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Original Scientific Article

Olympics: Improving the Competition Strategy in Each Skill Technique of Elite Swimmers for the 400 meters Freestyle

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

Background. In swimming championships, strategy setting is considered to be the main factor, especially in the middle and long-distance events. Implementing a strategic change can indirectly affect the final results.

Objectives. The study aimed to find out whether there were any significant differences in reaction time (RT), final time (FT), and strategy for each split time (ST) in the men's and women's 400 meters freestyle events at the Olympic Games held in Tokyo (2021), Rio de Janeiro (2016), and London (2012).

Materials and methods. This study used quantitative methods with a sample size of 48 athletes. The data source included using the secondary data. Descriptive statistics are presented in the form of means and standard deviations. The Shapiro–Wilk test was used to test the normality of the data. To compare RT, FT, and ST data, the one-way ANOVA test was conducted. The linear regression test was used to determine the effect of RT on the first ST.

Results. The findings of this study indicate that there were differences in the RT of male athletes during the 3 Olympics. The study also revealed variations in average speed. In general, swimmers accelerated their speed at ST1 and ST8. This occurred at the Tokyo 2021 and Rio de Janeiro 2016 Olympics, while at the London 2012 Olympics, swimmers accelerated their speed only at ST1. Additionally, the results demonstrated that RT had an influence of 0.381 (14 %) on the first ST in male athletes, whereas the influence in female athletes was less marked – 0.066 (4 %).

Conclusions. This study concludes that ST1 and ST8 are the most crucial components in the 400 meters freestyle swimming for both male and female athletes. Coaches and athletes must be very careful in carrying out special training at the tapering stage so that athletes can achieve the right time to produce the best performance.

Keywords: swimming strategy, performance, analysis, olympics.

Introduction

In swimming competitions where a small difference of milliseconds can determine success especially in the Olympic championships (Post et al., 2020; da Silva, 2019). By optimizing the performance speed athletes can achive their best performance (Bishop et al., 2009). To achive the best performance in swimming really depends on several factors such as biomechanics, swimming strategy, physiology and physicology (Ben-Zaken et al., 2022; Gonjo & Olstad, 2020; Meggs & Chen, 2019; Price et al., 2024). Small mistakes made by swimmers in making disproportionate changes in movement can cause enormous hydrodynamic resistance in changing speed (Pramono et al., 2023; Takagi et al., 2023). These obstacles cause a loss of energy in swimmers that should be used to accelerate swimming (Fone, 2022).

The 400-meter freestyle swimming event is a middle-distance race lasting approximately 3.5 to 5 minutes, characterized by a predominantly aerobic energy contribution of about 88 % (Correia et al., 2020). This race number requires strength and VO_2max that is high enough to be able to maintain performance while swimming (Sokołowski, Bartolomeu et al., 2022; Sokołowski, Strzała, & Żegleń, 2022). This number is supported by a combination of contribution of lactic acid and anaerobic glycolysis (Campos et al., 2017). Therefore the coach must understand what energy is used in athlete during the race.

Planning the right competition strategy is a major factor and is considered very important in swimming championships (Polach et al., 2021). Athletes who have reached their elite level have an excellent strategy (Born, Lomax, & Romann, 2020). Although there are slinght physiological differences from other athletes, winning or losing athletes depend on their ability to regulate energy to prevent premature fatigue (Skorski & Abbiss, 2017). In a race swimmers may try to disrupt their copetitors race strategy by accelerating at the start or slowing down earlier than expected, this makes some swimmers position themselves in such a way to avoid the turbulence strategy created by their competitors (McGibbon et al., 2018).

Changes in strategy in swimming competitions can indirectly affect the speed of movement, therefore it is im-portant for a coach to update his understanding of startegies in starting, half time, turning, and time before the finish (Morais et al., 2019; Morais, Barbosa, Forte et al., 2021). In Indonesia, there are still many athletes and coaches who do not know the strategy for swimming in the middle and long distances, so athlete just swim as fast as possible to the finish line without understanding how much energy they are using. The coach must also be careful in applying the understanding of race analysis to the athlete's strategy, because the strategy in the old championships may have been different from the current championship strategy (Gonjo & Olstad, 2020).

Materials and Methods

Study Participants

This research was conducted using quantitative research method, where the number of samples taken 48 athletes with each number consisting of 8 athletes. To obtain a respresentative sample, athletes who won position 1-8 in the final match were chosen from number 400 meters freestyle in 3 Olympic London 2012, Rio 2016 and Tokyo 2021 (table 1).

Data Collection

In this study, data on reaction time (RT), Split Time (ST) and Final Time (FT) were taken from the website[1] used as secondary data. This research sample also does not use an objective from because the data has been verified through the official website of the Olympic.

Table 1. Profile athlete male and female in 400-meters freestyle

Rank	Sex	London 2012 (Age)	Rio 2016 (Age)	Tokyo 2021 (Age)
1	Male	YS (20 years)	MH (20 Years)	AH (18 Years)
	Female	AS (22 Years)	KL (19 Years)	AT (20 Years)
2	Male	TP (22 Years)	YS (24 Years)	JM (26 Years)
	Female	CM (22 Years)	SS (22 Years)	SH (23 Years)
3	Male	PV (28 Years)	GD (21 Years)	KS (21 Years)
	Female	BB (23 Years)	EM (22 Years)	PO (21 Years)
4	Male	YH (17 Years)	CD (27 Years)	HM (24 Years)
	Female	MF (17 Years)	FP (28 Years)	JY (19 Years)
5	Male	CD (23 Years)	CJ (25 Years)	FA (24 Years)
	Female	FP (23 Years)	DS (19 Years)	KL (24 Years)
6	Male	GK (24 Years)	JG (20 Years)	GD (26 Years)
	Female	VA (21 Years)	BB (27 Years)	BS (21 Years)
7	Male	DC (30 Years)	DM (24 Years)	EW (21 Years)
	Female	CM (26 Years)	MC (22 Years)	FP (32 Years)
8	Male	RN (22 Years)	JP (21 Years)	JM (19 Years)
	Female	KP (22 Years)	CB (21 Years)	MW (27 Years)

Statistical Analysis

The descriptive statistics presented are the mean and standart deviation, test the normality of the data using Shapiro-Wilk test. In comparing data between Olympiads, the multi-comparasion One-Way ANOVA method was used to verify RT, ST, and FT between difference Olympiads. Linear regression is used to determine how much influence RT has on the first ST.

Results

Table 2 above shows the results of the Shapiro-Wilk normality test on male and female athletes in the 400-meter freestyle during the 3 Olympic Games. All results show that both male and female athletes in each round have normal scores with a value above 0.05.

Table 2. Description of normality tes ton splite time

Sex	Olympic	Shapiro-Wilk									Information
		df	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	
Male	Tokyo 2020	8	0.207	0.363	0.624	0.871	0.557	0.850	0.533	0.788	Significant
	Rio 2016		0.962	0.885	0.132	0.688	0.063	0.579	0.381	0.315	
	London 2016		0.962	0.317	0.618	0.094	0.353	0.348	0.803	0.851	
Female	Tokyo 2020	8	0.265	0.729	0.835	0.976	0.420	0.919	0.585	0.705	Significant
	Rio 2016		0.325	0.054	0.349	0.228	0.838	0.449	0.764	0.956	
	London 2016		0.468	0.963	0.062	0.571	0.789	0.341	0.308	0.158	

[1] https://www.worldaquatic.org and https://www.swimswam.com

Table 3. Description of average result test on split time

Sex	Olympic	M ± SD								
		df	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8
Male	Tokyo 2020	8	26.06 ± 0.54	28.17 ± 0.16	28.43 ± 0.12	28.63 ± 0.23	28.51 ± 0.33	28.65 ± 0.12	28.37 ± 0.20	27.48 ± 0.33
	Rio 2016		26.03 ± 0.27	28.10 ± 0.16	28.53 ± 0.17	28.65 ± 0.23	28.60 ± 0.47	28.60 ± 0.34	28.28 ± 0.78	27.41 ± 0.99
	London 2012		26.08 ± 0.33	28.23 ± 0.33	28.58 ± 0.15	28.84 ± 0.37	28.50 ± 0.36	28.69 ± 0.40	28.40 ± 0.75	27.68 ± 0.86
ANOVA			0.971	0.632	0.145	0.324	0.842	0.845	0.919	0.157
Female	Tokyo 2020	8	28.38 ± 0.51	30.35 ± 0.44	30.52 ± 0.47	30.79 ± 0.47	30.72 ± 0.52	30.94 ± 0.60	30.82 ± 0.80	30.12 ± 0.99
	Rio 2016		28.50 ± 0.41	30.47 ± 0.49	30.67 ± 0.47	30.98 ± 0.42	30.81 ± 0.51	30.95 ± 0.44	30.78 ± 0.61	29.89 ± 0.57
	London 2012		28.27 ± 0.33	30.43 ± 0.25	30.87 ± 0.22	31.09 ± 0.20	30.94 ± 0.40	31.22 ± 0.33	31.01 ± 0.44	30.28 ± 0.65
ANOVA			0.567	0.837	0.255	0.311	0.648	0.415	0.748	0.608

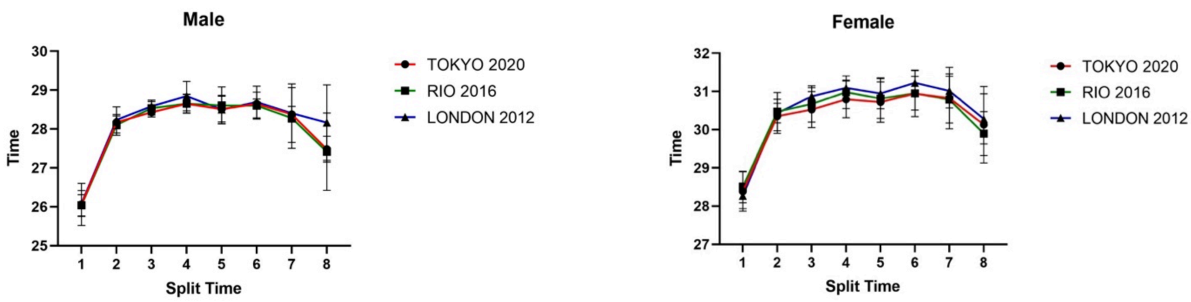

Fig. 1. Graph of the average male and female athletes for each 50-meter lap time

Table 3 above shows the results of the One-Way ANOVA test and the average test results for male and female athletes in the 400-meter freestyle during the 3 Olympic Games. It can be seen that all the results show that both male and female athletes did not experience changes in time during the 3 Olympic Games with a value of > 0.05.

Fig. 1 shows that there are differences in strategies among male athletes ahead of the Tokyo 2020, Rio 2016 and London 2012 Olympics. At the 2012 London Olympics, on average swimmers increased their speed at ST1, at ST2 to ST8 swimmers decreased and held their speed. Meanwhile, at the Tokyo 2021 and Rio 2016 Olympics, on average, swimmers increased their speed at ST1, at ST2 swimmers slowed down and held their speed until ST7, at ST8 swimmers increased their speed again. Female athletes experienced the use of the same strategy as male athletes by using time acceleration at ST1 and ST8 at the 2016 Rio Olympics only. This reduction in speed can be a strategy chosen by swimmers to avoid fatigue in the middle of the ST. Researchers also observed that by using this strategy swimmers could increase their speed in the final ST. This study also found a difference in the average time at ST8. This can be influenced by increasing stroke frequency and stroke length in swimmers. This is also in accordance with research (Barbosa et al. 2008). States that the greater the stroke rate, the faster the swimmer.

Table 4 above shows the average results of swimming times for male and female athletes in the 3 Olympic Games. Can be seen in male athletes, the acceleration in the 100-lap occurred at the 2016 Rio Olympics with a time of 54.14, the 200-lap occurred at Tokoyo 2020 with a time of 57.08, the men's 300 lap occurred at Tokyo 2020 with a time of 57.13, and in the 400 lap it occurred in Rio 2016 with a time of 55.71. While for female athletes the first lap acceleration occurred at the 2012 London Olympics with a time of 58.70, in the 200 lap it occurred at Tokyo 2020 with a time of 61.32, in the 300 lap it occurred at Tokyo 2020 with a time of 61.66, and in the last lap there was an acceleration in Rio 2016 with a time of 60.68.

Table 4. Description of the average swimming time result for each 100-meters

Sex	Olympic	M ± SD			
		100	200	300	400
Male	Tokyo 2020	54.23 ± 0.63	57.08 ± 0.34	57.13 ± 0.43	55.83 ± 0.40
	Rio 2016	54.14 ± 0.32	57.20 ± 0.26	57.36 ± 0.92	55.71 ± 1.71
	London 2012	54.32 ± 0.61	57.43 ± 0.51	57.19 ± 0.69	56.57 ± 1.66
Female	Tokyo 2020	58.73 ± 0.90	61.32 ± 0.93	61.66 ± 1.07	60.95 ± 1.78
	Rio 2016	58.97 ± 0.88	61.65 ± 0.86	61.77 ± 0.92	60.68 ± 1.06
	London 2012	58.70 ± 0.55	61.96 ± 0.38	62.17 ± 0.72	61.29 ± 1.00

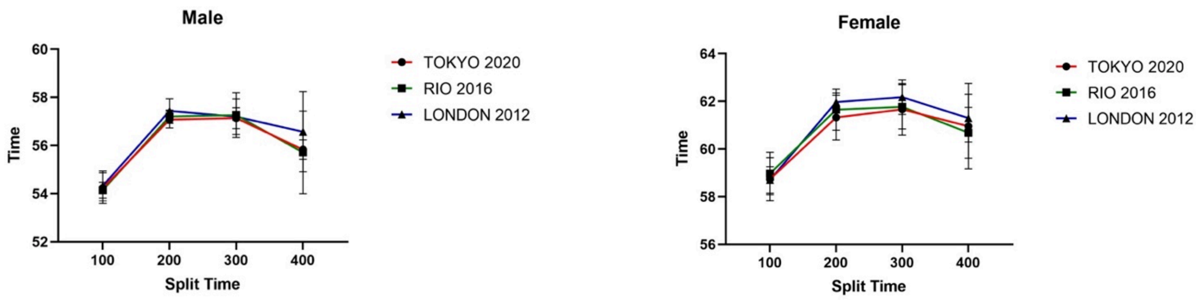

Fig. 2. Graph of the average male and female athletes for each 100-meter lap time

Fig. 2 above shows the average results in each 100-meter lap for male and female athletes. Male athletes experienced time acceleration at the Tokyo 2020 and Rio 2016 Olympics, while at London 2012 they did not experience time acceleration. Meanwhile, female athletes did not experience time acceleration during the 3 Olympic Games.

Table 5. Normality test result on RT and FT during 3 Olympic Games for male and female athletes

Sex	Olympic	Shapirow-Wilk		Information
		RT	FT	
Male	Tokyo 2020	0.806	0.056	Significant
	Rio 2016	0.564	0.128	
	London 2012	0.921	0.402	
Female	Tokyo 2020	0.482	0.494	Significant
	Rio 2016	0.200	0.394	
	London 2012	0.600	0.244	

Table 5 shows the results of the normality test carried out on the RT and FT variables for male and female athletes. All results show a normal distribution with values above 0.05 so that a difference test can be carried out.

Table 6. Average result and one way ANOVA difference test RT and FT

Sex	Olympic	RT	ANOVA	FT	ANOVA
		M ± SD		M ± SD	
Male	Tokyo 2020	0.70 ± 0.03	0.746	224 ± 0.70	0.461
	Rio 2016	0.71 ± 0.04		224 ± 2.25	
	London 2012	0.71 ± 0.02		225 ± 3.16	
Female	Tokyo 2020	0.72 ± 0.04	0.854	242 ± 4.17	<.001*
	Rio 2016	0.72 ± 0.03		252 ± 3.46	
	London 2012	0.73 ± 0.03		254 ± 1.92	

Table 6 shows the One-Way ANOVA test on the RT and FT variables, In the RT table, male athletes show no difference with a value of 0.746 for the FT variable, there is also no difference with a value of 0.461. Interestingly, in female athletes, there is a significant difference in the FT value with a value of < .001, but in RT there is no change in time acceleration with a value of 0.854.

Furthermore, the table explains the effect of RT on ST1 using a linear regression test. Based on the results of the analysis above, male athletes have an influence of 0.381 (14%) with a value of 0.001, and for female athletes, RT has a slight influence on ST1 with 0.066 (4%) with a value 0.342 in the 400-meter freestyle.

Table 7. Linear regression test on the influence of the RT to first ST

Sex	Variable	R Square	Sig.
Male	RT vs ST1	0.381	0.001
Female		0.066	0.342

Discussion

The aim of this research is to provide standards in strategies for developing swimming sports training programs, especially in the 400-meter freestyle. This analysis was carried out based on two categories ST, RT and FT for male and female swimmers who made it to the final round at the Olympics between 2012 and 2020.

The main finding in this research is that there are different strategies for each of the 3 Olympics held. At the 2012 London Olympics, the average swimmer only accelerated at ST1, while in the next ST until the end of the lap, both male and female athletes used constant speed. In contrast to the Tokyo 2020 and Rio 2016 Olympics, at ST1 the swimmers accelerated their speed, then at ST2 to ST7 the swimmers reduced their speed and used a constant rhythm and did not change their speed. Then in the last lap the swimmer relatively increases his speed. The strategy used by the average swimmer at the Tokyo 2020 and London 2016 Olympics uses a parabolic strategy, characterized by speeding up the swim at the start, followed by decreasing speed in the middle, and increasing speed in the last 50 meters (Mauger et al., 2012; Mytton et al., 2015; Oliveira et al., 2019). By reducing speed in the middle of this lap, we hope this will save energy for athletes until the last distance before the finish. Not only that, an increase in the number of strokes can cause an increase in swimming speed (Simbaña-Escobar, Hellard, & Seifert, 2020). Thus, elite swimmers can implement strategic settings in decreasing the total number of strokes or increasing the total number of strokes to minimize the decrease in speed in the middle of the race (Hellard et al., 2008). Elite athletes can minimize the decrease in speed very well in remembering every pull they do (Skorski & Abbiss, 2017). To achieve these abilities they must have experience and excellent training (Micklewright et al., 2010; Skorski et al., 2014). So the ability possessed by swimmers can utilize their own energy effectively and at the same time can reduce fatigue in the initial phase (Puce et al. 2023).

ST1 times in all Olympics in this study, both male and female athletes produced faster times due to the large amount of energy the athletes had as well as the additional jumps and glides, this resulted in much faster times than the next ST (Mazzilli, 2019). This research found another thing that RT can have an influence of 14% (0.381) on the first ST. So this research is in accordance with previous research stating that when a swimmer leaves the starting block, speeding up the RT can provide an advantage to the swimmer, although this may decrease as the distance of the race increases (Born et al., 2024). By speeding up the jump from the starting block in the first ST, the speed of time will be much faster than in the next ST. Elite swimming at the start is related to the lower limb strength generated at the start (Carvalho et al., 2023) and in the water phase (Peterson Silveira et al., 2018). So that in the first 50 meters there is an acceleration of time, this is also the same as several other studies which state that optimal RT will have an impact on the swimmer's first ST (da Silva 2019). However, this has not had a high enough influence on female athlete's with an influence level of 4% (0.066). However, in contrast to the results of different RT and FT tests at each Olympics, this study found that the RT and FT 400-meter freestyle did not change over time during the 3rd Olympics. These differences indicate that each coach and athlete has adapted a unique strategy to improve their performance when starting swimming competitions. so that increases in ST, RT and FT are also related to the final results of the swimming athlete's performance. When jumping, swimmers can reach their maximum speed, so that swimmers can reach the 15-meter limit in a faster time (Morais, 2023; Thng et al., 2020), this is due to the lower drag force when underwater compared to when on the surface (Tor, Pease, & Ball, 2015).

Other results in this study found that the RT and FT 400-meter freestyle did not experience changes in time for male athletes during the 3 Olympics. However, this is different from female athletes, where there is a difference in final acceleration during the 3 Olympic Games. This difference in time acceleration indicates that each coach and athlete has adapted a better strategy to improve their performance when starting swimming competitions. So that increases in ST, RT and FT are also related to the final results of the swimming athlete's performance.

Conclusions

This study found a very interesting new thing in the strategy used by swimmers in the 400 meters, the first and last splits are the most important part of the strategy for achieving the best time in the 400 meters freestyle. These two indicators look so simple, but in the process of realizing the first and last split time athletes must have very optimal performance. Besides that the split time in each lap must be conditioned by being measured by each athlete. Athletes and coaches must be very careful in carrying out swimming exercises, especially in tapering exercises, the achievement of time must be ensured precisely and measurably so as to produce the best time in the 400 meters freestyle. Tapering exercises will provide experience for athletes in managing the energy expended while swimming. Future research will be better by adding other indicators such as calculating stroke rate, physiology, and biomechanics of movement.

Conflict of Interest

The author states that there are no conflicts of interest regarding the publication of this manuscript.

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Олімпійські ігри: Удосконалення стратегії змагальної діяльності щодо розвитку майстерності техніки елітних плавців на дистанції 400 метрів вільним стилем

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Реферат. Стаття: 8 с., 7 табл., 2 рис., 36 джерела.

Історія питання. На чемпіонатах з плавання визначення стратегії вважається головним чинником, особливо у змаганнях на середні та довгі дистанції. Впровадження змін до стратегії може опосередковано вплинути на кінцеві результати.

Мета дослідження. Метою дослідження було з'ясувати, чи існують достовірні відмінності у наступних показниках: час реакції (ЧР), фінальний час (ФЧ) та стратегії для кожного періоду проміжного часу (ПЧ) у змаганнях з плавання на дистанції 400 метрів вільним стилем серед чоловіків та жінок на Олімпійських іграх в Токіо (2021), Ріо-де-Жанейро (2016) та Лондоні (2012).

Матеріали та методи. У дослідженні застосовано кількісні методи з обсягом вибірки 48 спортсменів. Джерело інформації включало використання вторинних даних. Описова статистика представлена у вигляді середніх значень і стандартних відхилень. З метою перевірки нормальності даних використовувався критерій Шапіро-Вілка. За допомогою однофакторного дисперсійного аналізу (ANOVA) проведено порівняльний аналіз даних ЧР, ФЧ та ПЧ. Для визначення впливу ЧР на показник першого періоду ПЧ застосовано тест лінійної регресії.

Результати. Результати проведеного дослідження вказують на наявність відмінностей у показниках ЧР спортсменів-чоловіків впродовж 3-х Олімпійських ігор. Дослідження також виявило зміни в показниках середньої швидкості. Загалом плавці збільшили свою швидкість на рівнях ПЧ1 та ПЧ8. Такі дані спостерігалися на Олімпійських іграх у Токіо-2021 та Ріо-де-Жанейро-2016, тоді як на Олімпійських іграх у Лондоні-2012 плавці збільшили швидкість лише на рівні ПЧ1. Крім того, результати продемонстрували, що ЧР мав вплив 0,381 (14 %) на показник першого періоду ПЧ у спортсменів-чоловіків, тоді як у спортсменок це значення було менш вираженим — 0,066 (4 %).

Висновки. У цьому дослідженні встановлено, що показники ПЧ1 і ПЧ8 є найважливішими компонентами у плаванні на 400 метрів вільним стилем як серед спортсменів чоловічої, так і жіночої статі. Тренери та спортсмени мають з особливою ретельністю підходити до проведення спеціальних тренувань на етапі тейперінгу (англ. tapering — це фаза підготовки, що передує змаганням, під час якої проводять зниження тренувального навантаження), щоб забезпечити спортсменам потрібний час для досягнення найкращого результату.

Ключові слова: стратегія плавання, результативність, аналіз, олімпіада.

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