Journal of Fundamental Movement Skills Vol. 1, No. 1, Tahun 2026, pp. 11-20
ISSN: xxxx-xxxx (Print), xxxx-xxxx (Online)
https://jfms.smartmotionjournals.com

Utilization of Digital Analytics System in Tracking Swimmers Progress in Real-Time

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Article Info:
Received: *23-02-2026*
Revised: *28-02-2026*
Accepted: *11-03-2026*
Online: *13-03-2026*

Keywords:
stroke rate efficiency; visual feedback; goal setting theory; evidence-based coaching; swimming biomechanics

ABSTRACT

This study aims to analyze the use of digital performance analytics systems in tracking the progress of swimmers in real time at the swimming club, with a primary focus on providing a clear visual overview for athletes and parents and serving as a motivational tool. Using a descriptive case study method with a biomechanical approach, data was collected through a digital platform that recorded performance variables in Age Group (AG) III athletes during integrated training sessions. The results of the study show that the implementation of this system successfully identified the athletes' performance characteristics accurately; the latest performance recorded in the 50m Freestyle event was 31.45 seconds, which is equivalent to the athlete's current personal best time. Supporting data showed a Stroke Per Minute (SPM) of 85.9 and a Heart Rate of 132 bpm, which placed the athlete in the Aerobic zone (63.8%). The conclusion of this study is that the use of digital analytics has proven to be very effective in providing objective visual feedback through trajectory graphs, which facilitates precise technical monitoring and increases athletes' intrinsic motivation through an evidence-based coaching approach.

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INTRODUCTION

In today's world of swimming, accurate monitoring of performance has become a key factor in determining success in achieving the best results. The shift in training methods from manual recording using paper to digital performance analysis has greatly influenced the way kinetic and kinematic data is collected (Indah et al., 2024). The use of an integrated analytics platform enables the collection of performance variables with a very high degree of accuracy, something that cannot be achieved with ordinary observation or a traditional stopwatch (Cruz et al., 2024). However, the main issue today has shifted from simply collecting data to how to convert this large collection of data into useful information for all parties involved.

The main problem in training young atlet is the large feedback gap between coaches, athletes, and parents (Fadluoh et al., 2024). Although digital technology is becoming more widely accepted, data is often presented in a form that is too complex, making it difficult for athletes to evaluate themselves (Sari et al., 2018). The lack of immediate visual feedback results in athletes having a poor understanding of their training progress, which in turn can hinder technical improvement and reduce parental involvement in supporting the training environment (Ntalachani et al., 2025). Without a clear monitoring system, stories about athlete development are often filled with personal assessments and are difficult to measure.

Previous studies have explored the use of sensor technology and the validity of aquatic performance analysis systems to improve the accuracy of kinetic and kinematic monitoring of athletes. For example, Cruz et al., (2024) highlighting advances in sensor technology in monitoring water sports biomechanics to obtain precise data, while Born et al., (2024) emphasizing the importance of the reliability of analysis systems in the field to avoid technical misinterpretations. Although monitoring technology is beginning to develop, the data produced is often presented in a form that is too complex, creating a feedback gap between coaches, athletes, and parents.

This study focuses on the integration of complex biomechanical variables such as the relationship between Strokes Per Minute (SPM), Distance Per Stroke (DPS), and physiological responses into the Swimatrics digital platform, which simplifies these metrics into intuitive, real-time Progress Trajectory visualizations. Unlike studies by Morais et al., (2023) While most studies tend to focus on the technical validity of raw data, this research emphasizes the use of digital analytics as a transparent communication tool that strengthens athletes' intrinsic motivation through Knowledge of Performance (KP) and builds parental trust by presenting real-time data that is easily accessible to the entire training ecosystem. Functionally, these trajectory graphs act as Knowledge of Performance (KP), providing an objective picture of the athlete's current technical position compared to previous sessions. In addition to being a biomechanical evaluation tool for detecting fatigue or technical degradation, this visualization also plays a crucial psychological role in supporting a more realistic goal-setting process through transparent tracking of personal best (PB) targets.

Regular monitoring of performance trajectories is very important because swimming effectiveness is the result of optimizing propulsion and reducing water resistance (Silveira et al., 2019). Progress Trajectory in the Swimatrics system applies the principle of data reliability by only depicting performance graphs based on the best results obtained after data

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collection. This procedure ensures that important variables such as the relationship between stroke rhythm, stroke length, and speed are analyzed from the athlete's most consistent and optimal performance, so that fatigue detection or technical improvements can be made with a higher degree of accuracy (Sanders et al., 2015). The best use of information from this series of experiments provides an objective basis for coaches to implement rapid technical interventions (Yu Kwok et al., 2021), while reducing the possibility of performance stagnation that is often overlooked in traditional single data collection (Ardiyanto & Widiyanto, 2019).

This study aims to explain the use of digital systems in displaying performance visualization through Progress Trajectory as a self-evaluation tool for athletes and as a useful communication medium for parents. The core of this study focuses on the application of digital platforms (such as Swimetrics) to simplify complex metrics into easy-to-understand progress charts. With this approach, performance is no longer viewed as a single number at the end of a race, but as a journey of development that is systematically and objectively documented in an integrated dashboard.

The advantages of implementing this system include strengthening the understanding of data that is essential for the development of athlete independence (Hamidi Rad et al., 2022). Visualizing personal goals or Personal Best (PB) achievements serves as a powerful incentive in supporting the process of setting more realistic and flexible goals (Nathalie Pattyn, 2024). Psychologically, observing a chart that shows an upward trend provides immediate happiness and reinforces internal motivation (Citra Rumondang et al., 2025). In addition, this openness of information forms the basis of parents' trust in the training program (Mitsalina et al., 2021), which in turn creates good cooperation in supporting the athletes' journey at the swimming club.

METHODS

This section outlines the methodological framework used to evaluate the implementation of digital performance analytics systems. This study uses an observational approach with a case study design to explore the phenomenon of real-time aquatic performance tracking in specific subjects.

Participants and Sampling

The research subjects consisted of swimmers at the Bhirawa Swimming Aquatic Club who were categorized in Age Group (AG) III (age range 12–13 years). Sample selection was conducted using purposive sampling with the inclusion criteria of active athletes who participated in training programs at least four times a week and had official time records or achievements in the freestyle event.

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Instruments and Apparatus

The main instrument is the Swimatrics digital platform, a web-based performance analytics system designed specifically for the swimming ecosystem. This device functions as a data processing unit that records key variables:

1. Temporal Variables: Total time (t) and split time per 50 meters measured using a digital stopwatch with an accuracy of 0.01 seconds.
2. Biomechanical Variables: Stroke rate in strokes per minute (SPM) is obtained from the formula total strokes/travel time = result x 60 = result (SPM), where the device only needs to input the total number of strokes per single arm achieved and the travel time achieved automatically converts the data into strokes per minute (SPM). There is also Strokes Per Meter (SPMtr) as a way to determine the efficiency of an athlete's technique, obtained from the formula total strokes/distance with classifications ranging from "very efficient" (<0.6) to "needs improvement" (>1.0). This technique was chosen to ensure the accuracy of biomechanical data instantly at the poolside.
3. Physiological Variables: Post-exercise heart rate (Heart Rate Recovery) is measured by palpating the carotid artery for 10 seconds immediately after the athlete touches the finish wall, then multiplied by 6 to obtain beats per minute (bpm). There is also HR Percentage, which is implemented as a performance analysis to determine heart zone classification according to the athlete's age, covering the categories "Recovery" (<62%) to "Max Effort" (>92%).

Procedures / Data Collection

Data collection was conducted once at maximum intensity using a protocol to ensure data reliability:

1. Standardization: Athletes performed a structured warm-up (standardized aquatic warm-up) for 15–20 minutes, which included aerobic activities and specific freestyle drills.
2. Implementation Phase: Athletes performed freestyle swimming with one trial over a distance of 50 meters at maximum intensity (all-out).
3. Data Input: Coaches input the results (data input date, style, distance, time, stroke count, heart rate) into the Swimatrics system immediately after the data is obtained at the poolside.
4. Instant Visualization: The system automatically generates a preview in the form of a matrix graph to evaluate the relationship between stroke rate and heart rate against time.

Data Analysis

Data analysis focused on visual interpretation of the relationship patterns between variables, given that the data collection design used a cross-sectional approach based on a single measurement with maximum intensity in the 50-meter freestyle swim. The data analyzed included elapsed time, stroke rate (strokes/min), and heart rate (bpm), which were obtained and then entered directly into the Swimatrics system immediately after the athlete touched the finish wall.

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The Swimatrics system automatically generates a matrix visualization graph that displays the relationship between stroke rate and heart rate against the 50-meter time. The analysis focused on the visual interpretation of the relationship between variables, without conducting inferential statistical tests, given that the data collection design used a single maximal trial.

Performance evaluation was carried out by examining the proportionality between the increase in stroke rate and the heart rate response to the achievement of time. Performance improvement was categorized as positive if a faster time was achieved through a stroke rate within the optimal range with a relatively controlled heart rate (technical efficiency). Conversely, high stroke rate and heart rate without an improvement in time were interpreted as a decrease in biomechanical efficiency. The results of this graphical analysis were used as a basis for determining the characteristics of each athlete's performance.

The results of the graphical analysis are used as a basis for determining the characteristics of an athlete's swimming performance, particularly in distinguishing whether the achievement of speed is more influenced by improvements in technical efficiency or by an increase in physiological load due to excessive stroke frequency.

RESULTS

The presentation of these research results is based on a single maximal trial protocol for the 50-meter freestyle. The data is visualized using the Swimatrics system to demonstrate the application of the Swimatrics digital performance analytics system in describing athlete performance data. The results presented are baseline performance characteristics that serve as a starting point for digital tracking.

Data Visualization: Progress Trajectory

The Swimatrics system automatically generates a Performance Analytics dashboard that integrates all performance variables into a single visual display (Figure 1). Based on data collected on February 18, 2026, the system presents a Progress graph showing the athlete's current performance position against their historical track record.

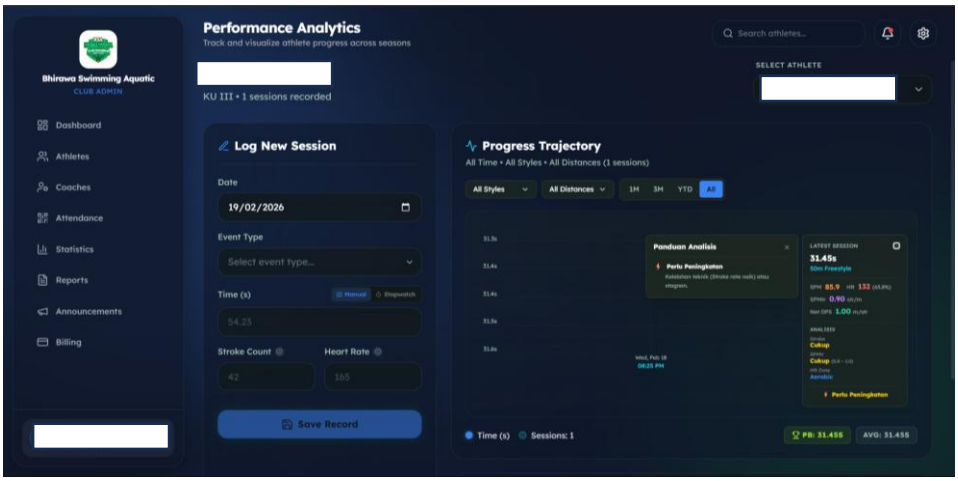

Figure 1. *Progress Trajectory in Swimatrics System*

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Although it currently shows only one data point, this interface is designed to transform complex metrics into easy-to-understand visual representations. For athletes, coaches, and parents, the visualization goes beyond just a final time to an understanding of the technical aspects underlying that time.

Data Characteristic of Single Performance

Data extracted from a single-subject trial session demonstrates the system's ability to automatically classify athlete efficiency.

Table 1. Metrics Resume of Athlete Performance

Variables	Indicator	*n*	Status/Category
Temporal	Travel Time (50m)	31.45 sec	-
Biomechanics	Stroke Per Minute (SPM)	85.9 SPM	Sufficient
	Net Distance Per Stroke (DPS)	1,00 m/str	Steady
Physiology	Heart Rate (HR)	132 bpm (63.8%)	Aerobic

Categories in Table 1

Integration of digital system algorithms that harmonize physiological standards and aquatic biomechanical parameters to provide an objective performance evaluation. The determination of "Aerobic" status is based on the athlete's Heart Rate result of 132 bpm (63.8%), which refers to the submaximal intensity zone for the adolescent age group. This is in line with studies Shookster et al., (2020) which states that the accuracy of maximum heart rate predictions is crucial for determining physiological workload thresholds in order to remain within the appropriate endurance development zone. Meanwhile, the "Steady" category for Net Distance Per Stroke (DPS) and "Sufficient" for Strokes Per Minute (SPM) represent the athlete's technical efficiency level.

This assessment is based on the biomechanical principles proposed by Lopes et al., (2022) Efficient swimming performance is determined by the athlete's ability to optimize the relationship between stroke frequency and reach length in order to minimize active drag. Thus, the "Needs Improvement" notification appears because the system detects a proportional imbalance, where high movement frequency has not been accompanied by maximum propulsive efficiency, thereby providing athletes with precise knowledge of performance.

DISCUSSION

With the existence of a feedback gap in the conventional swimming training ecosystem, where performance data is often presented manually, making it difficult for athletes and parents to understand. The platform aims to digitize kinetic and kinematic variables into intuitive visualizations, transforming raw numbers into a transparent communication tool.

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Digital Analytics Integration: Measurable Biomechanical and Physiological Evaluation

Findings on a single subject show that athletes are able to achieve their best time (31.45 seconds) at a heart rate of 132 bpm. Physiologically, this figure is in the aerobic zone (63.8%), well below the estimated maximum heart rate for 12-13 years old, which ranges from 207-208 bpm. The advantage of this digital system is its ability to detect that this speed was achieved through a high stroke rate (85.9 SPM) but with moderate stroke efficiency (Distance Per Stroke) of 1.00 m/str.

In line with the findings, Schreven et al., (2022) which states that swimming effectiveness is the result of optimizing propulsion and reducing drag. Through the "Needs Improvement" notification, Swimatrics successfully performs a diagnostic role that normally requires complex manual biomechanical analysis. Unlike studies from Born et al., (2024) Focusing on the technical reliability of raw data in the field, this research emphasizes how the data is instantly interpreted for rapid technical intervention.

Visual Feedback as a Communication Medium and Motivation Booster

The application of the Progress Trajectory graph serves as Knowledge of Performance (KP), which provides an objective overview of the athlete's technical position. Psychologically, this transparent visualization supports Goal Setting Theory, whereby athletes can set more realistic targets based on data trends, rather than just verbal instructions (Nugraha et al., 2021). This is supported by (Nathalie Pattyn, 2024) which emphasizes that clear visual feedback can strengthen intrinsic motivation through a documented sense of achievement.

This system demonstrates that it is an effective means of communication between coaches and parents. The problem of parental involvement in youth sports is often hampered by a lack of technical understanding. With an integrated dashboard, subjectivity in assessing an athlete's progress can be reduced. These findings reinforce the research (Ntalachani et al., 2025) regarding the importance of transparency in building trust in the coach-athlete-parent relationship.

Implication and Recommendation

The implications of this study indicate that digitization through systems such as Swimatrics can modernize data management in swimming clubs, changing the training paradigm from subjective assessment to evidence-based coaching. In practical terms, the use of this system facilitates early detection of technical degradation or potential fatigue before performance stagnation occurs. The researcher suggests some recommendations for further development. Future research could use Heart Rate and SPM data simultaneously to ensure that speed improvements are driven by technical efficiency (technique-driven velocity). In the other hand, given the limitations of this cross-sectional study with a single subject, future research is recommended to test the long-term effectiveness of visual feedback interventions on sustained performance improvement.

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CONCLUSION

Based on the results of the analysis and discussion, it can be concluded that the use of digital performance analytics systems such as Swimatrics makes an important contribution to modernizing swimming performance monitoring. This system demonstrates its effectiveness in bridging the feedback gap through Progress Trajectory visualization, which facilitates instant identification of performance characteristics. The use of integrated metrics allows coaches to reveal that speed (v) is the result of the interaction between stroke rate (SR) and technical efficiency (stroke length) in a transparent manner.

In a single-subject trial, the system successfully identified a "Needs Improvement" status. This provided objective information that a high stroke frequency (85.9 SPM) in the low intensity zone indicated great potential for improving time through improved water pull efficiency.

Digital data visualization serves as a psychological instrument that improves athletes' data literacy. Easily accessible graphics facilitate a more measurable goal-setting mechanism and strengthen intrinsic motivation through transparency in achieving personal targets.

The transparency of data provided by the web-based platform builds trust between coaches, athletes, and parents. This creates a more informative, supportive environment where athlete development is based on factual, objective data rather than subjective assessments.

Overall, this study shows that the use of digital analytics is not just about collecting numbers, but about simplifying complex metrics into information that is useful to all parties involved in athlete development.

ACKNOWLEDGMENTS

The authors like to convey their appreciation to the athletes, coaches, and parents of the Bhirawa Swimming Aquatic Club for their involvement and collaboration during the data collection process. We express our gratitude to the to the College of Education, University of Batangas; Faculty of Sport and Health Science, Universitas Negeri Surabaya; and Faculty of Health Sciences, Universitas Kristen Satya Wacana for their cooperation and for providing the institutional support required to complete this study.

FUNDING STATEMENT

This research did not receive any specific support from public, commercial, or non-profit agencies.

CONFLICT OF INTEREST

The authors assert that they own no conflicts of interest pertaining to the publishing of this article.

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