joint	(DEG/S)
23	The Angular velocity of the right elbow joint	(DEG/S)
24	The Angular velocity of the right wrist joint	(DEG/S)
25	The angular velocity of the ankle joint of the back leg	(DEG/S)
26	The angular velocity of the knee joint of the back leg	(DEG/S)
27	The angular velocity of the hip joint of the back leg	(DEG/S)
28	The Angular velocity of the Left shoulder joint	(DEG/S)
29	The Angular velocity of the of the left elbow joint	(DEG/S)
30	The Angular velocity of the Left-hand wrist joint	(DEG/S)
31	the Angular acceleration of the ankle joint of the back leg	$(DEG/S)^2$
32	The Angular acceleration of the knee joint of the back leg	$(DEG/S)^2$
33	The Angular acceleration of the hip of the back leg	$(DEG/S)^2$
34	The Angular acceleration of the right shoulder joint	$(DEG/S)^2$
35	The Angular acceleration of the right elbow joint	$(DEG/S)^2$
36	The Angular acceleration of the right wrist joint	$(DEG/S)^2$
37	The Angular acceleration of the ankle joint of the front leg	$(DEG/S)^2$
38	The Angular acceleration of the knee joint of the front leg	$(DEG/S)^2$
39	The Angular acceleration of the hip joint of the front leg	$(DEG/S)^2$
40	The Angular acceleration of the left shoulder joint	$(DEG/S)^2$
41	The Angular acceleration of the left elbow joint	$(DEG/S)^2$
42	The Angular acceleration of the left wrist joint	$(DEG/S)^2$

Table (4)
Shows the statistical characterization of the Biomechanical indicators under study during the (relative stillness) moment (N = 12)

Variables			mean	median	standard deviation	skewness	kurtosis	min	max
velocities (m/s)	cg	Horizontal	0.47	0.40	0.33	1.06	1.67	0.01	1.23
		vertical	0.27	0.22	0.13	1.00	-0.52	0.11	0.50
		resultant	0.59	0.52	0.27	1.31	2.35	0.22	1.24
acceleration (m/s) ^{2}	cg	horizontal	4.89	5.10	1.98	-0.77	1.59	0.43	8.17
		vertical	3.17	2.40	2.99	1.42	1.40	0.21	9.82
		resultant	6.25	5.73	2.71	0.00	2.19	0.48	11.77
Degrees positions (deg)	lower limb+ front leg	ankle	88.00	88.00	6.85	-0.07	-0.81	77.00	99.00
		knee	119.08	117.50	14.68	-0.21	-0.34	91.00	141.00
		hip	37.75	37.50	4.43	0.90	1.60	31.00	48.00
	upper limb	shoulder	79.50	75.50	13.84	0.74	-0.38	63.00	107.00
		elbow	170.50	172.00	7.59	-0.72	-0.93	159.00	179.00
		wrist	155.92	162.00	16.38	-0.71	-0.66	127.00	179.00
Degrees positions (deg)	lower limb+ back leg	ankle	76.25	76.50	6.24	-1.18	2.44	61.00	84.00
		knee	116.08	115.50	12.96	0.23	-1.40	99.00	136.00
		hip	61.25	59.50	7.30	0.58	0.38	49.00	76.00
	upper limb	shoulder	76.75	73.00	14.64	0.85	-0.19	60.00	105.00
		elbow	165.00	166.00	7.79	-0.27	-1.09	152.00	176.00
		wrist	158.83	161.50	14.45	-0.65	0.48	128.00	178.00
Degree's velocities (deg/s)	lower limb+ front leg	ankle	78.00	71.50	57.97	0.39	-0.95	7.00	181.00
		knee	153.67	155.50	96.94	0.10	-0.56	1.00	319.00
		hip	82.33	72.50	70.86	2.18	6.31	1.00	282.00
	upper limb	shoulder	196.42	169.00	112.95	1.61	2.77	75.00	478.00
		elbow	200.25	168.50	156.44	0.77	-0.33	7.00	498.00
		wrist	241.50	204.50	178.99	0.35	-1.24	20.00	542.00
Degree's velocities (deg/s)	lower limb+ back leg	ankle	61.33	45.00	56.91	1.84	3.38	16.00	207.00
		knee	148.33	120.00	103.35	0.46	-1.05	10.00	320.00
		hip	89.17	71.00	81.50	0.93	-0.32	12.00	242.00
	upper limb	shoulder	144.00	125.00	100.73	0.94	0.85	22.00	371.00
		elbow	252.42	248.50	143.33	1.35	2.66	67.00	607.00
		wrist	290.58	185.50	218.66	0.89	-0.69	78.00	703.00
Degree's acceleration (deg/s) ^{2}	lower limb+ front leg	ankle	1744.58	1334.00	1263.94	0.96	-0.07	269.00	4288.00
		knee	1336.67	1115.50	1145.12	0.89	0.42	40.00	3809.00
		hip	1879.83	1331.50	2209.16	2.57	7.53	130.00	8322.00
	upper limb	shoulder	3138.08	1969.00	3340.16	1.71	3.21	328.00	11707.00
		elbow	5060.58	6119.50	3460.26	-0.06	-1.00	23.00	10977.00
		wrist	6055.08	4806.50	5033.44	1.25	0.75	742.00	17182.00
degrees acceleration (deg/s) ^{2}	lower limb+ back leg	ankle	2185.00	1720.00	1698.01	1.29	1.59	40.00	6153.00
		knee	2517.17	898.00	4198.19	2.83	8.55	60.00	15045.00
		hip	2233.08	1653.50	2408.80	1.19	0.23	49.00	6754.00
	upper limb	shoulder	4616.50	4396.00	3785.59	0.87	0.70	113.00	12981.00
		elbow	5624.08	3635.50	4381.65	0.70	-1.29	12870	13111.00
		wrist	8888.25	6415.00	9888.14	2.09	4.87	880.00	35778.00

Table (4) shows that the data of the total research sample are moderate, not scattered, and characterized by the normal distribution of the sample, where the skewness coefficient values are close to zero, and they lie in the moderation curve

between (±3), which confirms the moderation of the sample in the general variables under study at the (relative stillness) moment.

Table (5)

Shows the statistical characterization of the Biomechanical indicators under study during the (reaction from stillness) moment (N = 12)

Variables			mean	Median	standard deviation	Skewness	Kurtosis	Min	Max
velocities (m/s)	CG	Horizontal	0.78	0.73	0.40	0.58	0.55	0.23	1.62
		vertical	0.21	0.19	0.15	0.25	-1.06	0.01	0.45
		resultant	0.84	0.75	0.35	1.14	1.70	0.37	1.66
acceleration (m/s) ²	CG	horizontal	4.54	5.08	2.21	-0.75	-0.37	0.61	7.78
		vertical	2.04	1.57	1.66	0.79	-0.21	0.10	5.46
		resultant	5.15	5.35	2.40	-0.31	0.56	0.62	9.50
Degrees positions (deg)	lower limb+ front leg	ankle	86.33	87.00	6.87	-0.71	0.61	72.00	97.00
		knee	110.75	108.50	13.54	0.95	0.97	94.00	141.00
		hip	41.17	39.00	10.16	1.13	0.67	29.00	61.00
	upper limb	shoulder	73.92	74.50	13.57	0.17	0.23	49.00	98.00
		elbow	172.25	175.50	7.83	-1.27	0.73	155.00	179.00
		wrist	162.83	166.50	12.22	-0.63	-0.66	139.00	177.00
Degrees positions (deg)	lower limb+ back leg	ankle	77.50	79.50	6.99	-1.18	1.71	61.00	87.00
		knee	113.92	112.50	11.73	0.83	0.54	98.00	139.00
		hip	68.33	65.50	11.39	1.27	1.71	54.00	95.00
	upper limb	shoulder	73.83	71.50	13.23	0.59	-0.42	55.00	98.00
		elbow	168.00	167.50	7.19	0.01	-0.77	156.00	180.00
		wrist	159.33	158.00	11.17	0.24	-1.33	144.00	177.00
Degree's velocities (deg/s)	lower limb+ front leg	ankle	40.67	29.00	31.58	0.20	-1.52	0.00	85.00
		knee	123.33	108.50	56.57	0.06	-0.83	29.00	211.00
		hip	91.00	62.50	97.28	1.95	4.42	14.00	352.00
	upper limb	shoulder	103.92	93.00	88.46	0.57	-0.42	0.00	279.00
		elbow	67.17	40.00	62.47	0.97	-0.39	4.00	179.00
		wrist	115.17	96.50	91.41	0.58	-0.87	6.00	270.00
Degree's velocities (deg/s)	lower limb+ back leg	ankle	44.33	28.50	56.56	2.30	5.94	1.00	203.00
		knee	97.67	54.50	106.86	1.89	4.28	1.00	383.00
		hip	143.83	126.50	98.39	0.95	1.42	0.00	369.00
	upper limb	shoulder	87.67	71.50	69.18	0.61	-0.52	6.00	224.00
		elbow	94.58	70.50	69.82	0.59	-0.79	13.00	228.00
		wrist	136.00	113.00	95.04	1.16	1.45	25.00	357.00
Degree's acceleration (deg/s) ²	lower limb+ front leg	ankle	890.17	827.00	610.14	0.04	-1.74	121.00	1769.00
		knee	879.83	687.50	679.72	0.96	0.25	182.00	2352.00
		hip	1299.67	1280.50	990.36	0.97	1.35	27.00	3547.00
	upper limb	shoulder	1542.42	1413.50	1437.50	1.29	1.42	182.00	4881.00
		elbow	2857.83	2610.50	1885.71	1.52	2.96	953.00	7639.00
		wrist	3017.08	2347.00	2852.65	1.40	2.52	82.00	10069.00
degrees acceleration (deg/s) ²	lower limb+ back leg	ankle	1001.50	629.00	1012.81	2.45	6.91	29.00	3910.00
		knee	1443.17	865.50	1835.98	1.78	2.14	83.00	5643.00
		hip	1481.25	1152.50	1159.62	1.21	1.20	93.00	4131.00
	upper limb	shoulder	2098.00	1771.00	1791.95	1.23	0.87	186.00	6076.00
		elbow	2479.42	2294.50	1718.75	0.46	-0.94	410.00	5251.00
		wrist	2563.83	2269.00	2409.36	1.87	4.55	317.00	9038.00

Table (5) shows that the data of the total research sample are moderate, not scattered, and characterized by the normal distribution of the sample, where the skewness coefficient values are close to zero, and they lie in the moderation curve between (±3), which confirms the moderation of the sample in the general variables under study at the (reaction from stillness) moment.

Table (6)
Shows the statistical characterization of the Biomechanical indicators under study during the (maximum flexion of the knee (front leg)) moment (N = 12)

variables			Mean	Median	standard deviation	Skewness	Kurtosis	Min	Max
velocities (m/s)	CG	Horizontal	1.73	1.92	0.52	-1.56	1.48	0.60	2.22
		vertical	0.36	0.38	0.19	-0.57	-0.54	0.01	0.61
		resultant	1.78	1.97	0.50	-1.54	1.31	0.72	2.22
acceleration (m/s) ²	CG	horizontal	6.09	5.91	1.76	-0.97	1.90	1.93	8.67
		vertical	2.78	2.34	2.46	0.64	-0.52	0.17	7.72
		resultant	6.96	7.32	2.26	-0.49	1.27	2.03	10.68
Degrees positions (deg)	lower limb+ front leg	ankle	80.08	80.00	5.57	-0.68	-0.28	69.00	87.00
		knee	101.58	103.00	8.66	-0.65	0.03	84.00	114.00
		hip	80.50	87.50	22.77	-0.99	-0.11	36.00	107.00
	upper limb	shoulder	94.25	66.00	59.16	0.24	-1.84	18.00	170.00
		elbow	139.67	160.50	49.80	-1.58	1.32	34.00	179.00
		wrist	162.25	167.00	21.65	-2.85	9.09	97.00	180.00
Degrees positions (deg)	lower limb+ back leg	ankle	96.58	100.00	16.43	-0.05	-1.58	76.00	120.00
		knee	134.08	135.00	21.49	0.54	-0.46	108.00	177.00
		hip	115.42	125.50	26.43	-1.11	0.78	57.00	148.00
	upper limb	shoulder	95.42	85.00	53.92	0.03	-1.60	15.00	163.00
		elbow	144.45	167.00	45.30	-1.75	2.82	34.00	179.00
		wrist	157.33	161.00	22.28	-1.33	2.18	103.00	180.00
Degree's velocities (deg/s)	lower limb+ front leg	ankle	70.92	74.50	47.72	0.35	0.74	2.00	172.00
		knee	171.25	203.50	79.81	-0.48	-1.40	54.00	273.00
		hip	294.92	300.00	114.29	-1.06	0.74	63.00	429.00
	upper limb	shoulder	353.58	374.50	247.96	0.25	-1.07	18.00	760.00
		elbow	317.50	159.00	330.55	1.42	1.14	1.00	1045.00
		wrist	155.92	91.50	168.20	1.57	1.68	6.00	547.00
Degree's velocities (deg/s)	lower limb+ back leg	ankle	321.75	369.50	188.36	-0.25	-1.43	20.00	570.00
		knee	340.92	358.00	148.78	-0.49	-0.83	81.00	540.00
		hip	311.25	348.00	119.17	-0.57	0.39	83.00	513.00
	upper limb	shoulder	396.92	396.50	286.23	0.24	-1.17	15.00	868.00
		elbow	308.75	146.00	362.35	1.49	1.06	1.00	1084.00
		wrist	130.67	96.00	97.40	0.65	-0.81	12.00	314.00
Degree's acceleration (deg/s) ²	lower limb+ front leg	ankle	1936.67	2079.00	1292.20	-0.20	-1.17	22.00	3818.00
		knee	2651.25	2637.50	1078.55	0.24	0.40	695.00	4722.00
		hip	1565.83	1662.50	855.45	-0.30	-0.27	92.00	2925.00
	upper limb	shoulder	6047.83	1644.00	8550.59	1.85	3.04	62.00	27751.00
		elbow	5013.67	3593.00	5011.01	1.20	1.08	50.00	16496.00
		wrist	5562.58	3005.50	6020.19	1.49	1.45	282.00	19205.00
degrees acceleration (deg/s) ²	lower limb+ back leg	ankle	2991.17	2987.00	1802.75	0.20	-1.46	604.00	5943.00
		knee	3998.83	4122.50	1509.60	0.61	0.18	2041.00	7188.00
		hip	1536.50	1492.50	615.95	0.71	2.02	451.00	2933.00

variables			Mean	Median	standard deviation	Skewness	Kurtosis	Min	Max
	upper limb	shoulder	5881.17	4864.50	5759.81	1.60	3.03	420.00	20532.00
		elbow	7533.00	4536.00	9295.15	1.88	4.01	81.00	31299.00
		wrist	6965.92	5584.00	5231.01	1.19	0.89	980.00	18248.00

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Table (7)
Shows the statistical characterization of the Biomechanical indicators under study during the (beginning of pushing) moment (N = 12)

variables			Mean	Median	standard deviation	Skewness	Kurtosis	Min	Max
velocities (m/s)	CG	Horizontal	2.18	2.29	0.50	-2.32	6.55	0.77	2.72
		vertical	0.52	0.49	0.23	0.07	-0.59	0.11	0.87
		resultant	2.25	2.39	0.48	-2.44	6.88	0.87	2.74
acceleration (m/s) ^{2}	CG	horizontal	5.65	5.94	1.61	-0.65	0.07	2.31	7.90
		vertical	3.65	2.94	2.17	0.37	-1.33	0.63	7.17
		resultant	6.90	7.01	2.19	-0.58	0.01	2.40	9.70
Degrees positions (deg)	lower limb+ front leg	ankle	87.08	84.50	8.28	0.90	0.06	76.00	104.00
		knee	117.17	123.00	11.68	-0.28	-2.10	103.00	131.00
		hip	105.42	112.50	22.56	-1.06	-0.05	61.00	130.00
	upper limb	shoulder	92.08	85.50	69.81	-0.04	-1.90	0.00	175.00
		elbow	145.42	168.00	59.38	-2.04	2.70	10.00	180.00
		wrist	162.58	168.50	18.32	-2.15	5.38	112.00	179.00
Degrees positions (deg)	lower limb+ back leg	ankle	126.83	131.50	22.30	-0.35	-1.57	93.00	155.00
		knee	162.00	172.50	17.91	-0.86	-0.41	125.00	179.00
		hip	141.33	151.50	24.99	-1.32	1.15	84.00	167.00
	upper limb	shoulder	99.83	114.00	66.16	-0.26	-1.77	3.00	175.00
		elbow	144.00	166.00	51.91	-1.90	2.24	31.00	178.00
		wrist	159.17	164.50	18.02	-1.48	2.06	116.00	178.00
Degree's velocities (deg/s)	lower limb+ front leg	ankle	228.92	233.00	134.88	-0.14	-1.35	15.00	401.00
		knee	306.83	347.00	138.10	-0.47	-0.80	76.00	523.00
		hip	363.33	373.50	87.49	-2.31	6.65	114.00	443.00
	upper limb	shoulder	180.08	88.50	220.25	1.58	2.86	0.00	739.00
		elbow	205.67	149.00	192.46	2.11	5.18	9.00	733.00
		wrist	98.83	85.50	75.91	1.44	2.88	15.00	290.00
Degree's velocities (deg/s)	lower limb+ back leg	ankle	355.17	367.50	111.66	-0.78	0.21	129.00	498.00
		knee	290.25	306.50	166.84	-0.23	-1.36	15.00	502.00
		hip	314.92	322.50	95.38	-0.38	-0.86	158.00	449.00
	upper limb	shoulder	252.58	199.50	200.10	0.77	-0.22	12.00	620.00
		elbow	284.36	168.00	262.76	0.76	-1.21	39.00	729.00
		wrist	166.42	105.50	179.00	1.73	1.82	20.00	555.00
Degree's acceleration (deg/s) ^{2}	lower limb+ front leg	ankle	3853.83	3063.50	1760.63	0.76	-0.88	1811.00	6822.00
		knee	2403.50	2684.50	1258.29	-0.19	-0.55	248.00	4526.00
		hip	830.92	707.00	517.89	0.80	-0.10	106.00	1841.00

variables			Mean	Median	standard deviation	Skewness	Kurtosis	Min	Max
degrees acceleration (deg/s) ²	upper limb	shoulder	4222.67	3450.00	3112.28	1.30	1.61	582.00	11415.00
		elbow	5614.25	2646.00	7009.91	2.10	4.64	497.00	24545.00
		wrist	4179.50	3247.50	3179.41	0.43	-1.20	194.00	9328.00
	lower limb+ back leg	ankle	3972.92	4290.00	1812.07	-0.21	-1.25	1323.00	6429.00
		knee	4700.00	3969.00	3494.58	0.51	-1.20	797.00	10365.00
		hip	2055.33	1119.50	2444.89	1.93	3.82	232.00	8447.00
	upper limb	shoulder	5842.83	3834.00	5362.25	1.52	1.18	1348.00	17192.00
		elbow	7972.91	6202.00	7549.48	1.06	0.23	519.00	23037.00
		wrist	3582.25	3344.50	3113.87	0.40	-1.33	175.00	8952.00

Table (7) shows that the data of the total research sample are moderate, not scattered, and characterized by the normal distribution of the sample, where the skewness coefficient values are close to zero, and they lie in the moderation curve between (±3), which confirms the moderation of the sample in the general variables under study at the (beginning of pushing) moment.

Table (8)
Shows the statistical characterization of the Biomechanical indicators under study during the (pushing off) moment (N = 12)

variables			Mean	Median	standard deviation	Skewness	Kurtosis	Min	Max
velocities (m/s)	CG	Horizontal	2.76	2.84	0.64	-1.97	6.39	0.96	3.72
		vertical	0.39	0.34	0.33	1.84	4.01	0.08	1.26
		resultant	2.80	2.93	0.64	-2.00	6.27	1.03	3.73
acceleration (m/s) ²	CG	horizontal	2.14	2.02	1.47	1.50	3.73	0.32	5.93
		vertical	7.30	8.26	2.34	-2.71	7.99	0.40	8.78
		resultant	7.86	8.50	1.87	-2.34	5.95	2.62	9.30
Degrees positions (deg)	lower limb+ front leg	ankle	136.42	135.00	11.31	0.14	-1.33	121.00	153.00
		knee	166.92	170.00	9.19	-0.68	-1.11	152.00	177.00
		hip	155.33	155.50	12.32	-0.11	-1.48	137.00	171.00
	upper limb	shoulder	121.67	145.50	56.29	-0.52	-1.37	20.00	175.00
		elbow	140.75	156.50	46.01	-1.18	0.23	47.00	178.00
		wrist	155.75	162.00	20.85	-1.24	0.62	114.00	179.00
Degrees positions (deg)	lower limb+ back leg	ankle	156.83	155.50	7.15	0.42	0.48	144.00	170.00
		knee	171.17	172.50	6.34	-0.16	-1.70	162.00	179.00
		hip	165.08	168.00	11.43	-2.23	6.02	133.00	176.00
	upper limb	shoulder	129.58	160.00	57.23	-1.00	-0.31	13.00	179.00
		elbow	134.33	154.50	53.27	-1.30	1.30	10.00	179.00
		wrist	162.50	167.50	13.06	-1.07	0.07	135.00	176.00
Degree's velocities (deg/s)	lower limb+ front leg	ankle	368.92	372.50	157.23	-0.29	-0.64	115.00	616.00
		knee	263.50	295.50	105.22	-0.74	-0.01	48.00	412.00
		hip	273.67	288.00	110.68	-0.33	-0.78	70.00	429.00
	upper limb	shoulder	292.67	150.00	309.67	1.26	-0.18	39.00	890.00
		elbow	367.92	189.00	401.08	0.98	-0.62	5.00	1103.00
		wrist	112.17	63.00	129.16	1.59	1.39	16.00	378.00
Degree's velocities (deg/s)	lower limb+ back leg	ankle	75.50	62.00	49.84	0.54	-0.52	1.00	164.00
		knee	37.00	18.50	43.70	2.61	7.70	5.00	165.00
		hip	161.75	155.00	70.95	1.01	1.46	76.00	327.00

variables			Mean	Median	standard deviation	Skewness	Kurtosis	Min	Max
	upper limb	shoulder	225.00	130.50	286.61	1.93	2.57	22.00	894.00
		elbow	285.25	137.00	307.69	1.35	0.52	44.00	929.00
		wrist	84.83	52.00	119.56	2.89	9.03	14.00	445.00
Degree's acceleration (deg/s) ²	lower limb+ front leg	ankle	2872.08	3044.50	1560.27	-0.17	-0.35	60.00	5309.00
		knee	4602.58	4366.50	3208.86	0.39	-0.78	609.00	10581.00
		hip	3290.83	3069.50	1622.71	0.15	-1.15	878.00	6014.00
	upper limb	shoulder	8482.58	4163.00	8938.64	1.26	0.93	457.00	28920.00
		elbow	9330.25	6438.50	9199.52	1.12	0.93	267.00	30339.00
		wrist	3936.58	2968.50	4439.56	2.89	9.17	921.00	17345.00
degrees acceleration (deg/s) ²	lower limb+ back leg	ankle	2512.92	3102.00	1293.40	-0.49	-1.24	414.00	4180.00
		knee	1978.33	1830.50	996.58	0.61	0.58	487.00	4091.00
		hip	2644.42	2473.50	2035.54	1.05	1.47	136.00	7406.00
	upper limb	shoulder	6992.83	2701.00	8882.96	1.42	0.91	178.00	26953.00
		elbow	8332.92	3913.00	10171.37	1.85	3.69	548.00	34888.00
		wrist	3636.58	3056.00	3276.15	1.95	4.66	226.00	12426.00

Table (8) shows that the data of the total research sample are moderate, not scattered, and characterized by the normal distribution of the sample, where the skewness coefficient values are close to zero, and they lie in the moderation curve between (±3), which confirms the moderation of the sample in the general variables under study at the (pushing off) moment.

Table (9)
Shows the statistical characterization of the Biomechanical indicators under study during the (beginning of flight) moment (N = 12)

Variables			mean	Median	standard deviation	Skewness	Kurtosis	Min	Max
velocities (m/s)	CG	Horizontal	2.81	2.88	0.59	-1.96	6.05	1.16	3.61
		vertical	0.58	0.40	0.50	1.44	1.14	0.06	1.72
		resultant	2.90	2.99	0.61	-2.05	5.79	1.20	3.63
acceleration (m/s) ²	CG	horizontal	1.71	1.66	1.12	0.11	-0.74	0.17	3.72
		vertical	7.89	8.31	2.96	-1.76	4.12	0.06	11.16
		resultant	8.31	8.47	2.41	-0.95	1.49	2.75	11.77
Degrees positions (deg)	lower limb+ front leg	ankle	156.50	156.00	4.78	0.12	1.27	147.00	166.00
		knee	174.25	174.00	3.31	-0.05	-1.51	169.00	179.00
		hip	166.50	167.00	6.36	-0.33	-0.61	155.00	176.00
	upper limb	shoulder	133.75	142.00	42.78	-1.37	1.37	37.00	180.00
		elbow	147.58	168.50	46.00	-1.89	2.70	36.00	178.00
		wrist	166.33	166.00	10.38	-0.57	-0.21	145.00	179.00
Degrees positions (deg)	lower limb+ back leg	ankle	155.42	155.00	8.27	0.70	0.66	144.00	173.00
		knee	171.67	171.50	5.23	-0.58	-0.21	161.00	178.00
		hip	159.33	160.50	16.93	-1.20	1.81	119.00	179.00
	upper limb	shoulder	134.17	149.00	39.61	-1.39	1.26	47.00	176.00
		elbow	145.50	166.50	44.52	-1.73	2.34	38.00	179.00
		wrist	161.75	168.50	13.83	-0.78	-0.56	135.00	177.00
Degree's velocities (deg/s)	lower limb+ front leg	ankle	179.42	156.50	112.65	0.27	-1.29	8.00	346.00
		knee	84.00	65.50	68.15	0.52	-1.42	10.00	189.00
		hip	133.58	139.00	79.95	0.25	-0.13	15.00	290.00

Variables			mean	Median	standard deviation	Skewness	Kurtosis	Min	Max
Degree's velocities (deg/s)	upper limb	shoulder	291.75	152.50	263.01	0.99	-0.59	36.00	814.00
		elbow	153.33	88.00	183.59	1.66	2.92	0.00	619.00
		wrist	115.08	96.50	121.57	2.41	7.04	5.00	465.00
	lower limb+ back leg	ankle	64.92	57.00	49.73	0.67	-0.63	3.00	154.00
		knee	59.58	48.50	41.74	1.35	2.04	16.00	161.00
		hip	92.25	65.50	73.28	1.96	4.21	25.00	287.00
	upper limb	shoulder	284.00	183.50	224.32	0.67	-1.61	59.00	606.00
		elbow	196.50	115.50	273.32	2.28	5.87	0.00	962.00
		wrist	86.00	91.50	46.20	-0.18	-1.48	20.00	143.00
Degree's acceleration (deg/s) ^{2}	lower limb+ front leg	ankle	3955.25	3972.50	2245.93	0.74	1.05	867.00	8984.00
		knee	2281.83	1924.50	1755.25	0.92	0.35	303.00	6019.00
		hip	3054.42	2784.50	2582.54	2.43	7.55	95.00	10558.00
	upper limb	shoulder	4083.50	3202.50	3559.66	1.35	1.24	11.00	11287.00
		elbow	5177.67	5003.00	5007.09	0.72	-0.58	216.00	13828.00
		wrist	4642.00	3426.00	4285.46	1.49	1.72	120.00	14405.00
degrees acceleration (deg/s) ^{2}	lower limb+ back leg	ankle	1261.17	1395.00	861.10	0.87	1.21	222.00	3238.00
		knee	1071.25	867.50	801.07	0.66	-0.30	79.00	2686.00
		hip	2444.75	1924.50	1193.60	0.36	-1.07	667.00	4523.00
	upper limb	shoulder	4449.25	2245.50	4270.73	1.39	1.69	749.00	14653.00
		elbow	6360.67	2040.00	9479.83	2.35	5.77	60.00	32786.00
		wrist	3114.17	2069.50	2793.28	1.04	0.42	509.00	9250.00

Table (9) shows that the data of the total research sample are moderate, not scattered, and characterized by the normal distribution of the sample, where the skewness coefficient values are close to zero, and they lie in the moderation curve between (±3), which confirms the moderation of the sample in the general variables under study at the (beginning of flight) moment.

Table (10)

Shows the statistical characterization of the Biomechanical indicators under study during the (flight off) moment.

(N = 12)

variables			mean	Median	standard deviation	Skewness	Kurtosis	Min	Max
velocities (m/s)	CG	Horizontal	2.50	2.24	0.84	1.76	1.99	1.70	4.28
		vertical	2.69	2.73	0.97	-1.59	4.49	0.11	4.04
		resultant	3.73	3.55	1.09	0.64	1.53	1.70	5.84
acceleration (m/s) ^{2}	CG	horizontal	4.92	3.42	4.75	1.35	0.97	0.18	15.59
		vertical	5.30	6.26	3.34	0.07	-1.22	0.76	11.08
		resultant	8.01	8.04	4.56	0.21	-1.21	2.04	15.64
Degrees positions (deg)	lower limb+ front leg	ankle	152.25	153.00	9.38	0.53	2.59	135.00	174.00
		knee	175.17	177.00	4.45	-0.96	-0.16	166.00	180.00
		hip	165.83	166.00	9.95	-0.32	-0.85	148.00	179.00
	upper limb	shoulder	158.50	156.50	9.49	0.10	-1.16	144.00	173.00
		elbow	171.58	172.50	4.81	-0.51	-0.11	162.00	179.00
		wrist	170.33	170.50	5.68	-0.10	-0.57	161.00	179.00
Degrees positions (deg)	lower limb+ back leg	ankle	151.58	150.50	8.26	0.34	-0.39	139.00	167.00
		knee	174.42	174.00	2.78	0.40	-1.46	171.00	179.00
		hip	167.42	172.00	11.19	-0.70	-1.07	148.00	179.00

variables			mean	Median	standard deviation	Skewness	Kurtosis	Min	Max
	upper limb	shoulder	154.00	156.50	11.54	-0.25	-1.11	136.00	171.00
		elbow	170.92	169.00	5.43	0.67	-0.87	164.00	180.00
		wrist	170.50	172.50	8.79	-1.39	2.22	149.00	180.00
Degree's velocities (deg/s)	lower limb+ front leg	ankle	132.00	139.00	56.37	0.02	-0.78	56.00	229.00
		knee	67.42	30.00	64.67	0.74	-1.11	1.00	177.00
		hip	138.17	134.00	100.46	0.52	-0.88	18.00	312.00
	upper limb	shoulder	188.25	164.50	123.91	0.36	-1.18	35.00	394.00
		elbow	120.92	103.00	69.89	0.12	-1.52	23.00	222.00
		wrist	142.42	125.00	62.15	0.43	-1.36	66.00	249.00
Degree's velocities (deg/s)	lower limb+ back leg	ankle	121.75	81.00	99.50	0.93	-0.35	25.00	302.00
		knee	68.17	49.50	59.37	1.01	-0.61	11.00	171.00
		hip	88.00	89.50	48.88	0.26	-0.38	10.00	179.00
	upper limb	shoulder	123.42	115.50	99.26	1.15	1.33	16.00	354.00
		elbow	116.92	120.50	66.22	-0.30	-0.37	3.00	211.00
		wrist	156.50	166.00	94.64	-0.03	-0.89	20.00	314.00
Degree's acceleration (deg/s) ^{2}	lower limb+ front leg	ankle	4411.17	3566.50	4634.72	1.41	1.91	49.00	15515.00
		knee	3177.67	3142.50	1683.78	0.09	-0.16	258.00	6296.00
		hip	2312.25	1206.00	2932.20	2.05	3.65	240.00	9823.00
	upper limb	shoulder	3350.00	3021.50	2208.29	0.77	0.27	505.00	8003.00
		elbow	2197.00	1251.50	2929.03	2.45	6.87	8.00	10607.00
		wrist	6513.17	5083.00	5593.84	0.42	-1.56	226.00	15283.00
degrees acceleration (deg/s) ^{2}	lower limb+ back leg	ankle	2866.92	2872.00	1525.73	0.48	-0.04	650.00	5970.00
		knee	2386.17	2308.00	2302.87	1.82	4.60	170.00	8576.00
		hip	2793.92	1883.00	2795.51	2.50	7.05	443.00	10857.00
	upper limb	shoulder	3079.75	2784.00	2041.01	0.64	0.14	310.00	7378.00
		elbow	3090.50	2710.00	2175.41	0.56	-0.62	148.00	6886.00
		wrist	8121.92	5992.00	7115.89	0.81	-0.27	493.00	22616.00

Table (10) shows that the data of the total research sample are moderate, not scattered, and characterized by the normal distribution of the sample, where the skewness coefficient values are close to zero, and they lie in the moderation curve between (±3), which confirms the moderation of the sample in the general variables under study at the (flight off) moment.

Table (11)
Shows the statistical description of the general Biomechanical indicators understudy (N = 12)

Variables		Mean	Median	Standard deviation	Skewness	Kurtosis	Min	Max
Temporal analysis	Break-time	0.27	0.27	0.13	1.37	3.28	0.13	0.60
	Push-time	0.20	0.20	0.08	1.41	2.16	0.13	0.40
	Flight time	0.35	0.40	0.08	-0.55	-0.74	0.20	0.47
Support phase	Cg horizontal breaking distance	0.32	0.34	0.14	-0.28	0.10	0.06	0.56
	Cg vertical breaking distance	0.05	0.05	0.03	0.29	-0.30	0.01	0.10
	Cg resultant breaking distance	0.32	0.34	0.14	-0.13	-0.13	0.08	0.57
	Cg horizontal pushing distance	0.49	0.49	0.18	1.03	0.63	0.31	0.88

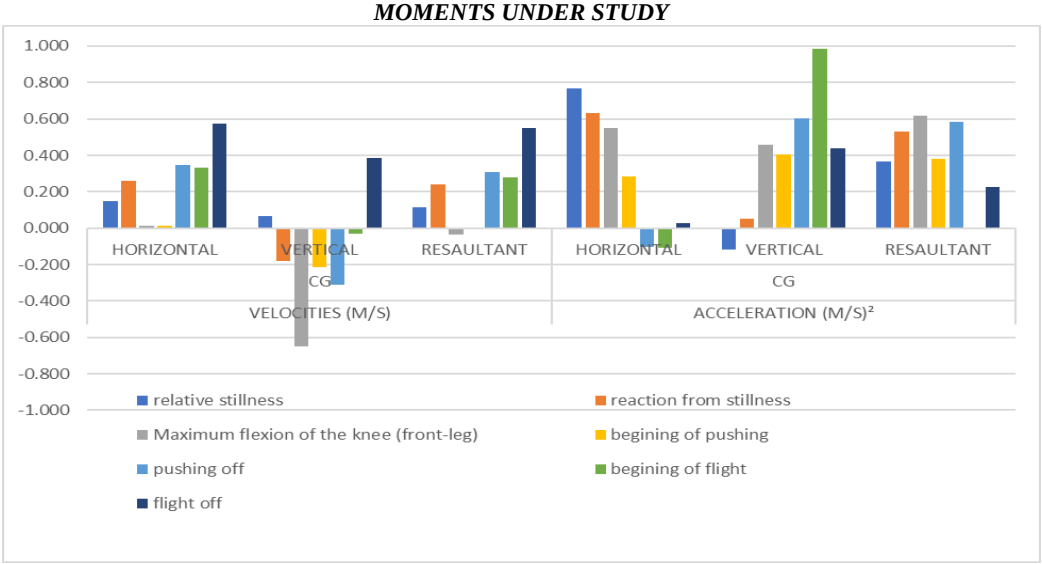
Variables		Mean	Median	Standard deviation	Skewness	Kurtosis	Min	Max
Flight phase	Cg vertical pushing distance	0.11	0.12	0.07	0.17	-0.77	0.01	0.23
	Cg resultant pushing distance	0.51	0.51	0.18	0.93	0.36	0.32	0.90
	Cg horizontal flight distance	1.48	1.37	0.42	0.52	-1.32	1.03	2.20
	Cg vertical flight distance	0.48	0.49	0.09	0.18	-0.91	0.36	0.62
	Cg resultant flight distance	1.56	1.42	0.41	0.59	-1.26	1.12	2.28

Table (11) shows that the data of the total research sample are moderate, not scattered, and characterized by the normal distribution of the sample, where the skewness coefficient values are close to zero, and they lie in the moderation curve between (±3), which confirms the moderation of the sample in the general variables under study at the mentioned moment.

Moderation of the sample in the general variables under study at the mentioned moment.

Figure (1)

SHOWS THE CORRELATION COEFFICIENTS BETWEEN THE VARIABLES AND THE RESULTANT VELOCITYOF THE CENTER OF GRAVITY DURING PUSHING OFF (THE BEGINNING OF FLIGHT) AT THE MOMENTS UNDER STUDY



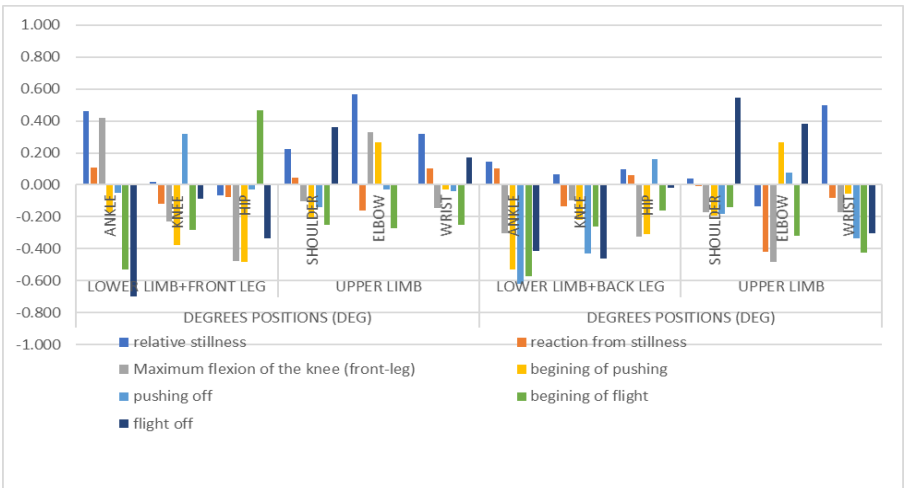
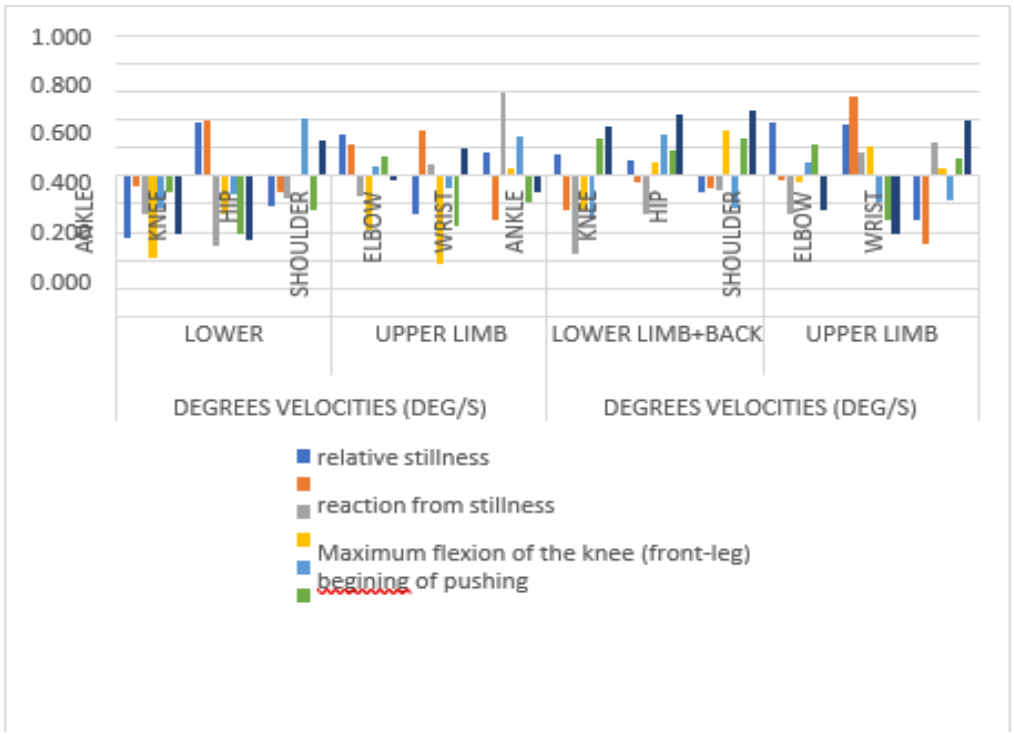


Figure (2)
shows the correlation coefficients between the variables and the resultant velocity of the center of gravity during pushing off (the beginning of flight) at the moments under study



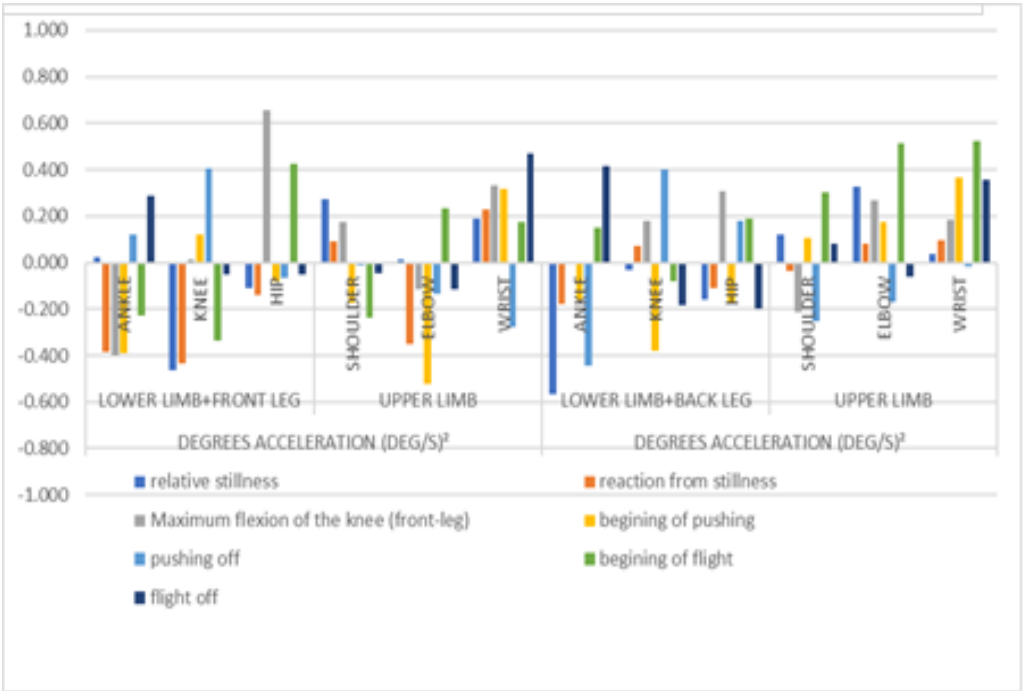
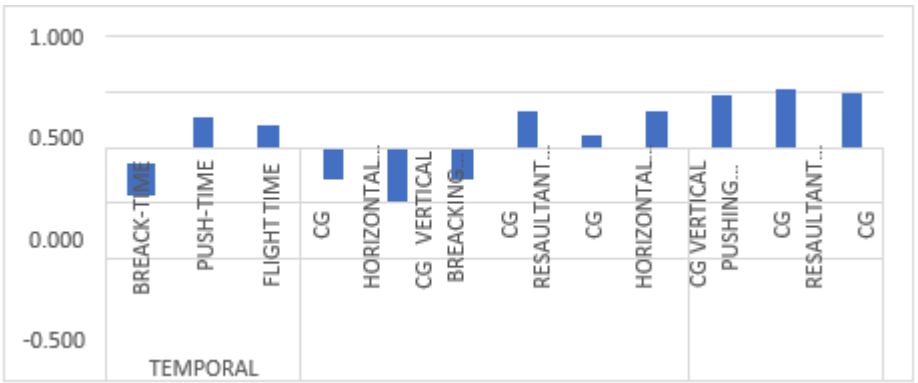


Figure (3)
SHOWS THE CORRELATION COEFFICIENTS BETWEEN THE GENERAL VARIABLES AND THE RESULTANTVELOCITY OF THE CENTER OF GRAVITY DURING PUSHING OFF (THE BEGINNING OF FLIGHT)



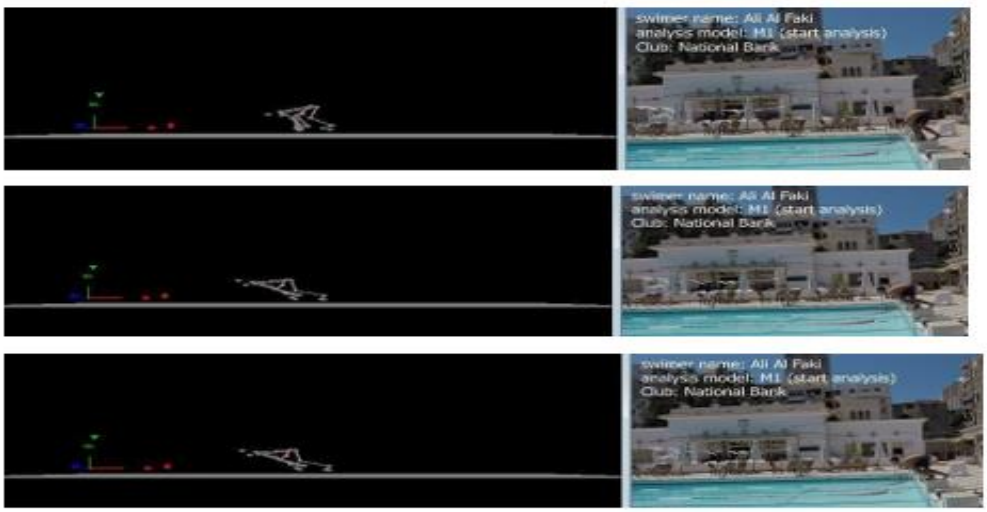
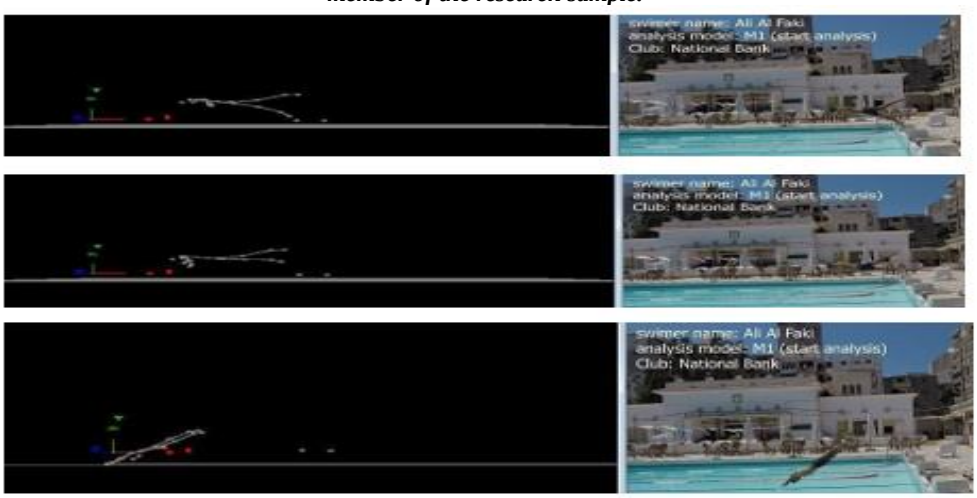


Figure (4)
Performance and stick shapes of the moments of analysis of the push off technique in freestyle swimming for a member of the research sample.



Discussing the results:

A. There is a statistically significant positive correlation between the horizontal velocity, the resultant velocity, the horizontal acceleration, the resultant acceleration, and the resultant velocity of the center of gravity during pushing off.

There is a positive correlation between the horizontal velocity of the center of gravity and the resultant velocity of the center of gravity during pushing off (beginning of flight) at the (flight off) moment, where the calculated (t) value was greater than the tabulated (t) value at the level (0.05) = 0.574

Adel Abdel-Bassir (1998) believed, and Mohamed Ramzy (2012) agreed with him that at the last moment of flight before entering the water, the body must be straight in the horizontal position so that the water resistance of the body is low during collision with water at the entrance moment.

(248: 9) (78:14)

Youssef Lazem and Qassem Hassan (2011) note that flying aims to maintain the push off velocity because of applying the force behind the body's center of gravity during pushing off, as the straight horizontal position helps reduce the air resistance of the swimmer's body. (187:8)

There is an negative correlation between The vertical velocity of the center of gravity and the resultant velocity of the center of gravity during pushing off (beginning of flight) at the (maximum flexion of the front knee joint) moment where the calculated (t) value was greater than the tabulated (t) value at the level (0.05) = -0.650

This is because the nature of the swimmer's performance requires achieving the maximum velocity rates in the horizontal direction and not in the vertical direction. At this point, the correlation is negative because the main goal of the pushing off phases from the starting block is to obtain the largest possible horizontal distance in the shortest possible time.

Adel Abdel-Bassir (1998) believes that the swimmer bends the knees to lower his center of gravity to be able to push forward, as the swimmer goes forward quickly leaving the starting block to overcome the inertia of the body and the body becomes in a horizontal position. (246: 9)

- There is a positive correlation between the resultant velocity of the center of gravity and the resultant velocity of the center of gravity during pushing off (beginning of flight) at the (flight off) moment, where the calculated (t) value was greater than the tabulated (t) value at the level (0.05) = 0.548

Gamal Alaa-Eldin, Nahed Anwar El-Sabbagh (1999) note that the velocity of the player's body can be analyzed into two horizontal and vertical vehicles, and we find that the vertical velocity reaches its maximum at the last moment of the flight, as it produces the largest movement energy and this energy decreases when entering the water as a result of the earth's gravity to which the body is subjected during its flight as a project.)46:11(

There is a positive correlation between The horizontal acceleration of the center of gravity and the resultant velocity of the center of gravity during pushing off (beginning of flight) at the (relative stillness) moment and(reaction from stillness) moment and (maximum flexion of the front knee joint)moment where the calculated (t) value is greater than the tabulated (t) value at the level (0.05) in the first moment = 0.768, the second moment = 0.634, and the third moment = 0.550.

At this point, the swimmer is required to perform the maximum rates of acceleration on the horizontal level in 3 moments, and they are the most important because the nature of performance on the horizontal level is more than the vertical, as the acceleration rates are related to the force rates wheref= m×a is the sum of the mass multiplied by the acceleration, and this is confirmed by Mohamed Bereka and Khairiya El-Sokkary (2002) (189:2).

There is a positive correlation between the vertical acceleration of the center of gravity and the resultant velocity of the center of gravity during pushing off (beginning of flight) at the (pushing off) moment at the (beginning of flight) moment where the calculated (t) value is greater than the tabulated.

(t)value at the level (0.05) in the first moment = 0.602 and the second moment = 0.983.

Since the swimmer is required to perform acceleration rates at the vertical level, but in two moments, the beginning of the push and the beginning of the flight, he/she is also required to perform the upward flight angle, even if the flight angle is not large, but vertical, resulting in velocity rates and acceleration rates on the vertical level and appears after the pushing off moment. Adel Abdel-Bassir (1998) indicated that the amount of pushing that the swimmer must exert has to be vertical behind the center of gravity on the line between him/her and the fulcrum, which can be determined by the vertical compound resultant resulting from pushing the two legs downward. (246:9)

Samira Mohamed Oraby (2017) shows that the flight pushes the body forward by extending the body in a sagittal shape where the swimmer pushes the starting block and the center of gravity advances forward and begins to descend downward as a result of the gravity. (99:4)

There is a positive correlation between The resultant acceleration of the body's center of gravity and the resultant velocity of the center of gravity during pushing off(beginning of flight) at the (reaction from stillness) moment (maximum flexion of the front knee joint) moment and the (pushing off) moment where the calculated (t) value was greater than the tabulated value (t) at the level (0.05) in the first moment = 0.531, the second moment = 0.617 and the third moment = 0.585.

We find that the acceleration of the center of gravity of the body is a horizontal and vertical sum, and here we find that the horizontal acceleration of the center of gravity of the body in two moments, reaction from stillness, and maximum flexion of the front knee joint resulted in a positive correlation on the horizontal level and on the net, and we also find that the vertical acceleration the center of gravity at the moment of pushing off resulted in a positive correlation on the vertical level and the resultant. Here we find that the horizontal acceleration is highly effective because the nature of performance on the horizontal level is greater than the vertical level, because bending the knees in

preparation for the player pushing the starting block, the swimmer gains a greater acceleration, and we find that the horizontal distance achieved by the swimmer depends on the horizontal velocity of the swimmer's body at the pushing off moment. (78:13)

B. THERE IS A STATISTICALLY SIGNIFICANT POSITIVE CORRELATION BETWEEN THE ELBOW AND SHOULDER ANGLE AND THE RESULTANT VELOCITY OF THE CENTER OF GRAVITY DURING PUSHING OFF.

There is a positive correlation between Right elbow joint angle and the resultant velocity of the center of gravity during pushing off (the beginning of flight) at the (relative stillness) moment where the calculated (t) value was greater than the tabulated (t) value at the level (0.05) at the first moment = 0.568.

There is a positive correlation between Right shoulder joint angle and the resultant velocity of the center of gravity during pushing off (the beginning of flight) at the (flight off) moment where the calculated (t) value was greater than the tabulated (t) value at the level (0.05) at the first moment. = 0.544.

The swimmer must pose the arms straight during flight, as the shoulder angle, which consists of the brachium angle and the trunk joint, helps in directing the swimmer's body and adjusting the path of the center of gravity during flight, which is the most important moment in the beginning.

The human body is composed of links and the largest link is the trunk (middle of the body), where the trunk represents 48% of the body weight, as it is the center of the movements, and swimming depends on the trunk to transfer power during performance.

Gamal Alaa-Eldin and Nahed Anwar El-Sabbagh (1999) see that the movement transfer from an orgasm to another until it ends with the one responsible for carrying out the motor duty, whether from the motor transfer from the limbs to the trunk or from the trunk to the limbs, therefore we find that the movement has transferred in the beginning from the trunk to the shoulder angle to help the swimmer achieve a long flight path in the shortest possible time and enter the water at the ideal angle(114:11)

C. THERE IS A POSITIVE CORRELATION BETWEEN THE ANGULAR ACCELERATION OF THE THIGH JOINT, ELBOW AND WRIST, AND THE RESULTANT VELOCITY OF THE CENTER OF GRAVITY DURING PUSHING OFF.

There is a positive correlation between Angular acceleration of the hip joint of the front leg and the resultant velocity of the center of gravity during pushing off at the (beginning of flight) at the (maximum flexion of the front knee joint) moment where the calculated (t) value was greater than the tabulated (t) value at the level of (0.05) in the first moment = 0.658.

Since the thigh joint connects the upper and lower limbs at the maximum flexion moment of the frontleg knee, where it is ready to perform the rotational movement, which helps to curve the trunk forwardin a way that allows the swimmer to enter the water very smoothly, which reduces the resistance to friction forces, because the greater the angular wheel of the thigh joint was the faster the full extension gets and thus obtaining a greater push off in the shortest time. As the law of angular acceleration

states that it is the rate of change in angular velocity with respect to time $\Delta w = w2 - w1 = a$. (89: 6)

$t \qquad t$

Allen, David (1997) notes that a swimmer uses energy to reach the maximum horizontal distance in the air as quickly as possible, and this requires the use of the muscles of the trunk, buttocks, thighs, and legs in an organized sequence. (26: 15)

Adel Abdel-Bassir (1998) believes that the swimmer bends the knees to lower his center of gravity where the line of gravity is perpendicular to the base center that consists of the feet and the distance between them that is proportional to the width of the pelvis in order to be able to push forward as the swimmer goes quickly leaving the starting block forward to overcome the self-shortcoming of the body. (246:9)

Salah El-Din Mohamed (1994) believes that the thigh joint is responsible for determining the final direction of the starting angle from the block. (25:3)

There is a positive correlation between The Angular acceleration of the left elbow joint and the resultant velocity of the center of gravity during pushing off (beginning of flight) where the calculated.

(t) value was greater than the tabulated (t) value at the level (0.05) = 0.512.

There is a positive correlation between The Angular acceleration of the left wrist joint and the resultant velocity of the center of gravity during pushing off (beginning of flight) where the calculated.

(t) value was greater than the tabulated (t) value at the level (0.05) = 0.522.

The angular wheel increases at the beginning of flight moment, the movement of the arms continues forward and the head rises slightly to be looking forward, and then the body reaches the full extension phase, and this indicates the good motor transfer of power now of flight to enter the water at an ideal angle.

The quantity of movement m = m×v is the sum of multiplying the mass by the velocity, and when the amount of movement of the arms is transferred to the trunk, the amount of movement of the body increases and thus the acceleration increases. This is confirmed by Sawsan Abdel Monaem et al. (1991) (228:5).

STATISTICAL TREATMENTS:

The following statistical treatments were found using SPSS version 25:

-Arithmetic mean.
-Standard deviation.
-Media.
-Skewness.
-Kurtosis.
-Min value.
-Max value.
-Pearson correlation.

Conclusions:

1. The horizontal velocity and the resultant velocity at the flight off moment are important.
2. The horizontal wheel reached its maximum rates of acceleration on the horizontal level at the moments of relative stillness, reaction from stillness, and maximum flexion of the knee (front leg).
3. The vertical wheel has reached its maximum acceleration rates on the vertical level at the moments of pushing off and beginning of flight.
4. The horizontal wheel greatly affected the resultant wheel at the pushing off moment.
5. The angle of the shoulder and elbow help direct the swimmer's body and adjust the path of his center of gravity during flight.
6. The full extension of the thigh joint increases the angular wheel and the entry into the water quickly and smoothly.

RECOMMENDATIONS:

1. Using the results of the study in evaluating the performance of junior swimmers.
2. The coaches committee of the Egyptian Swimming Federation should take into consideration the importance of implementing kinetic analysis courses.
3. Developing training programs to address the points of weakness, especially for the ankle joint.

References:

Arabic References:

1. **Abu-Ela Abdel-Fattah (1994):** Swimming training for higher levels, Dar Al-Fikr Al-Arabi, Cairo
2. **Mohamed Bariqa, Khayriyah Al-Sukari (2002):** Basic Principles of Biomechanics in the Sports Field, Part One, Source of Knowledge, Cairo.
3. **Salah Al-Din Malik (1994):** Some variables of the flash start as a function of the angular change in swimming competitions, Assiut Journal of Physical Education Sciences and Arts, Vol. 4, Volume 2.
4. **Samira Orabi (2017):** Swimming, "Education, Training, Organizing", first edition, Dar Majid Publishing
5. **Sawsan Abdel Moneim, Mohamed Sabry Omar, Mohamed Abdel Salam Ragheb (1991):** Biomechanics in the Sports Field, Part I Biodynamics, Alexandria, Dar Al Maaref.
6. **Talha Husam El-Din (1993):** Biomechanics," theoretical and applied foundations", Arab Thought House, Cairo,
7. **Wafiqa Salem (2000):** Water sports, its objectives, methods of teaching, foundations of its training, methods of evaluation, Dar Al Maaref, Cairo.
8. **Youssef Kammash, Qassem Hussein (2011):** The sport of swimming "anthropometric, physiological and training principles", Zahran Publishing House, Cairo.
9. **Adel Abdel-Basir (1998):** Biomechanics between theory and practice in the mathematical field,2nd edition, Al-Kitab Center for Publishing, Cairo
10. **Essam Helmy (2008):** A strategy for training juniors in swimming, Dar Al Maaref, Alexandria.
11. **Gamal Aladdin, Nahed Anwar Al-Sabbagh (1999):** Kinesiology, faculty of physical education for boys ،Alexandria university ،seventh printing.
12. **Howaida Al-Saadani (2003):** Mechanical differences between some common methods of starting from the block in competitive swimming, Journal of Physical and Sports Sciences, Menoufia University, No. 3, Volume 2
13. **Manar Obeidat (2004):** The kinematic analysis of the skill of starting and spinning in crawling swimming, a master's thesis, Faculty of Physical Education, Yarmouk University, Oman.
14. **Mohamed Ramzy (2012):** Principles of Biomechanics and its Applications in the Sports Field, Rashid Publishing, Zagazig, Cairo.

FOREIGN References:

15- Allen, D. (1997): A kinetic and kinematic comparison of the grab start and track start in swimming (Doctoral dissertation).

16- Hannula, D. & Thornton, N. (2001). The swim coaching bible, worlds swimming coach's association. Human Kinetics, United States of America, 107-108.