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Analysis of Explosive Power in the Paddle Stroke of Elite Rowing Athletes in Iraq

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Abstract

The advancement of modern assistive technologies, including devices and tools, has made it essential to utilize scientific and technological progress for motion analysis and to assess the performance level of skills and movements. Among these is the paddle stroke, which relies on a two-part performance: one part above the water as an unsubmerged section, and the other part below or in contact with the water as a submerged section. This analysis depends on the body position and performance of the athlete (the rower) using the tool (the paddle). The importance of this study lies in measuring and analyzing variables such as speed, time, and angle to assess the explosive power on the key body joints relied upon by the rower at the moment of take-off to reach the peak of movement. The researcher used the descriptive approach with correlational methods. The research sample was deliberately selected from elite players within the Iraqi national rowing team for 2022, consisting of 5 athletes from a total population of 8, chosen through purposive sampling. The researcher concluded that the values of the biomechanical variables for the total stroke time were significant, as were the biomechanical variables for explosive force in terms of time and stroke length, which were also significant. The relationship between these variables was positive, demonstrating that the explosive stroke time and its length impacted the total stroke time, performance, and fluidity. The researcher recommends placing continuous emphasis on biomechanical variables, given their substantial effect in identifying the strengths and weaknesses of rowers. This is because the foundation of a stroke consists of angles, extensions, and forces applied both in and out of the water. and this achieves one of the sustainable development goals of the United Nations in Iraq which is (Quality Education).

Keywords **Analysis – Explosive Power – Paddle – Elite Athletes**

Introduction:

The benefits of sports sciences are often realized in practical applications and analysis to achieve athletic excellence, as these sciences work to reveal the athlete's need to enhance physical and functional capabilities, which positively affects performance and results. Physical and functional performance advances only with the improvement of physical ability and the function of contributing internal organs, so that these factors can be aligned with the body's mechanical capabilities and its variables by using a variety of modern assistive technologies and developmental tools. Scientists affirm that strength in high-performing athletes develops in all its forms only with the advancement of body structure, functional capacities, and the ability to adapt to changes in performance and training. Through continuous research into the logical reasons behind achievement, sports sciences provide ample space to study the visible aspects of obstacles to an athlete's success in performance. Biomechanics, for example, offers critical insight into the details of the movement

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chain specific to the sport, including angles, distances, speeds, arcs, deviations, and trajectories, whether in the upper or lower parts of the body. Additionally, it provides an understanding of movement details involving tools and equipment used to perform the activity or skill, as well as the correlations between these elements. Therefore, skilful performance in rowing relies on an interconnected movement chain that begins with the body's posture and preparation for the movement and its requirements. This necessitates eliminating all obstacles that may disrupt the movement, including natural resistances such as air and water, as well as the equipment used in the sport, such as the paddle and the boat (Latif) (8).

As a result of the advancement of modern assistive technologies, including devices and tools, it has become essential to leverage scientific and technological progress for motion analysis and to assess the performance level of skills and movements. One such movement is the paddle stroke, which consists of two parts: one above the water (non-submerged) and the other below or in contact with the water (submerged). This depends on the body position and performance of the athlete (the rower) using the tool (the paddle), with the body moving in a balanced manner, supported by a sliding seat and fixed feet in the boat through special shoes with adjustable supports. These measurements are determined by the athlete according to their body position, which allows the movement of the legs with the seat, the torso, and the arms holding the paddle. This movement must be executed dynamically and error-free, as any mistake in this motion is the primary obstacle or resistance to optimal performance.

Based on the above, the importance of the study lies in measuring and analyzing variables such as speed, time, and angle to assess explosive force on the key joints used by the rower during the take-off phase to reach the peak of movement. The researcher agrees with Sareh Abdul Karim Al-Fadhli, who stated: "The explosive power performance for moving the boat with the paddle depends on the player's strength and skill in moving the paddle above and below the water with high force to push the water forward, overcoming surrounding conditions in the shortest time, with the least effort, and over the greatest distance. This is achieved when analyzing the movement, observing any defects and weaknesses in the performance, identifying areas of strength, and addressing and enhancing them" (Al-Fadhli) (7). The study addresses the following questions: Do the variables we analyze affect performance and achievement? Is there a relationship between explosive power performance and the variables?

The study aimed to identify the values of the total time variable for explosive power performance, explore the values of certain biomechanical variables for skill performance, and determine the relationship between these variables.

Methodology and Tools:

The researcher used the descriptive method with a correlational approach due to its suitability for the nature of the study. **The research population consisted** of advanced-level rowers, and a purposive sample was selected from the elite players of the Iraqi national rowing team for 2022, with a total of 5 participants chosen from the entire research population of 8 players. To enhance **validity and reliability**, the researcher clarified the homogeneity of the sample in relation to the research topic.

Table (1)
It shows the homogeneity of the research sample

Statistical Measures	Arithmetic Mean	Standard Deviation	Coefficient of Variation	The value
Length / cm	184.2	1.131	0.614	Significant
Age	21	0.96	0.68	Significant
Training Age	9.5	0.68	2.62	Significant
Mass	81	0.56	0.691	Significant

The tools, instruments, and devices used in the research:

- Measurement and testing (used as a means of data collection).
- Whistle, 1 unit.
- Starting platform, 1 unit.
- Olympic rowing boat, 1 unit.
- Oar, 2 units.
- Medical scale (for measuring weight).
- Rotameter (for measuring height).
- Arcometer, 1 unit.
- Iron measuring caliper, 1 unit.
- Laptop (HP), 1 unit.
- Camera (Canon), capable of capturing 240 frames per second, 1 unit.
- Analysis software: DARTFISH and KINOVEA.

Biomechanical Analysis of Rowing

1- Analysis of the Oar Entry Angle

The angles of the oar's entry and exit in the water were analyzed using an angular analysis system. Two different coordinate systems were employed to analyze the oar angle. The horizontal oar angle was used to determine the stages of the rowing stroke as follows:

1. The first system is defined as zero degrees when the oar is in the vertical position relative to the boat's axis.
2. The second system is defined as zero degrees when the oar is parallel to the line (Komor) (6).
3. The boat's axis (Challis) (5).

The first coordinate system was applied:

The oar angle is negative during the preparation phase and becomes positive at the start of the stroke. It can be determined at the beginning of the movement cycle, specifically at the moment when the oar is at zero degrees during the preparation phase in the vertical position. The grip angle is defined as the minimum angle, while the exit angle is defined as the maximum angle. Diagram (1) illustrates this.

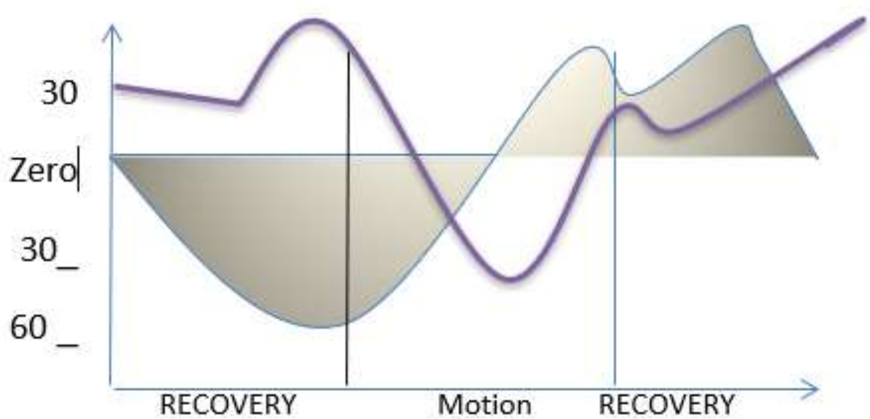

Diagram (1)
Transformations of the oar shape by measuring the horizontal and vertical oar angles.

- The bold line represents the vertical movement of the oar.
- The shaded area represents the horizontal movement of the oar.

2- Boat Speed Analysis:

The boat speed can be analyzed after recording it using the boat speed curves as follows:

- The average boat speed (a result directly linked to performance).
- The minimum and maximum speed values.
- The standard deviation of boat speed and its coefficient of variation during the movement cycle (calculated as the ratio of the standard deviation to the mean value). Diagram (2) illustrates this.

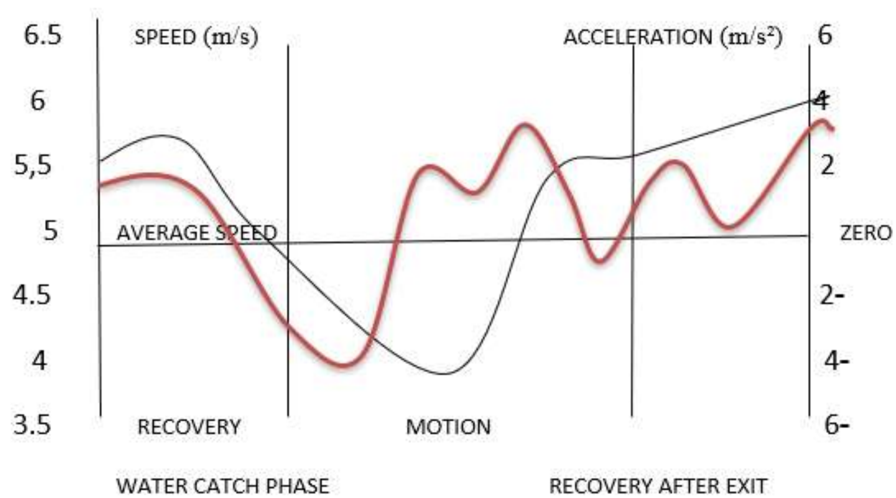

Diagram (2)

It illustrates the typical curves for boat speed (solid line) and acceleration (dashed line) during movement.

3- Seat Speed Analysis:

The analysis of seat speed (linear speed of the legs) relative to trunk movement is performed by measuring the ratio of the difference between the highest calculated speed of the seat movement and the trunk movement.

4- Arm Speed Analysis:

Arm speed analysis is conducted by subtracting the trunk speed from the linear speed of the oar handle. The latter is calculated using the angular velocity of the internal radius of the oar.

Diagram (3) shows the curves for analyzing seat movement relative to leg movement, as well as the oar handle movement relative to arm and trunk movements.

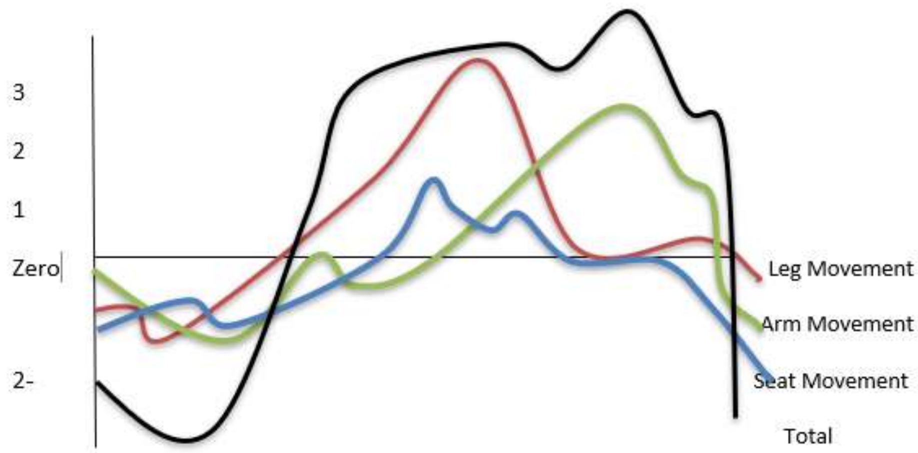

Figure (3)

It illustrates the curves analyzing the movement of the seat, legs, and arms.

5- Analysis of the Oar Movement in the Water, performed as follows:

- Calculation of the total stroke time.
- Measurement of the stroke length.
- Determination of the pull time.

Performance Tests:

1. Pull Test on the Arcometer Device, Scale (7), (Hajjaji) (3).

Purpose:

To measure the explosive power of the stroke.

Method of Performance:

The athlete sits on the device's seat, securing their feet with the specialized shoes and holding the pull handle, which represents the oar. After preparation and hearing the start whistle, the athlete performs a full rowing stroke back and forth with explosive force. Each athlete performs five (5) attempts.

Recording Method:

The data displayed on the device screen is recorded according to the researcher's requirements, represented by the distance covered during each stroke. The total distances from all attempts are summed and divided by five (5) to calculate the arithmetic mean for each athlete. Figure (1) illustrates the method of performance on the device.

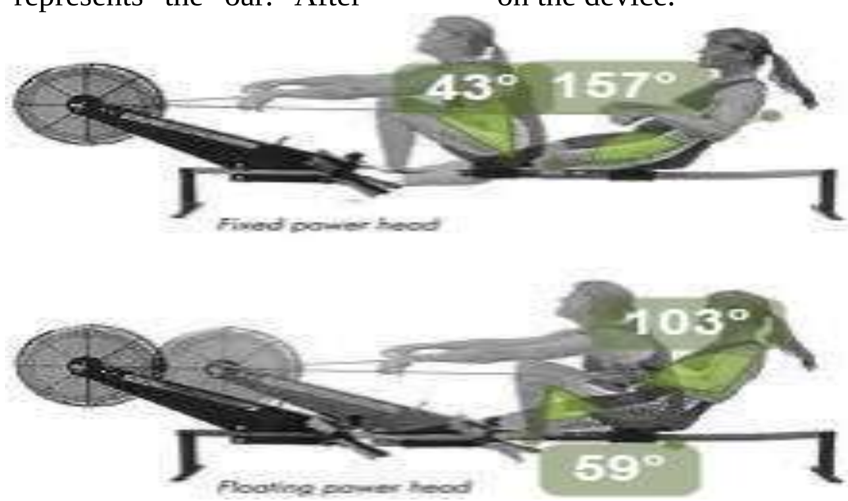

Figure (1) illustrates the method of performance on the device.

2. Pull Test on the Multigame (Iron) Device

Purpose:

To measure the speed of a single stroke on the

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device by dividing the distance by time. The researcher set the weight of the iron to be a maximum of half the body weight of each player.

Procedure:

The player performs a stroke on the device, moving back and forth after securing the weight. The time for each attempt is recorded. Each player performs five (5) attempts.

Recording Method:

The data is recorded by the assistant team, represented by the time taken for each stroke. The total time from all attempts is summed and divided by five (5) to calculate the arithmetic mean for each athlete. Figure (2) illustrates the method of performance on the device.

Pilot Study:

The assistant team prepared and filmed the tests, recording the data from a 3-meter distance on the Arcometer device and 2 meters on the Iron device, at a height of 60 cm above the water and 100 cm above the ground while recording the performance time on Friday, September 2, 2022, at 4:00 PM. Tests were conducted with reserve elite athletes, outside the research sample, to assess the readiness of the devices and the accuracy of data recording.

Main Experiment:

The main experiment was conducted on Saturday, September 1, 2022, at 4:00 PM. The research team set up a camera with a frame rate of 240 frames per second on the follow-up boat, positioned next to the test boat at a distance of 3 meters from the nearest point of the paddle's motion in the water at the moment of its vertical drop. This setup was designed to capture footage for calculating and measuring the research variables (time, distance, angles of each player's body position, and the movement of the paddle blade). The researcher, with the help of the team, placed fluorescent markers on the players' joints and movements during the performance, ensuring they were visible above the surface of the boat. The movement of the joints was indicated with their corresponding angles by placing reference lines for analysis, which were later used to draw the general movement diagram. The researcher also employed a method to convert actual movement into imaginary lines and used the analysis programs DART FISH and KINOVEA to ensure accurate data collection. The measurement of the paddle movement was conducted at the moment of preparation, followed by the vertical cutting of the water to execute the pull motion, and up to the moment the paddle exited the water, as follows:

- The movement time was calculated by multiplying the number of frames captured during the motion by the duration of each frame.
- The time of the paddle's cut through the water, up to the moment the pull began, was calculated by dividing the vertical distance by the time.

- The horizontal speed of the paddle's pull through the water was calculated by dividing the horizontal distance by the time (Abdul-Latif) (9).

The distance travelled by the boat was calculated from the moment the paddle cut through the water and initiated movement to push the water horizontally, up to the point where the paddle exited the water at the end of the stroke. This was done by identifying the starting and ending points, drawing an imaginary horizontal line, and measuring the distance in meters.

Statistical Methods:

The researcher used the statistical software package to obtain the data.

Presenting and Discussing the Results

Presentation of the Total Time Average Results for the Paddle with Explosive Power, as shown in Table (2).

Statistical Parameters Performance	Research Group		t-test	Error level	Significance
	Arithmetic Mean	Standard Deviation			
Total rowing time rate /s	2.095	0.046	4.466	0.004	Significant

Presentation of the Results for Paddle Length and Time Variables, as shown in Table (3).

Statistical Parameters Performance	**Research Group**		**t-test**	**Error level**	**Significance**
	Arithmetic Mean	**Standard Deviation**			
Paddle length /m	11.500	0.270	2.585	0.011	Significant
Pull time /s	1.320	0.035	3.407	0.014	Significant

Presentation of the Results of the Relationship Between Total Time, Paddle Length, and Stroke Time Variables, as shown in Table (4)

Statistical Parameters Performance	**Research Group**		**Pearson Correlation**	**Error level**	**Significance**
	Arithmetic Mean	**Standard Deviation**			
Total paddle time	11.500	0.270	0.76	0.4	Significant
Pull length	2.095	0.046			
Pull time	1.320	0.035			

Discussion:

Discussion of Table (2): It is evident from Table (2) that the results obtained from the test showed statistically significant findings. The average total paddle time was at a good level, which clearly impacted the numerical performance of the players in the research group.

The researcher attributes this improvement to the training program implemented, which was specifically designed to enhance the players' performance through targeted exercises. Given the nature of the activity, this program is expected to improve the explosive strength attribute through the exercises prescribed by the coach and executed by the research group. The positive effects of this training were reflected in the observed progress, as this attribute is directly correlated with the player's maximal performance.

Discussion of Table (3):

The results obtained from the tests for the variables (oar length, pull time, and distance) are as follows:

1. **Oar Length:**
   This is clearly demonstrated in the above table, which highlights the importance of oar length in the research sample. Increasing the

distance by extending the oar length to approximately 11 meters contributes significantly to enhancing explosive strength. This aligns with the findings of Latif, who states:

"This helps reduce the frequency of the oar stroke accompanied by the full pull phase, by increasing the motion range, which delays the onset of fatigue, allowing the athlete to maintain the same pace and achieve the maximum level of strength and speed endurance" (Abdul-Latif) (8).

2. **Pull Time:**
   This reflects the development in the number of strokes and the length of the pull, as shown in the above table with a value of 1.32 J/s. This is a commendable figure compared to the duration of the training, as it generates high pressure on the working muscles, particularly during the explosive rowing phase. This controlled pressure conditions the muscles to resist continuous repetitions and progressive intensities, leading to the development of explosive strength capacity.

This finding aligns with the perspective of Abdul-Lateef, who states:

"Performance that relies on the length of the pull and the oar stroke time leads to significant development in the various functional systems related to the sport. Explosive strength will only develop if there is internal adaptation within the body. This development also comes from an increased ability to apply and refine technique, as technique is closely linked to physical capabilities. Training induces fatigue, which, in turn, results in a proportional increase in the development of the functional systems" (Abdul-Latif) (1).

Discussion of Table (4):

The results obtained from the test and the significant outcomes show that there is a strong correlation between the total time and the variables of stroke length and stroke time. These variables have clearly influenced the numerical performance of the player. Based on this, it can be confirmed that there is a positive statistical and temporal correlation, and the researcher believes that both the pull length and pull time have a direct effect on the total rowing time.

This leads to an important question: how is this possible?

"The effectiveness of rowing, which specifically depends on the number of strokes per minute and the speed of the boat measured in kilometres per hour, confirms that the better the stroke length—without excessively extending the arms—and with strict adherence to the set stroke time, it helps determine the number of strokes per minute. In individual races, this number is typically around 40-46 strokes per minute" (Haider) (2).

Additionally, continuous training specificity from the start of the race, which begins with moving the boat from zero speed to reaching maximum speed during the launch phase, is emphasized by all world-class coaches in the discipline (Faten Ismail) (4).

This connection requires local coaches to emphasize to athletes the importance of determining both the pull length and pull time in order to achieve the optimal rowing stroke in terms of form and proper displacement.

Conclusions:

1. There is a strong positive statistical relationship between the total rowing time, pull length, pull time, and the overall performance time.
2. Elite rowers rely on pull length and exert high speed and effort during the first part of the 2000-meter race, which positively impacts the speed of race segments and the final race result.
3. The optimal method identified is a systematic approach that balances the technical execution between pull length and pull time.

Recommendations:

1. Emphasize to coaches the importance of teaching athletes the correct technique in terms of stroke length and timing, which positively affects overall performance.

2. Adopt a rowing strategy focused on steady speed, which is considered the optimal method for 2000-meter rowing performance. This approach leads to direct corrections of the athlete's angles regarding stroke length and timing.
3. Develop a specialized training program for athletes to enhance their awareness and sense of distance and time while rowing.

Author's declaration:

Conflicts of interest: None

We confirm that all tables and figures in this article are ours and written by the researchers themselves.

Ethical-Clearance: this manuscript approved by local ethical committee of physical education and sport sciences college for women on (October /2024)

Author's contributions:

All contributions of this study were done by the researcher (A.A.) who get the main idea and work on writing and concluding also with number of experts, Ali Abdul-lateef (University of Baghdad/ Physical education and sport sciences college) in Statistics, Ibrahim Dabayebeh in revision, Ayman Sabah in translating, Huda Shihab in proofreading

Facilitate the task: this study was supported by National rowing team players – Iraq.

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تحليل القوة الانفجارية لضربة المجداف للاعبين النخبة بالتجديف في العراق

اياد عبد اللطيف علي
المديرية العامة لتربية الكرخ الثانية / بغداد – العراق

مستخلص البحث

نتيجة تطور التقنيات الحديثة المساعدة من اجهزة وادوات اصبح لزاما استثمار التطور العلمي والتقني لأغراض التحليل الحركي ومعرفة مستوى اداء المهارات والحركات ومنها ضربة المجداف التي تعتمد على الاداء بجزئين احدهما (فوق الماء) كجزء غير مغمور والثاني (تحت الماء او ملامس له) كجزء مغمور بالاعتماد على وضعية جسم واداء الرياضي (المجدف) باستخدام الاداة (المجداف) ، اهمية الدراسة تعتمد في قياس المتغيرات وتحليلها من سرعة وزمن وزاوية قياس قوة انفجارية على مفاصل الجسم المهمة التي يعتمدها المجدف لحظة اداء الانطلاق للوصول الى قمة الحركة ، استخدم الباحث المنهج الوصفي بأسلوب العلاقات الارتباطية , تم اختيار عينة البحث بالطريقة العمدية من لاعبي النخبة ضمن المنتخب الوطني العراقي للتجديف لعام 2022 وعددهم (5) من مجتمع البحث البالغ عددهم الكلي (8) لاعبين , وتم اختيارهم بالطريقة العمدية , واستنتج الباحث ان قيم المتغيرات البايوكينماتيكية لزمن الكلي للجدفة كانت بالاتجاه المعنوي , فضلا عن المتغيرات البايوميكانيكة للقوة الانفجارية من حيث الزمن وطول السحبة ايضا بألاتجاه المعنوي , وكانت العلاقة بين المتغيرات كانت ايجابية لما لزمن الجدفة الانفجاري وطولها الاثر على الزمن الكلي على الجدفة والاداء والانسيابية , ويوصي الباحث التأكيد على البحث المستمر في المتغيرات البايوكينماتيكية لما لها الاثر الكبير في الكشف عن مكامن القوة والضعف للاعبي التجديف لان اساس الجدفة عبارة زوايا وامتدادات وقوى مسلطة على الماء وخارج الماء . وهذا ما يحقق احد اهداف التنمية المستدامة للامم المتحدة في العراق (التعليم الجيد).

الكلمات المفتاحية	التحليل – القوة الانفجارية – المجداف – لاعبي النخبة