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Studying the Relationship between some Biokinematic Variables and some Physical Measurements with the Level of Achievement in 25-meter Freestyle Swimming

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Abstract

Study purpose. Swimming experienced significant growth and achievement in the late twentieth century and early second millennium, marked by the creation of advanced records. This progress is due to rigorous training, practical experience, and the utilization of modern scientific techniques and applied sciences such as biomechanics. This study aims to evaluate several bio-kinematic variables, physical measurements, and completion times in 25-meter freestyle swimming.

Materials and methods. Researchers used a descriptive approach to suit the nature of the research. The research sample consisted of 6 swimmers in the Nineveh Governorate applicant category. There was a digital camera with a speed of 7 images/second.

Results. There is a positive significant correlation between the anthropometric variable (arm length) with the total time. The researchers attribute this to the fact that the length of the distance of one stroke in swimming (25) meters depends primarily on the length of the total arm and thus, which will lead to covering the total distance of completion in the shortest possible time, given that the length of the arm is part of the length of the stroke.

Conclusion. The researchers concluded that the bio-kinematic variables studied played a very important role in achieving the best sample performance, even though the sample performance was generally poor. The large number of arm strokes in the study sample led to an increase in stroke frequency at the expense of decreasing the average length of arm strokes, thereby increasing completion time.

Keywords: Kinetic Sports, Completion Level, Freestyle Swimming, Average stroke length, physical measurements

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Introduction

Swim today is one of the most comprehensive and widespread activities and sports in the countries of the world because of its wide popularity and great interest among all age groups, its importance is clearly demonstrated because of the physical, health, psychological, and social benefits it gains to human (Shatha, 2024). As well as the prominent place it occupies in the Olympics. The sport of swimming witnessed great development and great achievement in the late twentieth century and the beginning of the second millennium in recording advanced records. That came as a result of training, experience, field practice, and reliance on the latest modern scientific techniques and applied sciences, including biomechanics, the science that is concerned with studying human movement and analyzing it quantitatively and qualitatively to increase the efficiency of human movement, and identification of the causes and phenomena of movement (Yeadon & Pain, 2023).

Many scholars in this field, agree that biomechanics plays an important role in improving the digital levels of swimmers through the improvement and development of modern equipment, which enabled the diagnosis of strengths and weaknesses of motor performance scientifically after it was just an observation like video imaging. Professional swimming coaches utilize video analysis to assess their athletes' performances. These videos are manually examined to observe the swimmer's body movements during practice, allowing targeted feedback on technique improvement. Additionally, wearable sensors, such as accelerometers or photoplethysmographic sensors, along with optical markers, can enhance reliability and accuracy. For instance, a single 8-megapixel wide-angle camera can effectively estimate a swimmer's pose during exercise while ensuring precise measurements (Giulietti, et al., 2023).

The variables (strike length rate, strike frequency rate, strike speed rate, strike time, and count of strikes to the arm are among the Bio-kinematic variables that play an important role and contribute to determining the achievement time in swimming, as mentioned (Patoz, et al., 2024). The swimmer's speed depends on the distance of the race on two main factors: the strike length and the strike frequency rate (Housh, et al., 2017). Freestyle swimming is one of the four types of Olympic swimming used in the Olympic and world championships and competitions, and it is of great importance in obtaining many medals and decorations, and free-swimming occupies the first place. The four swimming methods in terms of speed and count of activities in the Olympic program (Housh, et al., 2017).

Therefore, the importance of the research is determined by the inability of the research sample to coordinate smoothly between the length, number, and time of the stroke to maintain flow in the water and reduce water resistance as much as possible by reducing excessive movements during the arm's exit and entry into the water, which prompted us to conduct an analytical and descriptive study. Away from the naked eye and with the help of a modern digital camera with high-frequency images to evaluate the motor performance of some biokinetic variables (stroke length rate, stroke frequency rate, stroke speed rate, stroke time, and number of strokes) of the arms, the time to complete freestyle swimming (25) m, and identification. To investigate the extent to which these variables of the arms relate to the completion time in swimming (25 m) freestyle for the sample, and to shed light on them and benefit from the research results for those working in the field of swimming training to reach the best performance.

The main research problem is to determine the low freestyle swimming records of the swimmers of Nineveh Governorate in particular and the Iraqi national team in general compared to the records recorded for swimmers in other countries of the world. In addition to the presence of some ambiguity in the bio-kinematic aspects regarding the variables (the rate of strike length, the rate of strike frequency, the rate of strike speed, the time of the strike, and

the count of strikes) of the arm their relationship with the completion time (Waldron & Schmiedeler, 2016)
That prompted the researchers to conduct an analytical and descriptive study to assess the variable's scores and the values of completion time in the (25) m freestyle swimming. To identify the extent of the relationship between those variables and the completion time.
To clarify and then benefit and then benefiting from the results of the research for workers in the swimming field to reach good performance and better achievement, the research aims to identify: 1) Evaluate some bio-kinematics variables, some physical measurements, and completion time in the 25-meter freestyle swim, 2) The relationship between the values of some bio-kinematics variables and some physical measurements with the values of completion time in a 25-meter freestyle swim.
Research hypothesis: The researchers assume that there is a significant relationship between the values of some bio-kinematic variables of the arm and the values of completion time in a 25-meter freestyle swim.

MATERIALS AND METHODS

Study participants

Research sample: The research sample included swimmers for the Nineveh Governorate national team, a category of applicants consisting of (6) swimmers, who were chosen intentionally for the 2022/2023 sports season. Table 1 shows some statistical features of the sample:

Table 1. Shows Some Statistical Features Of The Sample

T	Variables / Swimmer	Length (cm)	Mass (kg)	Age Year	Training age year	Achievement second
1	First Swimmer	173	73	23	2	13.2
2	The Second Swimmer	185	84	24	3	14
3	The Third Swimmer	176	78	25	3	13,6
4	The Fourth Swimmer	184	80	23	3	14.2
5	The Fifth Swimmer	170	72	22	2	14.6
6	The Sixth Swimmer	175	80	21	2	14.5
7	Arithmetic Mean	177.167	77.83	23	2.5	13.72
8	Standard Deviation	6.47	4.579	1.414	0.548	0.722
Coefficient of variation 30%		3.652	5.883	6.148	21.909	5.262

Table 1 Noting the value of the coefficient of variation of 30%, in these variables its value is less than 30%, and this is evidence of the homogeneity of the sample with these variables.

Research organizations

Research methodology: The researchers used the descriptive method using a survey method to suit the nature of the research. The research sample consisted of 6 swimmers in the Nineveh Governorate applicant category. There was a digital camera with a speed of 60 images/second. Japanese Canon type, made outside the water, tracking the movement of swimmers at a distance of 2 meters from the start to the end of the freestyle distance of 25 meters, to match the results of the assistant work team in calculating the number of strokes and the time of each stroke of the right arm. The left one is with what was photographed, The

following statistical methods were used, Arithmetic mean x, Standard deviation ± p, Simple correlation coefficient (Pearson) coefficient of variation is 30%.

Methods of collecting data: Researchers used technical scientific observation, measurement, and analysis as means of collecting data to obtain the values of (biokinematic) variables.

Scientific-technical observation: The scientific-technical observation was achieved through digital videography, using a Japanese-made Canon video camera at a speed of (60 images/second), moving with the swimmer's movement. Filming was done from the right side of the swimmer's movement and at a distance of (2) M of the swimmer. The filming took place in the closed swimming pool of the College of Physical Education and Sports Sciences, University of Mosul. It was only mobile to confirm and match the results calculated by the assistant work team.

Devices and tools used in the research:

1. Canon video camera (1)
2. Sony 8mm videotape (1)
3. Stopwatch (2)
4. Whistle to release the swimmers
5. Lenova computer
6. CD ROM
7. Canon laser printer.
8. Number plates showing the swimmer's name, sequence, and type of attempt

Physical measurements: The researchers measured the swimmer's mass (kg) while he was out of the water wearing only a swimsuit (shorts) with a medical scale that measures to the nearest (50 grams). They also measured the total length of the body and the lengths and circumferences of the joint parts of the body using a flexible measuring tape, and the time. Overall achievement in swimming (25) meters for the sample.

Research variables: The research variables included (kinematic) variables as follows:

1. The number of arm strokes: This is the number of times one arm moves out of the water and makes a complete circle until the moment it touches the surface of the water, whether for the right or left arm.
2. Average stroke length of the arm (meters/cycle). The next equation used to determine stroke length:

Stroke length rate = (traveled distance) / (complete in cycling terms count)

3. The time of the arm stroke (second) (Wayen Glodsmith, 2018)
4. The average stroke speed of the arm (meters/second). The next equation used to determine the average stroke speed:

$$\text{Average stroke speed} = \frac{\text{Horizontal distance traveled}}{\text{time taken}}$$ (Ohgi, Kaneda, 2014)

5. Average strike frequency of the arm (cycle/time). The next equation used to determine the average strike frequency:

$$\text{Stroke frequency} = \frac{\text{completing cycling terms}}{\text{time taken}}$$ (Gary, 2023)

6. Achievement (second)

Then identify their values by extracting the arithmetic mean and standard deviation for each variable separately, as shown in Tables 2 and 3.

How to conduct the test: Two attempts were given to each swimmer, and the best attempt was chosen at the expense of the shortest time. The swimmer's movement was

determined within a field of width (2.50 m) and according to the legal specifications designated for international races in Olympic swimming. Swimming was started from Inside the pool, to overcome individual differences between swimmers in starting, as in Figure 1, and Figures 2, 3, 4, and 5, which show the movement of the right arm to perform a single stroke and count its number. The total by the assistant work team and the length of a freestyle swimming distance of (25) meters for one of the members of the research sample.

Figure 1. Method of starting a swim (25) meters from inside the pool, to overcome individual differences between swimmers in starting for one of the sample members

Figure 2. Moment the right arm emerges from the water to begin calculating the single stroke and its length for one of the sample members (the beginning of making a circle for the right arm in the water)

Figure 3. The highest height of the right arm when performing a strike for one of the sample members

Figure 4. Moment the right arm enters the water to calculate the end and length of one stroke for one of the sample members

Figure 5. Moment the right arm emerges from the water to begin calculating the next stroke and its length for one of the sample members (the end of making a circle for the right arm in the water)

Exploratory experiment: The researchers conducted the exploratory experiment on the research sample in the swimming pool of the College of Physical Education and Sports Sciences, University of Mosul, on Tuesday 3/1/2022 at 11 am, to prepare the assistant work team, and ensure the validity and working status of the machine. Photography and correct measurement to prepare the swimmers to perform the main trial according to the legal regulations for swimming (25) meters freestyle. The work team counts the number of strokes for the right and left arms from the beginning until the end of the 25-meter freestyle swimming distance To avoid any difficulty or error that might occur in the main experiment.

The main experiment The main experiment was conducted on the research sample on Tuesday 3/8/2022 at 11 am in the swimming pool of the College of Physical Education and Sports Sciences, University of Mosul.

Programs used in the research: The following programs were used, each according to its function, to reach the research results:

Program: (AC-DSee 10 Photo Manager) Through this program, we can display each of the segmented images so that we can determine the beginning and end of the important parts that we want to analyze.

Microsoft Office Excel 2010: This program was used to mathematically process raw data and Charts.

Microsoft Office Word 2010: It is a global program used for printing and has useful features and properties for the student in terms of printing.

Paint program: It is a program located within the computer system that was used to process some images.

Statistical treatments: The following statistical methods were used:

a. Arithmetic mean x
b. Standard deviation ± p.
c. Simple correlation coefficient (Pearson).
d. The coefficient of variation is 30%. If its value is less than 30%, this indicates homogeneity of the sample with those variables under study.

The data was processed statistically using a computer and within the SPSS program.

Results

The following Figures 6, 7, and 8 show the average stroke length, frequency, and stroke speed with completion and for every (5) meter of a (25) meter freestyle swimming distance for the sample.

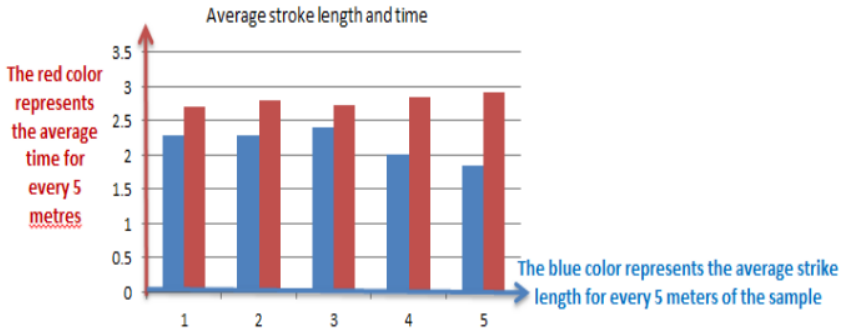

Figure 6. Average stroke length and time for each (5) meter of a (25) meter freestyle swimming distance for the sample.

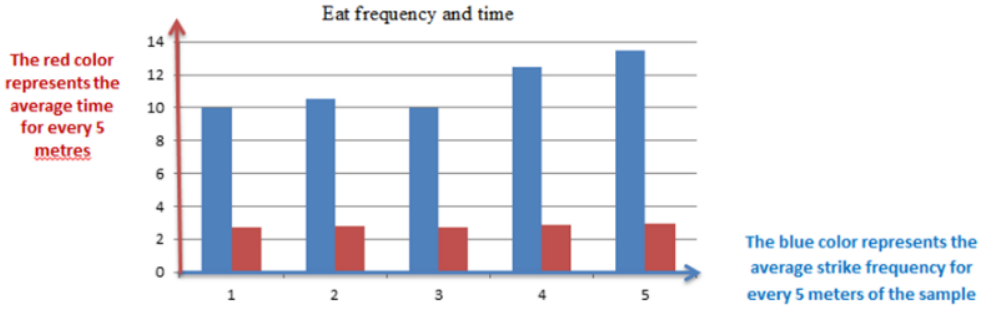

Figure 7. Average stroke frequency and time for each (5) meter of a (25) meter freestyle swimming distance for the sample

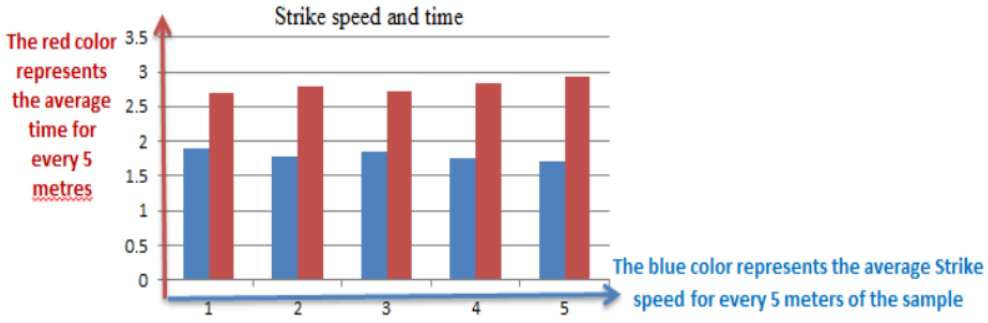

Figure 8. Average stroke speed and time for every (5) meter of a (25) meter freestyle swimming distance for the sample. Strike speed

The results of the biokinematic variables under study in a 25-meter freestyle swim for the sample: Table 2 displays the values of arithmetic means and standard deviations for the biokinematic variables under study in a 25-meter freestyle swim for the sample

Table 2. Arithmetic means and standard deviations of the values of the biokinematic variables under study in a 25-meter freestyle swim for the sample.

Biokinematic variables / Sample	Number of strokes (stroke)	Average stroke length (m)	Strike time (seconds)	average stroke speed (m/s)	Strike frequency rate Beat/second	Total time (second)
First swimmer	10	2.5	1.32	1.89	0.76	13.2
Second swimmer	10.5	2.38	1.33	1.79	0.75	14
Third swimmer	10	2.5	1.36	1.84	0.73	13.6
Fourth swimmer	12.5	2	1.14	1.75	0.88	14.2
Fifth swimmer	13.5	1.85	1.08	1.71	0.92	14.6
Sixth swimmer	12.5	2	1.16	1.72	0.86	14.5
Arithmetic mean-$\bar{x}$	11.5	2.20	1.23	1.87	0.82	14.01
Standard deviation ±p	1.52	0.29	0.12	0.07	0.07	0.54

Results of some values of the physical measurements under study in a 25-meter freestyle swim for the sample: Table 3 displays the values of arithmetic means and standard deviations of some of the physical measurements under study in a 25-meter freestyle swim for the sample.

Table 3. Arithmetic means and standard deviations of the values of some of the physical measurements under study in the 25-meter freestyle swimming for the sample.

T	Variables / Swimmer	Humerus length	Forearm length	Palm length	Arm length	Torso length poison	Leg length poison	Shoulder width	Chest circumference	Achievement second
1	First swimmer	32	28	18	78	70	88	56	97	13,2
2	The second swimmer	36	28	18	82	66	85	57	102	14

3	The third swimmer	30	27	18	75	69	82	56	96	13.6
4	The Fourth swimmer	37	27	20	84	64	78	58	97	14.2
5	The fifth swimmer	30	27	17	74	65	75	56	95	14.6
6	The Sixth swimmer	30	27	18	75	70	86	55	98	14.5
Arithmetic mean		32.5	27.333	18.167	78	67.333	82.333	56.333	97.5	13.72
standard deviation		3.209	0.516	0.983	4.147	2.658	5.007	1.033	2.429	0.722

Results of some bio-kinematic variables and some physical measurements under study with the completion of a (25) m freestyle swim at a significance level (0.05 ≥) for the sample: Table 4 shows the significant correlations calculated for some bio-kinematic variables and some physical measurements under study with the completion of a (25) m freestyle swim at a significance level (0.05 ≥) for the sample:

Table 4. Significant correlation values for the sample.

Kinematic variables	Number of hits (a hit)	Stroke length rate (M)	Strike time (second)	Strike speed rate (m/s)	Strike frequency rate (blow/second)	Chest circumference (centimeter)	Arm length (centimeter)
Completion (seconds)	0.907*	-0.917*	-0.836*	-0.998*	0.823*	-0.978*	0.886*

*Significant at (0.05 ≥) level and degree of freedom (4) = 0.811 for the tabular t value

Discussion

Tables 3 and 4 show different values in the biokinetic variables and some of the physical measurements of the sample under study. The values of the biokinetic variables differed depending on the physical values of each swimmer in terms of height, chest circumference, trunk length, number of hits, arm length, palm length, forearm length, etc. Since, physical measurement of (chest circumference and arm length) was the most effective when taking into account the correct arm movements (technique) by fully extending the arm to obtain an appropriate stroke length and thus better performance (Pebriyadi., 2024). This only happens when the arm stroke length is increased while maintaining an appropriate stroke repetition rate. The number of arm strokes in the research sample was large, which led to an increase in the repetition rate of strokes at the expense of a decrease in the average length of the arm stroke, the inability to benefit from the driving forces of the water that work in the direction of the swimmer's movement, and the reduction of the obstructive forces that work in the opposite direction of the swimmer's movement. Which led to an increase in the sample completion time. Figures 6, 7, and 8 display the average time for every 5 meters with the average strike length for every 5 meters of the sample.

Table 4 represents the values of the significant correlations between the bio-kinematic variables and the completion time in the 25-meter freestyle swimming, and shows the following:

There is a positive moral correlation between (the number of strokes of the arm) with the total time (completion time), as the calculated (t) value appeared (0.907), which is greater than the tabulated (t) value of (0.811) at the significance level (0.05) and a degree of freedom

(4). The researchers attribute this to the fact that there is a direct relationship between the variable number of arm strokes and the completion time. Whenever a swimmer works to increase the number of strokes at the expense of the length of the stroke, this leads to an increase in completion time, which agrees with the study of (Morais, et al., 2023).

There is a negative significant correlation between the variable (stroke length rate) of the arm and the completion time, as the calculated (R) value appeared (-0.917), which is greater than the tabulated (R) value of (0.811) at a significance level of (0.05) and degree Freedom (4). The researchers attribute that there is an inverse relationship between the variable of the stroke length rate of the arm and the completion time. The greater the stroke length rate, the more this leads to a decrease in the completion time This is consistent with (Mooney , et al., 2016)

There is a negative moral correlation between the variable (strike time) with the total time (completion time), as the calculated (t) value appeared (-0.836), which is greater than the tabulated (t) value of (0.811) at the significance level (0.05)) and a degree of freedom (4). The researchers attribute that there is an inverse relationship between the variable of the stroke time of the arm and the total time. The more the swimmer works by increasing the number of strokes of the arm, i.e. increasing the frequency of the stroke, this leads a decrease in the stroke time as a result of the shortening of the arm's rotation path (stroke length). This led to an increase in the total time spent by the research sample.

There is a negative significant correlation between the variable (stroke speed rate) with the total time, as the calculated (R) value appeared (-0.998), which is greater than the tabulated (R) value of (0.811) at a significance level of (0.05) and a degree of freedom. (4). The researchers attribute this to the fact that there is an inverse relationship between the variable rate of the stroke speed of the arm and the total time. The lower the rate of speed of the stroke, this leads to an increase in time. The less the distance traveled during the arm's rotation, the leads to decrease in the rate of stroke speed.

There is a positive significant correlation between the variable (stroke frequency rate) with the total time, as the calculated (t) value appeared (0.823), which is greater than the tabulated (t) value of (0.811) at a significance level (0.05) and degree of freedom (4), and the researchers attribute this to the fact that there is a direct relationship between the variable (stroke frequency rate) of the arm and the total time. Whenever the swimmer works to increase the number of strokes of the arm while shortening the stroke time, this leads to an increase in the rate of stroke frequency, which is reflected in a decrease in the rate of length. The stroke and thus an increase in the total time taken, and this is what appeared in the research sample in the increase in the average stroke frequency at the expense of the average length of the stroke and thus an increase in the total time, this is consistent with (Newsome & Young 2012).

There is a negative moral correlation between the anthropometric variable (chest circumference) with the total time, as the calculated (t) value appeared (-0.978), which is greater than the tabulated (t) value of (0.811) at a significance level of (0.05) and degree Freedom (4). Researchers attribute this to the inverse relationship between a larger chest circumference and achievement, as evidenced by the negative sign that appeared between them, which is somewhat of a negative influence on achieving better achievement because the body section as a whole is exposed to a larger area of water resistance during competition.

There is a positive significant correlation between the anthropometric variable (arm length) with the total time, as the calculated (t) value appeared (-0.978), which is greater than the tabulated (t) value of (0.811) at a significance level of (0.05) and degree Freedom (4). The researchers attribute this to the fact that the length of the distance of one stroke in swimming (25) meters depends primarily on the length of the total arm and thus, which will lead to covering the total distance of completion in the shortest possible time, given that the length of

the arm is part of the length of the stroke. The whole is in water, and by increasing the part, the whole will increase, and vice versa this is consistent with (Nawaf, 2010).

Conclusions

The bio-kinematic variables examined were crucial in optimizing the sample's performance, even though the overall performance was subpar. Selecting swimmers should be based on physical measurements, such as circumferences, muscle size, and body part lengths, which should be known in advance by those overseeing the training process. The physical measurements of chest circumference and arm length were most effective when proper arm movements were employed. Fully extending the arm to achieve an optimal stroke length enhances performance. This improvement occurs only when the stroke length is increased while maintaining an appropriate stroke repetition rate. We are recommended that to use use digital cameras inside the water to follow the movement of the arm and to know the strengths and weaknesses specifically to improve the overall achievement in 25-meter freestyle swimming

Conflict of interest

The authors state that they have no competing financial interests or personal relationships that could have influenced the work.

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