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Analysis of Pacing Strategy in the 400 m Freestyle Race

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Abstract

Pacing strategy refers to how a swimmer distributes speed and effort throughout a race and is widely recognized as a key factor influencing performance in middle-distance swimming events. A proper pacing strategy allows a swimmer to balance initial speed with fatigue management, especially in races like the 400m freestyle that demand both speed and endurance. The purpose of this study was to investigate how pacing strategies are used in the 400 m free style swimming race by analysis of 50 m split times for male and female swimmers. The data was taken cross sectionally from the swimmers during the West Java Series 3 (WJS-3) Championship at SOR R.A.A Adiwijaya. A descriptive: quantitative study was carried out with 16 swimmers (8 male and 8 female). Splits times were measured manually by the use of a stopwatch at every 50 m over the whole length of the race. Split times were averaged as a group median and pacing strategy was determined using descriptive statistics. Results revealed that female swimmers employed a positive pacing strategy, involving fast speeds in the initial segment and a progressive slowing across the laps. Male swimmers revealed a parabolic pacing pattern of fast start, controlled middle segment and acceleration in the final part of the race, indicating possibly an attempt to enhance finishing outcome. These results seem to indicate that pacing strategies at regional competition level are based on fast start approaches, and training programmes should be designed in function of speed distribution and maintenance during the race.

How to Cite

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INTRODUCTION

Swimming quality is determined not only by finish time, but also by the consistency of swimmers in maintaining their speed at various stages of the race. Split time stability is a highly relevant concept, as it reflects energy efficiency, technical consistency, and resistance to fatigue. Athletes who perform strongly show little variation in split times; this indicates that they are able to master the rhythm of the race and maintain good physiological control (Skorski & Abbiss, 2017). This stability is an important factor in maintaining performance from the start to the end of the race, especially in the 400 m event, which is between sprint and endurance. Swimmers who are unable to maintain consistency in their split times tend to experience a decline in performance in the second half of the race due to early fatigue or an imbalanced energy distribution.

In the context of swimming, pacing reflects not only physical ability, but also cognitive and strategic aspects. (Kevin G. Thompson, n.d.) explains that elite swimmers are able to maintain or adjust their speed strategically based on experience and training, especially in middle-distance events such as the 200 m and 400 m freestyle. Swimming speed is a key indicator in measuring a swimmer›s performance emphasizes that swimming performance depends on factors such as energy, kinematics (the relationship between swimming speed, stroke length, and stroke frequency), and kinetics (the swimmer›s ability to generate kinetic energy through propulsion in the water) (Fone & van den Tillaar, 2022)

In middle-distance swimming, swimming speed is influenced by pacing. Understanding and analyzing the pacing strategies used by elite swimmers can provide important insights for coaches and athletes in developing better training plans and competition strategies (Barroso et al., 2020). Knowing and understanding the pacing strategies applied by elite swimmers is not only important from a performance analysis perspective, but also highly beneficial for developing training programs and formulating competitive strategies. This aligns with the perspective of (Elferink-Gemser & Hettinga, 2017), who state that the ability to regulate speed and manage effort throughout a race is an important self-regulation skill in developing young athletes toward the elite level.

In most cases, athletes start the race at an excessively high speed. This causes them to fatigue quickly and, conversely, they often do not start at a high enough speed. (Menting et al., 2019) shows that high speed variation in young swimmers is particularly influenced by a lack of experience and unstable self-regulation abilities. This exercise also means that systematic speed strategy interventions are needed. Several factors influence swimming performance, including swimming speed. Swimming performance depends on factors such as energy, kinematics (the relationship between swimming speed, stroke length, and stroke frequency), and kinetics (the swimmer›s ability to generate propulsive force in the water (Fone & van den Tillaar, 2022).

A research conducted by (Lipinska & Hopkins, 2020), and (Mcgibbon, 2020), shows that pacing strategies such as even pacing, negative pacing, and parabolic pacing can have a significant impact on final race performance. The application of a controlled pacing strategy is a characteristic of athletes who are able to maintain consistent/efficient race times. However, the use of pacing strategies is not a common practice at the training level among young athletes. Therefore, it is important to investigate whether young athletes use pacing strategies and which strategies they adopt, given the demanding nature of the 400 m freestyle race that requires effective energy management.

Research on swimming speed strategies currently studies on speed strategies of swimming were mainly focused on international elite athletes however the application in regional training and competition is still unclear. Results derived from official regional races are also lacking to date, both in detailed speed development at 50-m and between sexes. Knowledge of speed behavior under actual competitive pressure at the regional level is important for optimizing racing strategies and training system. In this sense, the present research focuses on pacing profiles of male and female swimmers in the 400 m freestyle event within an official regional competition. The purpose of this study was to investigate how pacing strategies are used in the 400 m free style swimming race by analysis of 50 m split times for male and female swimmers. The novelty of this research lies in the use of race performance data collected directly during regional swimming competitions, combined with detailed speed analysis based on 50 m intervals. By examining speed behavior under actual race conditions, rather than simulations or secondary data, this study provides a clearer understanding of speed distribution and fluctuations throughout the 400-meter freestyle race at the regional level.

METHOD

This study employed a descriptive quantitative design to analyze pacing strategies in the 400 m freestyle. The sampling technique used was purposive sampling, with total participant were sixteen competitive swimmers, consisting of eight female and eight male athletes, who competed in 400 m freestyle at the West Java Series 3 swimming championship 2025 held at SOR R.A.A Adiwijaya. This study did not involve any experimental intervention, training program, time trial, pre-test, or post-test procedures. The analysis was solely based on race performance data collected directly during official competition.

Race performance data were collected using manual stopwatch timing, with split times recorded at every 50 m segment, resulting in a total of eight splits for each swimmer. The 50 m split approach was selected to provide a more detailed representation of speed distribution throughout the race compared to broader split intervals. Split time analysis has been widely used in swimming research to characterize pacing profiles and performance distribution (Tijani et al., 2021). Data analysis was conducted using descriptive statistics with the assistance of Microsoft Excel. For each 50 m segment, mean split times were calculated separately for male and female swimmers. Pacing strategies were identified based on the pattern of split-time distribution across the race. A positive pacing strategy was defined as a progressively slower split pattern following a fast start, a negative pacing strategy as faster splits in the latter part of the race compared to the initial segments, and a parabolic pacing strategy as faster splits at the beginning and end of the race with slower splits in the middle segments. The results were presented in the form of tables and figures to illustrate pacing profiles and gender-based comparisons.

RESULTS AND DISCUSSION

Mean split times recorded at every 50-m segment were used to describe pacing patterns of male and female swimmers competing in the 400-m freestyle event at the West Java Series 3 championship.

As shown in **Table 1**, female swimmers recorded their fastest split times in the first 50 m, with times ranging from 29.80 s to 34.71 s. After the initial segment, split times generally increased over the next distance of the race. The majority of athletes recorded slower split times between 150 m and 300 m, showing a decrease in swimming speed in the middle phase of the race. The slowest split times occurred between 250 m and 350 m, recording values from 46.30 s to 51.86 s. Despite minor variations in the final 50 m, most female swimmers did not return to their initial

Table 1. Female split time (s) every 50 m, final time 400 m, mean and median.

Female Athlete	50 m	100 m	150 m	200 m	250 m	300 m	350 m	400 m	Final Time	Mean	Median
A	30.85	35.09	36.03	36.41	36.86	37.31	35.89	36.81	285.25	35.66	36.03
B	29.80	36.09	35.32	36.46	35.85	35.93	36.03	35.30	280.78	35.10	35.85
C	31.16	34.28	35.58	37.28	37.46	38.47	37.82	37.80	289.85	36.23	37.28
D	32.75	35.58	37.32	37.22	37.49	37.88	37.73	37.09	293.06	36.63	37.22
E	34.21	41.51	42.52	42.78	42.11	42.32	41.54	40.05	327.04	40.88	41.54
F	34.71	41.33	42.92	43.54	44.14	44.04	43.94	41.04	335.66	41.96	42.92
G	34.17	41.52	44.69	45.37	46.30	45.47	47.28	51.86	356.66	44.58	45.42
H	30.76	34.98	35.60	36.45	36.02	37.36	37.15	36.35	284.67	35.58	36.19

Table 2. Male split time (s) every 50 m, final time 400 m, mean and median.

Female Athlete	50 m	100 m	150 m	200 m	250 m	300 m	350 m	400 m	Final Time	Mean	Median
A	29.22	31.23	32.23	32.76	32.59	33.05	31.86	29.19	252.13	31.52	32.05
B	28.71	33.31	33.53	34.09	34.16	35.02	34.37	31.12	264.31	33.04	33.81
C	29.56	33.40	34.40	35.23	34.95	36.16	35.62	36.12	275.44	34.43	35.09
D	31.17	35.92	34.36	36.53	32.54	32.45	31.07	30.73	264.77	33.10	32.50
E	29.54	32.86	33.10	33.19	34.01	32.68	32.84	30.64	258.86	32.36	32.85
F	29.04	32.23	32.84	32.70	33.37	32.29	32.98	31.72	257.17	32.15	32.50
G	28.10	31.63	32.11	33.08	32.30	33.11	31.80	29.47	251.60	31.45	31.96
H	28.73	31.87	32.95	33.36	33.39	34.39	35.10	35.17	264.96	33.12	33.38

race pace. The mean split times among female swimmers ranged from 35.10 s to 44.58 s, while the median values ranged from 35.85 s to 45.42 s, mirroring the differences in speed consistency among athletes.

Based on **Table 2**, male swimmers demonstrated faster overall split times compared to female swimmers. The fastest split times were consistently observed during the first 50 m, ranging from 28.10 s to 31.17 s. During the middle segments of the race 200 – 300 m, split times remained relatively stable for most male swimmers, generally between 32 s and 36 s. In the final 50 m, several male swimmers showed a reduction in split time compared to the preceding segment. Mean split times for male swimmers ranged from 31.45 s to 34,43 s, while median values ranged from 31.96 s to 35.09 s, suggesting more consistent pacing patterns than those observed in female swimmers.

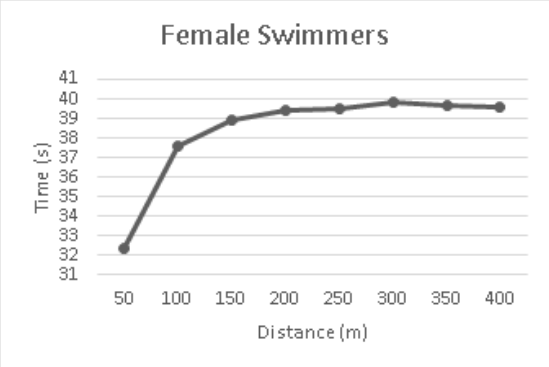

Figure 1. Mean female swimmers split time 50 m until 400 m.

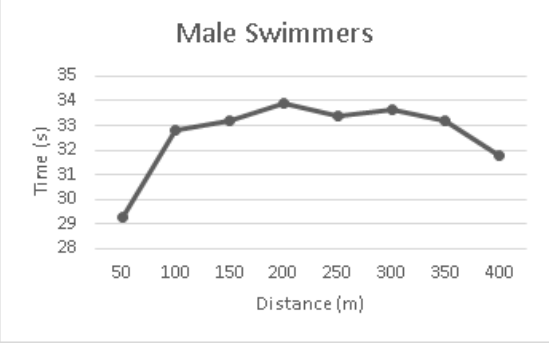

Figure 2. Mean male swimmers split time 50 m until 400 m.

The mean 50 m split times of female swimmers for each 400 m freestyle are shown in **Figure 1**. The pacing profile reveals a significant positive pacing, with incremental split times from beginning to end. After a faster 50 m opening pace, split times progressively slowed from the start in early and middle segments and tended to rise with decreasing number of remaining length toward the end of the race. This result points to a decrement in swimming velocity over the course of the race, showing difficulties in keeping up with the same speed at mid and end-race. Comparable pacing behaviours have been observed in competitive swimming investigations (López-belmonte et al., 2022) whereby sub-optimal control occurred more frequently in improving competitors racing over middle distances.

In contrast, **Figure 2** illustrates the mean pacing profile of male swimmers, which demonstrates a parabolic pacing pattern. After a fast initial 50-m segment, split times increased during the middle part of the race, reflecting a controlled reduction in speed. However, during the final segments, particularly toward the last 50 m, split times decreased again, indicating an increase in swimming velocity. This fast–slow–fast pattern are in line with (Hołub et al., 2023; Lipinska et al., 2016) that suggests a deliberate pacing strategy, where male swimmers conserved energy during the mid-race phases and subsequently increased effort during the final segment to improve finishing performance.

Male swimmers exhibited more stable pacing in the middle phases of the event and greater finishing speed than females. This result agrees with previous studies conducted at the elite level, which found more stable pacing and superior end-race performance in male swimmers in middle-distance freestyle swims. This finding is consistent with previous analyses of elite-level competitions, which reported greater pacing stability and end-race performance in male swimmers during middle-distance freestyle events. Such gender-related differences in pacing behavior may be influenced by variations in physiological capacities, including aerobic and anaerobic contributions, which are known to affect pacing regulation and performance in competitive endurance sports, including swimming (Knechtle et al., 2020).

The positive pacing pattern observed among female swimmers was characterized by progressively increasing split times across race segments, indicating a gradual reduction in swimming velocity as the race progressed (Fang et al., 2024). This distribution indicates that the swimmers wasted more energy in the first half of the race, causing a subsequent loss of power and capacity and deceleration in both middle and final segments. The occurrence of positive pacing has often been described in non-elite athletes and regional level runners, typically as a result

of sub-optimal regulation of effort with an early drop-off in performance and resistance to the race demands often experienced for races run in the middle-distance range (Hettinga et al., 2019).

Male swimmers showed a parabolic pacing strategy, marked by a fast start, a controlled speed reduction during the middle part of the race, and a significant speed increase leading up to the last 50 m. This distribution indicates that the swimmers wasted more energy in the first half of the race, causing a subsequent loss of power and capacity and deceleration in both middle and final segments. A similar pacing profile is reported in competitive swimming studies, where the ability to increase speed in the final segment is correlated with better performance outcome and more effective race strategy (Fang, Yunhui, Cheng Yan, Li Yunpeng, 2024). The observed differences between male and female swimmers may be related to variations in pacing strategy rather than race distance solely. Previous research suggests that swimmers with better pacing consciousness and competition experience are able to distribute their effort more and execute a strong final race acceleration (Menting et al., 2019). Furthermore, the application of real competition data in this study provides valid insights from an ecological perspective, as pacing behavior during official races may be different from that in simulation conditions.

The results of the study show that pacing strategy is a determining factor in the performance of the 400-meter freestyle at the regional competition level. Positive pacing strategies are more commonly found in female swimmers, suggesting that these athletes need to focus more on speed control and specific race strategy training. In contrast, the parabolic pacing strategy shown by male swimmers indicates that energy management and final speed are crucial for success in middle-distance swimming events.

CONCLUSION

The results of the study indicate that pacing strategy is a determining factor in the performance of the 400 m freestyle at the regional competition level. Positive pacing strategies are more commonly found in female swimmers. Based on the average 50 m split time, female swimmers generally exhibited a positive pacing strategy, where they gradually slowed down throughout the race. So it is recommended that these athletes focus more on pacing control and specific race strategy training. Male swimmers exhibited a parabolic pacing strategy with a faster start, a well-controlled middle section of the race, and an accelerated finish. Indicated that energy management and final speed are very important for success in middle-distance swimming events.

These results suggest that competitive performance task imposes sex-differential speed and effort regulation capacities. The occurrence of parabolic pacing in male swimmers might reflect a more efficient energy distribution strategy, leading to better finishing performances. The high prevalence of positive pacing in female swimmers, as opposed to very low for males, indicates that maintaining speed may be more difficult for females over the course of races. In conclusion, the present study highlights the relevance of pacing strategies in middle-distance swimming performance. Results of this study may offer practical implications to coaches and athletes, mainly from the regional level, by including a pacing-focused training program and race strategy development to maximize the performance in the 400-m freestyle.

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