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# Mechanical and Energy efficiency in Wellness programs with cyclical movements

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**Abstract**

**Objective**: Rewrite the text: The aim of this study was to assess the Mechanical and Energy efficiency in Wellness programs with cyclical movements through the quadrants system for acquiring new objective methodological approach of the didactic progress. **Materials and methods:** Our research focused on creating a new personalised methodology to evaluate the mechanical and energy efficiency of wellness programs. The study involved 107 participants, including people who know swim. **Results***:* This was accomplished by benchmarking the performance of all participants before and after implementing the recommendations derived from the quadrant system evaluation. The results demonstrated an improvement in technical skills, with the experimental group achieving significantly better mechanical and energy efficiency in their swimming technique. The 16-level evaluation system provides experts and coaches with a valuable tool to assess effectiveness in daily training routines. Incorporating this innovation into training or educational processes can enhance pedagogical progress and personalise the technical needs of each practitioner in a straightforward yet highly effective manner.**Discussion***:* The quadrant system's assessment, featuring 16 levels of precision, clearly demonstrated the relationship between mechanical and energy efficiency and the implementation of its recommendations. These findings highlight the system's potential to significantly enhance the quality of recreational programs. **Conclusion**: The quadrant system is a structured evaluation tool designed to assess mechanical and energy efficiency in physical activities, particularly within wellness and recreational programs. Its functions and priorities are aimed at enhancing the quality of training and personalising the educational experience for practitioners.

***Keywords****: Innovations in evaluation, Quadrants system, cyclique practices, health prevention, mechanic and energy effenciancy.*

## 1. Introduction

The positive impact of physical activity on maintaining health is well established, particularly in preventing and managing chronic diseases [1, 6, 12, 21]. As a result, precise measurement of physical activity and energy expenditure is crucial for both research and applications [10, 14, 16, 17].With numerous methods available, understanding their features is essential when selecting an appropriate technique [9, 13, 18, 20]. The actual publication focusing to explore the components of total energy expenditure and examine the advantages. An analysis is established to studying the limitations of various methods used to assess physical activity and energy expenditure [3, 7, 15, 19]. This has directed the focus of our scientific interests towards studying the specific interest of customers in Wellness programs with cyclical movements [5]. The various

approaches to practicing Recreation activities in order to apply Wellness lifestyle are proven to be effective for boosting the immune system [2, 26]. Wellness programs have emerged as an excellent remedy for countering the effects of social, professional or sport stress and its negative impact on health [8, 21, 23,]. As highlighted in our prior publications, "...There are no dangerous exercises when they are correctly executed, performed gently, and practiced in moderation" [5]. The primary consideration is determining the types and quality of technical skills provided in Wellness programs featuring cyclical movements. The second focuses on customising these programs to meet the specific needs of individual participants. Additionally, a third crucial aspect involves developing innovative marketing and management strategies to boost the promotion of Wellness services within the leisure industry and niche tourism [11, 22, 24].

## 2. Methods

**2.1. The Objective** of this study was to assess the Mechanical and Energy efficiency in Wellness programs with cyclical movements through the quadrants system for acquiring new objective methodological approach of the didactic progress.

**Expertise and tools**: Our research focused on creating a new personalised methodology to evaluate the mechanical and energy efficiency of wellness programs. The study involved 107 participants, including people who know swim (students, former athletes, and wellness lifestyle practitioners) from private recreational clubs, universities, and NGOs specialising in recreational practices. The participants were primarily Bulgarian, a balanced gender distribution and with an average age of 32 years. As this study is under the objectives of the Scientific Center of Excellence Heritage BG, all experts were recruited through a public announcement. The participants gave informed consent for the publication of their data. The study was conducted from May 2021 to February 2023. To ensure the accurate application of the quadrant system, a one-day training session was conducted for the participating experts, focusing on the mathematical principles involved.

**2.2. The Quadrant System** represents a set of methodological principles designed for monitoring and evaluating the performance efficiency of cyclical motor actions and the pedagogical progress of trainees [4]. The system is patented by the French University in Nancy. Its content has been published in a series of books edited by Bernard Thivent and Gilles Denis (1993). This book is a foundational resource for educators, coaches, and researchers aiming to adopt systematic and scientifically validated approaches to performance assessment in physical education and sports [25]. The authors provide a scientific basis for integrating notation systems into pedagogical practices, emphasising precision, reliability, and adaptability across diverse sports disciplines. These publications scientifically validate the system's applicability across all sports disciplines involving cyclical execution techniques.

**2.3. The system includes** the following logistical steps, which we strictly applied in our scientific experiment:

- **Recording the time in seconds** for 25 or 50 meters of freestyle (crawl stroke);

Simultaneously counting the actual cycles (one cycle consists of two consecutive strokes: one with the left hand and one with the right hand).

- **Measurement of Arm Length** using Denis' Standard Methodology: The arm is positioned sideways at a 90˚ angle, with the shoulder joint forming a depression (reference point) to the tip of the middle finger. To obtain the full arm span, the measured length is multiplied by two. While this value alone is not definitive, it is used to calculate the Synchronisation (Sync. Co.). The calculated average arm span for the studied individuals/group (Avg. Span) is compared with the individual arm span (Ind.Span), allowing the determination of Synchronisation Coefficient, which adjusts the recorded cycle count.

- **Recording Cycles and Adjusting with the Synchronisation Coefficient:**

The corrected cycle count is then used to calculate speed using Denis' methodology.

- **Description of the Speed Test - "V 25 max.":**

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This test records the time taken to swim a short distance (25 or 50 meters) in freestyle (crawl stroke). Simultaneously, the number of arm stroke cycles is counted.

- **Multifactorial Analysis:**

A detailed analysis of indicators evaluates movement efficiency during cyclical executions through the following metrics:

- ✓ *Energy Efficiency (En.Eff.): Measures energy expenditure.*
- ✓ *Mechanical Efficiency (Mech.Eff.): Assesses mechanical output.*

- **Measurement Protocol:** The distance is covered without a push-off start from the wall, recording both the time and the actual number of cycles completed.

## 3. Results

The indicators in this study reveal the internal mechanical and energy efficiency (strength and intensity) of the wellness program featuring cyclical movements. The methodology incorporated the Quadrant system designed to evaluate the relationship between speed and the body's energy balance. The system is divided into four quadrants, numbered in a counterclockwise direction. To enhance its precision, each quadrant is further subdivided into a secondary coordinate system. We accomplished by benchmarking the performance of all participants before and after implementing the recommendations derived from the quadrant system evaluation. The results demonstrated an improvement in technical skills, with the experimental group achieving significantly better mechanical and energy efficiency in their swimming technique. The 16-level evaluation system provides experts and coaches with a valuable tool to assess effectiveness in daily training routines. Incorporating this innovation into training or educational processes can enhance pedagogical progress and personalise the technical needs of each practitioner in a straightforward yet highly effective manner. Below are examples of mathematical formulas of the calculated Synchronisation Coefficient (Sync Co.) and its values, as applied in sports practice using the quadrant-based technique control system (see Tab. 1):

Table 1

Representation of positive and negative synchronisation coefficients during quadrant-based technique control application.

| CASES | Range | Synchron. Coefficient (Sync. Co.) |
|---|---|---|
| **Case A** | **Zero Sync. Co.** | |
| | Avg.Span−5 cm<Ind.Span≤Avg.Span+5 cmAvg.Span - 5 \, \text{cm} < Ind.Span \Avg.Span + 5 \, text{cm}Avg.Span−5cm<Ind.Span≤Avg.Span+5cm | 0 |
| | **Negative Sync. Co.** | |
| **Case A** | Avg.Span−10 cm<Ind.Span≤Avg.Span−5 cmAvg.Span - 10 \, \text{cm} < Ind.Span \leq Avg.Span - 5 \,text{cm}Avg.Span−10cm<Ind.Span≤Avg.Span−5cm | -1 |
| **Case B** | Avg.Span−20 cm<Ind.Span≤Avg.Span−10 cmAvg.Span - 20 \, \text{cm} < Ind.Span \leq Avg.Span - 10 \, \text{cm}Avg.Span−20cm<Ind.Span≤Avg.Span−10cm | -2 |
| **Case C** | Avg.Span−30 cm<Ind.Span≤Avg.Span−15 cmAvg.Span - 30 \, \text{cm} < Ind.Span \leq Avg.Span - 15 \, \text{cm}Avg.Span−30cm<Ind.Span≤Avg.Span−15cm | -3 |
| | **Positive Sync. Co.** | |
| **Case A** | Avg.Span+5 cm≤Ind.Span<Avg.Span+10 cmAvg.Span + 5 \, \text{cm} \leq Ind.Span < Avg.Span + 10 \, \text{cm}Avg.Span+5cm≤Ind.Span<Avg.Span+10cm | +1 |
| **Case B** | Avg.Span+10 cm≤Ind.Span<Avg.Span+20 cmAvg.Span + 10 \, \text{cm} \leq Ind.Span < Avg.Span + 20 \, \text{cm}Avg.Span+10cm≤Ind.Span<Avg.Span+20cm | +2 |
| **Case C** | Avg.Span+15 cm≤Ind.Span<Avg.Span+30 cmAvg.Span + 15 \, \text{cm} \leq Ind.Span < Avg.Span + 30 \, \text{cm}Avg.Span+15cm≤Ind.Span<Avg.Span+30cm | +3 |
| | | |

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### 3.3. Functioning of the Quadrants Control System:

*Logiistic:* The logic behind interpreting the data and plotting it on the coordinate system remains consistent with the swimming technique evaluation. The x-axis (abscissa) represents speed, while the y-axis (ordinate) represents the number of cycles. The system consists of four quadrants, numbered counterclockwise. To increase the precision of the system, each quadrant includes a sub-coordinate system. When each quadrant is viewed as a unity of sub-quadrants, it allows for refining individual efficiency evaluations of the specific handstroke technique. This setup enables scoring on a 16-point scale. Sub-quadrants are labeled in the same order as the quadrants used for swimming technique evaluation (see Fig.1).

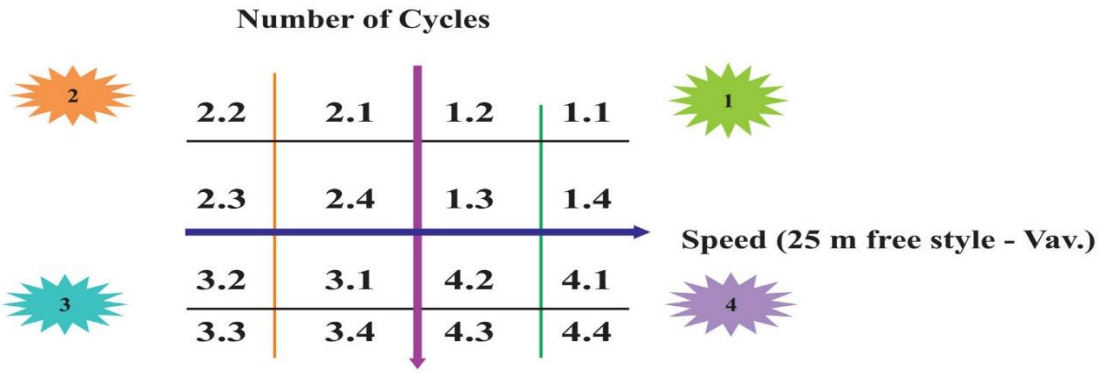



Figure 1. Numbering of the sub-quadrants in the coordinate system follows the designations for the quadrants x-axis and y-axis during the efficiency evaluation (25 m free style)

**Sub-quadrants** allow for the individualisation of evaluations for arms stan, while quadrants are more suited to collective assessments and the development of team tactical selection on reley paце in swimming. The effectiveness of the specialised technique for propulsion using leg support is evaluated through indicators of **Energy Efficiency (En.Ef.)** and **Mechanical Efficiency (Me.Ef.)** for movements performed by the arms over a distance of 25 meters. Two numerical values are used to position the learner within the coordinate system. The first digit indicates the quadrant zone, while the second specifies the secondary zone of the sub-quadrant. The sub-quadrants further refine the given quadrant assessment by four additional levels. This transforms the system into a 16-point precision method for monitoring and formulating evaluations. As a result, individual assessments of the technique for individuals positioned within the same quadrant can be distinguished across four sub-levels (achieving four times greater precision). Sub-quadrants enable individualisation in evaluations, whereas quadrants primarily serve the purpose of collective assessment and the development of team tactical actions.

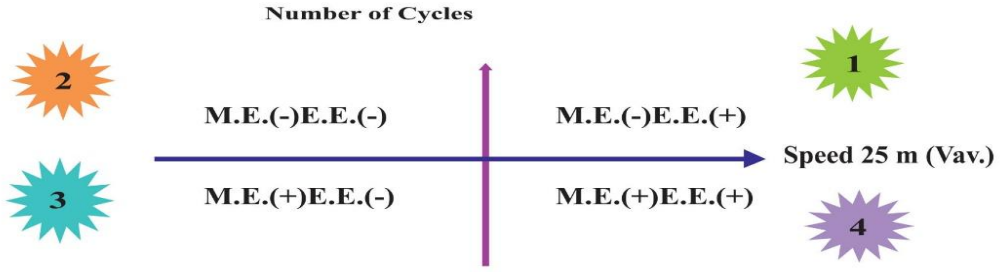



Figure 2. Positioning in the quadrants with different mathematical values for the coefficients of mechanical and energy efficiency in handstroke swimming

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The effectiveness of swimming technique is evaluated using indicators of Energy Efficiency (En.Ef.) and Mechanical Efficiency (Me.Ef.). Mathematical Symbols and Values in Verbal Assessments Using the Quadrant System Their placement within the quadrants determines the technical capabilities of the evaluated swimmer (see Fig. 2). The translation of mathematical symbols and values (placed in brackets) from the coordinate system into verbal assessments can be systematised as the representation of positive and negative synchronisation coefficients (see Tab. 2). The following individual verbal assessment categories (Quadrant 1 to 4) are assigned:

Table 2

Representation of positive and negative mechanical and energy coefficients
Insige of the sub-quadrants.

| Quadrant | Sub-Quadrant | Mechanical Efficiency (M.E.) | Energy Efficiency (E.E.) |
|---|---|---|---|
| : Quadrant No. 1 | 1.1 | Very Poor (M.E. - -) | Very Good (E.E. ++) |
| | 1.2 | Very Poor (M.E. - -) | Good (E.E. +) |
| | 1.3 | Poor (M.E. -) | Good (E.E. +) |
| | 1.4 | Poor (M.E. -) | Very Good (E.E. ++) |
| : Quadrant No. 2 | 2.1 | Very Poor (M.E. - -) | Poor (E.E. -) |
| | 2.2 | Very Poor (M.E. - -) | Very Poor (E.E. - -) |
| | 2.3 | Poor (M.E. -) | Very Poor (E.E. - -) |
| | 2.4 | Poor (M.E. -) | Poor (E.E. -) |
| Quadrant No. 3 | 3.1 | Good (M.E. +) | Poor (E.E. -) |
| | 3.2 | Good (M.E. +) | Very Poor (E.E. - -) |
| | 3.3 | Very Good (M.E. ++) | Very Poor (E.E. - -) |
| | 3.4 | Very Good (M.E. ++) | Poor (E.E. -) |
| Quadrant No. 4 | 4.1 | Good (M.E. +) | Very Good (E.E. ++) |
| | 4.2 | Good (M.E. +) | Good (E.E. +) |
| | 4.3 | Very Good (M.E. ++) | Good (E.E. +) |
| | 4.4 | Very Good (M.E. ++) | Very Good (E.E. ++) |

**Explanation**

- Categories: Groupings based on the quadrant location of the subject in the control system.
- Sub-Quadrants: Further refinement within each quadrant for increased precision.
- Mechanical Efficiency (Me.Ef.): Assesses technical execution efficiency.
- Energy Efficiency (En.Ef.): Evaluates the energy return of the movement.

As established, the first digit indicates the quadrant zone of the control system, while the second specifies the sub-quadrant. The subject can fall into one of four possible categories of return coefficients, which define the effectiveness of their swimming technique. This system provides a 16-point precision scale for control and evaluation, enabling nuanced assessments for individuals in swimming.

### 3.4. Analysis of the Coefficients for Mechanical and Energy Efficiency in Swimming Technique Evaluation

The analysis of the coefficient for motor or Mechanical efficiency (Me. Ef.) enables an evaluation based on three key indicators:

*Components of Mechanical Efficiency (Me.Ef.):* Acceleration/Trajectory is the efficiency of swimming technique stems from maintaining a proper relationship between the correct underwater trajectory of the

arm pull and acceleration during the pull phase. The trajectory is ensured by maintaining a high elbow position at the start of the underwater pull, while acceleration depends on establishing support (hand position) to propel forward. A lack of either element disrupts this relationship, resulting in inefficiency.

*Acceleration and Amplitude:* Acceleration is a constant value in practice, following the principle "slow at the start, fast at the end of the pull." Its intensity is directly related to the length of segment displacement.

*Trajectory and Amplitude:* These factors are directly linked and mutually influential. Reduced amplitude typically decreases forward propulsion unless the swimmer consciously controls the stroke frequency. In practice, the rule "low amplitude—high frequency" and vice versa generally applies. Maximising acceleration during the arm pull is crucial.

**3.5. Analysis** of the coefficient for energy efficiency (En. Ef.)

This indicator provides an evaluation based on four indicators:

- ✓ Resistance area during movement
- ✓ Relaxation of muscles during the above-water recovery phase
- ✓ Motor efficiency
- ✓ Balance disruptors (vortices)

**3.6 Components** of Energy Efficiency (En. Ef.): *Resistance Area:* Reducing resistance in the primary swimming position depends on aligning the body axis with the direction of movement.

*Muscle Relaxation:* Relaxing the arm muscles during the recovery phase above the water helps restore the muscle groups engaged during the pull phase.

*Motor Efficiency:* Inadequate mastery of swimming technique often leads to the unnecessary activation of large muscle groups, resulting in stiffness. Effective technique is achieved through the full automation of motor skills during training in water. Swimmers often exhibit deviations from theoretical models due to specialised training, leading to faster energy depletion and reduced swimming efficiency.

*Balance Disruption:* Balance is usually disrupted by the lack of or excessive lateral deviation of the head and shoulders (in freestyle) from the central axis of movement.

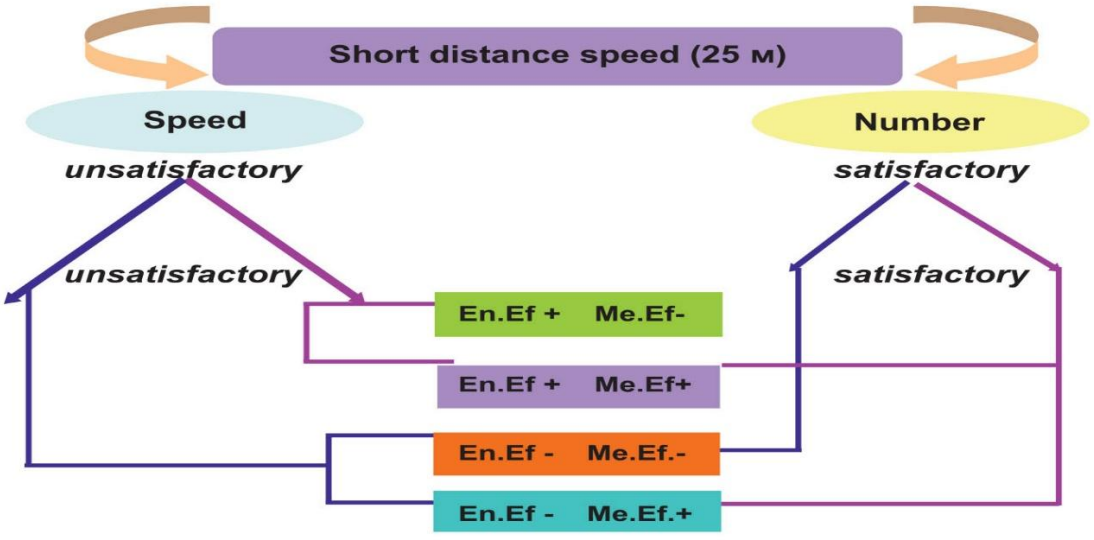



Figure 3. Representation of the interactive connections in the architecture of modeling based on the values of the coefficients for energy and mechanical efficiency using quadrants (According to Denis)

Other factors include pelvic stability, supportive leg movements, and the distance of the arm from the body's central axis during entry into the water after the recovery phase (see Fig. 3).

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From the analysis of the indicators influencing the evaluation provided by the quadrant system, the following interdependences are registered (see Tab.3):

Table 3

| Observation | Correlation Coefficient (r) | Remarks |
|---|---|---|
| Weak correlation between performance, height, and body mass of participants | $r_h = -0.27$; $r_x = -0.23$; $r_h = -0.27$; $r_x = -0.23$; $r_h = -0.27$; $r_x = -0.23$ | Indicates limited influence of height and body mass on performance. |
| Weak correlation between flexibility and body mass | $r^p/_t = 0.07$; $r^p/_t = 0.07$; $r^p/_t = 0.07$ | Flexibility is minimally influenced by body mass. |
| Moderate correlation between time to swim a standard distance and practice duration | $r = -0.53$; $r = -0.53$; $r = -0.53$ | Time decreases with increased practice duration. |
| Strong correlation between cycles and performance | $r = -0.58$; $r = -0.58$; $r = -0.58$ | Fewer cycles are needed as performance improves. |
| Strong correlation between body mass and flexibility relative to height | $r_1 = 0.67$; $r_2 = 0.79$; $r_1 = 0.67$; $r_2 = 0.79$; $r_1 = 0.67$; $r_2 = 0.79$ | Highlights a significant relationship between these variables. |
| Very strong correlation between time, number of cycles, and flexibility | $r_1 = 0.72$; $r_2 = 0.79$; $r_1 = 0.728$; $r_2 = 0.79$; $r_1 = 0.73$; $r_2 = 0.80$ | Strong interdependence of these factors. |
| Quadrant evaluation considers flexibility in diagnosing technique | N/A | Flexibility is indirectly influenced by height and body mass. |
| Quadrant evaluation reflects pedagogical progress in water-based techniques | N/A | Progress in specialized techniques is accounted for. |

Registered interdependences influencing the quadrant position after the evaluation by Quadtrants

## 4. Discussion

The Quadrants System functions and priorities analysis we systematising them as following:

### 4.1. Functions:

*Precision Assessment:*

- ✓ The quadrant system operates on a 16-level framework, providing a detailed and nuanced evaluation of mechanical and energy efficiency.
- ✓ This granularity allows for pinpointing specific areas for improvement, offering targeted insights into an individual's performance.

*Performance Benchmarking:*

- ✓ By measuring performance before and after interventions, the system evaluates the effectiveness of applied recommendations.

- ✓ It serves as a feedback loop for both participants and coaches to monitor progress over time.

*Personalisation:*

- ✓ The system identifies individual technical needs, enabling tailored training plans.
- ✓ This adaptability ensures that each practitioner receives guidance aligned with their unique capabilities and goals.

*Educational Enhancement:*

- ✓ By integrating into training or educational processes, the quadrant system provides a methodological approach to improving technical skills.
- ✓ It facilitates learning through a structured evaluation of movements and energy usage.

*Tool for Experts:*

- ✓ Coaches and trainers can use the system to determine the efficiency of training regimens and recreational programs.
- ✓ It acts as a diagnostic and planning tool, ensuring optimal resource allocation and effective program design.

### 4.1. Priorities of the Quadrant System:

*Advantages of the Quadrant System for Technique Control and Evaluation:*

- ✓ Adapting the didactic principles of quadrants for swimming technique analysis objectifies the control of swimming training..
- ✓ Evaluating mechanical and energy efficiency coefficients allows for individualised diagnostics to monitor cyclical technique.
- ✓ Sub-quadrants enhance precision in technique control, providing evaluations on a 16-point scale.
- ✓ Summarising individual assessments enables collective or team-based evaluations of technique in swimming.

## 5. Conclusions

Based on our analysis, we can draw the following conclusions in this study:

- ➢ The quadrant system serves as a comprehensive tool for evaluating and improving mechanical and energy efficiency in wellness and recreational programs.
- ➢ By prioritising precision, personalisation, and program quality, it offers a significant advantage to trainers, educators, and practitioners.
- ➢ The quadrant-based system for evaluating swimming technique efficiency focuses on the fundamental didactic principles in swimming education:
  - ✓ Control and evaluation of breathing
  - ✓ Control and evaluation of balance
  - ✓ Control and evaluation of gliding
- ➢ Its integration into educational and training frameworks has the potential to revolutionise pedagogical practices and set new benchmarks in the wellness industry.

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***Declarations*** *of informed consent have been signed regarding the publication of survey data.*

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