Progression and variation of competitive 100 and 200m performance at the 2021 European Swimming Championships

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ABSTRACT

Progressions in competitive swimming are necessary to ensure that peak performance occurs when medals are decided. This study aimed to: i) study the coefficient of variation (CV) and performance changes (%Δ) among swimmers who participated in different rounds (i.e., heats, semi-finals and finals); ii) study the CV changes as a function of FINA-points. A total of 1447 performances were analysed in the 100 and 200m-races during the Budapest 2021 European-Championships. Linear mixed-effects models were applied for total and split times to obtain intra-athlete CV and %Δ. The FINA-points were studied with two-way ANOVA and Pearson's correlation assessed the relations with the CV. The CV in 100m-races was: 0.48±0.21% for males and 0.50±0.20% for females (Δ=-0.66%); in 200m-races: 0.63±0.36% for males and 0.60±0.34% for females (Δ=-0.82%). There were differences in FINA-points between strokes and distances ($p<0.02$) and this was associated with higher CV for the 200m-races ($r=0.37$; $p=0.003$), indicating that best swimmers changed their performance over the rounds. In conclusion, swimmers who qualified for the finals performed easier during the heats by going slower in the first 50m-lap; however, some of them would have little chance of qualifying for the finals during major championships because some events were below FINA-points world-standards.

Keywords: Competition analysis; tactical and strategy; finalists and non-finalists; Budapest 2021

INTRODUCTION

Swimming is one of the few sports in which athletes repeatedly compete in the same event (distance and stroke), so the reliability of their performance may differ between races (Stewart & Hopkins, 2000). Progressions are often necessary to ensure the swimmer qualification for the semi-final and then the final in a given event, and that his or her peak performance occurs in the final, when medals are decided (Mujika et al., 2019; Pyne et al., 2004; Sánchez et al., 2021). According to Thompson et al. (2004), high-level competitors sometimes prefer to save their best performance for the final of a competition and try to conserve energy during heats (Skorski et al., 2014), especially if the event is at regional or national level. However, this may not be the case in major events such as the European Championships, where swimmers have to face the best competitors on the continent from the very beginning. Thus, they may only be able to reserve their peak performance to a certain extent during heats and semi-finals, otherwise, they have the risk of not qualifying for the final.

The multifactorial nature of sport outcomes implies that intra-individual competitive performances often differ (Thompson et al., 2004). This is known as the coefficient of variation (CV) and is defined as the percentage of random variation in athlete performance (Hopkins et al., 1999). In the study of Fulton et al. (2009) with Paralympic swimmers, intra-swimmer variability from race to race, expressed as CV, ranged from 1.2% to 3.7% over 15 events counted over a two-year period. In terms of intra-competition results, it has been reported that a strategy intended to significantly change performance in a closely matched competition (e.g., an Olympic final) must be equivalent to at least ~0.5% of that CV to be considered effective (Stewart & Hopkins, 2000). This could therefore be defined as the smallest worthwhile improvement in performance that will affect an athlete's chance of winning a medal or reaching a final.

Previous studies reported similar performance improvements from heats to finals in elite and competitive junior swimmers (-1.2%) (Skorski et al., 2014; Skorski et al., 2013). Additionally, Pyne et al. (2004) described that to be in the running for a medal in the Olympic 50, 100 and 200m events, swimmers experienced a CV of 0.7 to 1.0% between heats for given distances and strokes, with a change in performance of -0.6 to -0.7%

between heats and semi-finals, and -0.5 to -0.7% between semi-finals and finals. Therefore, tactical approaches to conserve energy may explain these differences. In this regard, research has shown that intra-swimmer CV in performance is more consistent between different distances of the same stroke than between the same distance in different strokes (Stewart & Hopkins, 2000). This suggests that, during a competition in which swimmers perform their preferred strokes, they may find it easier to voluntarily vary their pace to swim faster or slower in the different rounds (i.e., heats, semi-finals and finals).

It has been estimated that to have a realistic opportunity of winning an international medal, swimmers need to have a top 10 ranking in that event, and make a -0.6% progression in their world-ranking time (Trewin et al., 2004); whereby, these swimmers could predict their actual probabilities of success by observing their own performance and that of their rivals in the months leading up to the event (Mujika et al., 2019). Within the swimmers who participated in the 2021 European Championships, there were different groups of swimmers with different standards: those who aspired to reach a semi-final or a final, and those who focused exclusively on winning a medal or setting a new World Record (WR). This differentiation is observed through International Swimming Federation (FINA) points (i.e., a value of the swimmer's best mark relative to the world best mark) (Morais et al., 2020), and could be crucial in distinguishing the CV between them. For example, previous studies (Mujika et al., 2019; Stewart & Hopkins, 2000; Trewin et al., 2004) claimed that faster swimmers (i.e., with higher FINA points) might be more consistent in their performance than slower swimmers (i.e., with lower FINA points). However, this claim seems to be supported by comparisons between Olympic-level and national-level swimmers, but not by comparisons between faster and slower contenders within the same competition. Therefore, it was our interest to study this issue among competitors at the 2021 European Swimming Championships.

The purposes of this study were: i) to study the coefficient of variation (CV) and the actual changes in performance (%Δ) among swimmers who participated in the different rounds (i.e., heats, semi-finals and finals), and; ii) to study the competitive level of performance and CV changes based on FINA points. It was hypothesised that if faster swimmers decide not to excel during heats, then performance changes would be detected during the following rounds, leading to a significant change in CV (at least ~0.5%). Subsequently, this CV might be more evident in swimmers that achieved higher FINA points.

MATERIAL AND METHODS

Subjects

With the exception of disqualifications, individual performances in all 100 and 200m of the four swimming strokes (i.e., freestyle, breaststroke, backstroke and butterfly), counted during the Budapest 2021 European Championships, were evaluated. A total of 1447 performances of 1009 different elite swimmers (548 males [age: 22.78 ± 3.79] and 461 females [age: 21.92 ± 4.30]) were analysed, being 766 male-races (butterfly: 147, backstroke: 151, breaststroke: 161, and freestyle: 222) and 681 female-races (butterfly: 130, backstroke: 131, breaststroke: 151, and freestyle: 183).

Data collection

All data were obtained from the official publicly available Budapest 2021 European Championships swimming website (www.len.eu). As this study was a retrospective analysis of publicly available data, there was no participant recruitment, treatment or experimental intervention. Therefore, informed consent and ethical approval from the local committee were not required.

For each event, the results and changes in performance during the three rounds (i.e., heats, semi-finals, and final) and the split times were collected to analyse the process of sports performance. The official data was downloaded by implementing a Web Scraping routine in Python®. Once the automated process was completed, two independent researchers verified that no information was missing. The downloaded data consisted of "distance", "stroke", "round", "rank", "lane", "swimmer name", "reaction time", "split times", "race time" and the corresponding "FINA points". Therefore, using the final times, the following variables were calculated:

- The intra-athlete CV, which represents the random variation in performance between rounds (Hopkins et al., 1999). Three different intra-athlete CVs were obtained: 1) between heats and semi-finals (H-SF); 2) between semi-finals and finals (SF-F), and; 3) between heats and finals (H-F), including all three rounds, total times, and split times. The CV was calculated using the following equation:

$$CV = \frac{Standard\ deviation\ (e.g.,\ SF-F)}{Mean\ \ (e.g.,\ SF-F)} \times 100 \qquad (1)$$

- The inter-athlete CV, which represents the dispersion of ability among athletes in the different rounds. Three different inter-athlete CVs were obtained: 1) H, obtained from the performance of the participants in the heats; 2) SF, obtained from the semi-finalists; and 3) F, obtained from the finalists.

- Relative change (%Δ) in performance between rounds was calculated using the following equation:

$$\%\Delta = \frac{Round\ 2\ performance - Round\ 1\ performance}{Round\ 1\ performance} \times 100 \qquad (1)$$

where, *Round 2 performance* refers to the race time achieved on the second round and *Round 1 performance* refers to the race time achieved on the previous round. The criterion for performance progression, no change, or regression was %Δ being lower, equal, or higher than 0, respectively (Mujika et al., 2019).

- The FINA points were retrieved directly from the official results, being its calculation as follows: $1000 \times (\text{World Record time (s)} / \text{swim time (s)})^3)$.

Statistical Analysis

The normality of the distribution was confirmed with Shapiro-Wilk test and the homoscedasticity was confirmed with the Levene test. All analyses were conducted differentially by sex (Shapiro et al., 2021). Linear mixed-effects models were applied for all swimmers and performances both in the total and split times to estimate means (fixed effects) and within- and between-swimmer variations (random effects, modelled as variances), in accordance with equation (1), as explained in previous studies (Pyne et al., 2004; Stewart & Hopkins, 2000). The fixed main effects were event (100 and 200m), lap (e.g., from 0 to 50m) and rounds (e.g., heats, semi-finals, and final). Subsequently, analysis of variance (ANOVA) test was applied to explore differences in CV and %Δ between distances. Pearson's product correlation between performances (i.e., FINA points), CV and %Δ was conducted to assess whether the variability in performance was related to the swimmers' level. In addition, the FINA points of the finalists were analysed with two-way ANOVA (factors: distance [100 and 200m] × stroke [freestyle, breaststroke, backstroke and butterfly]) with Bonferroni post hoc pairwise comparisons. Statistical procedures were carried out using SPSS 24.0 (IBM, Chicago, IL, USA) with significance level set at $p < 0.05$.

RESULTS

The results of the linear mixed-effects model analysis, intra-subject CVs and Δ% progression between the different rounds, distances, and strokes are presented for total performances in Table 1. This analysis revealed interactions in CV and Δ% for swimmers who qualified for finals compared to heats, with 60% of the swimmers achieving a CV greater than 0.5% and with 82.8% of swimmers achieving performance improvements. The average race times for each round, distance and race are presented in Figure 1, in addition, this information has also been collected for each event including the results obtained by the medallists (see supplementary material). The results of the linear mixed-effect model analysis for the split times in 100 and 200m races are shown in Tables 2 (males) and 3 (females). Among the swimmers who progressed to the semi-finals and finals, the improvements in performance occurred predominantly in the first lap of the race ($p < 0.05$).

(Table 1 near here)

(Figure 1 near here)

(Table 2 near here)

(Table 3 near here)

ANOVA testing revealed no differences in intra-subject CV and Δ% between the heats and semi-finals, but showed differences in CV between the semi-finals and finals ($F = 5.804$; $p = 0.017$). Specifically, the 100m races showed a CV of 0.28-0.30%, while the 200m races showed a CV of ~0.43%. These differences were obtained for the whole group, but not according to sex. The inter-subjects CVs for each round and stroke are presented in Table 4. The highest inter-subject variation was obtained during the heats, and the lowest during the Finals.

(Table 4 near here)

Correlation analysis revealed no associations for the 100m races between FINA points and CV when finals performance was compared to heats ($p = 0.07$). However, an association was found for the 200m races when finals performance was compared to heats ($r = 0.37$; $p = 0.003$), and this relationship was confirmed by the association between FINA points and Δ% ($r = -0.50$; $p < 0.001$).

Two-way ANOVA showed a distance × stroke interaction on FINA points for both males ($F = 5.472$; $p < 0.001$) and females ($F = 2.791$; $p = 0.016$). Post hoc comparisons and FINA points achieved for each distance and stroke are presented in Table 5 and Figure 2.

(Table 5 near here)

(Figure 2 near here)

DISCUSSION AND IMPLICATIONS

The first objective of this study was to study the coefficient of variation (CV) and effective changes in performance (%Δ) between swimmers participating in different rounds of the same championship. It was hypothesised that if faster swimmers performed the heats more slowly, a change in performance would be detected in the following rounds and therefore, a significant change in CV (~0.5%) would occur. Our results showed that swimmers had a mean CV of ~0.5% between performances achieved during finals compared to heats, with a mean range of performance improvement of ~0.7%. When these differences between distances or rounds were studied, different trends emerged (e.g., higher CV in the medium versus short events or little improvement from semi-finals to finals); nevertheless, the strategy of increasing pace in the first lap of the race appeared to be common among swimmers who progressed to the next rounds.

It has been shown that distance swimmers achieve greater variation in performance from heats to finals than swimmers in shorter events (Pyne et al., 2004). In this study, combining males and females, the 200m races had the greatest variation and the 100m the least (Table 1). Specifically, in the progression from the semi-finals to the finals, in the 200m races, both males and females obtained a mean performance improvement value of -0.24% (Table 1), while in the 100m races, some female races obtained performance deteriorations, resulting in only -0.02% performance improvements for this distance (i.e., the improvements observed in some swimmers were offset by performance deterioration in others). Thus, although CV represented changes in performance, these were not always positive for performance.

Within the total sample of swimmers, at least 27.1% did not reach performance progression. This failure could be the result of ineffective planning or the swimmers' inability to perform at their best under the pressure of international competition (Mujika et al., 2019). Specifically, performance improvements for all finalists accounted for -0.7%, and this rose to -1.2% when only medallists were considered (See supplemental material). These results were lower than those obtained by Thompson (1998), who reported a -2.8% improvement in race time between heats and finals for national level swimmers. In contrast, our results appeared to be closer to that reported in the study of Trewin et al. (2004) with elite swimmers, as only gold medallists showed a progression as large as -0.9%. Hence, these results may be common to medal winners and/or finalists, and their particular ability to obtain variations in performance during the event.

Sporting achievements are influenced by a number of post-training factors that increase with years of practice (Nowacka & Słomiński, 2018). Therefore, multiple tactics and pacing strategies are applied in competition to progress from one round to the next (Foster et al., 2009). According to Stewart and Hopkins (2000), a strategy aimed at changing an athlete's performance must account for at least ~0.5% of the CV to be considered effective. Therefore, top-level swimmers who are unable to make such performance improvements at major international meets will reduce their chances of winning a medal (Trewin et al., 2004). In this study, performance improvements from heats to finals were greater than this percentage, especially in the 200m events (Table 1), confirming that swimmers who entered in the top 8 positions managed to perform during heats at a lighter pace than their maximum. However, the H-SF and SF-F CVs were around 0.3-0.4%, meaning that this variation may or may not be effective depending on the cumulative change in performance in each case (Trewin et al., 2004), with some of the improvements referred to as trivial (Table 1). Specifically, in swimming, the race time is made up of the start, swim, turn, and finish times; therefore, if turns account for 20% of the total time, a 2.5% gain in turn time would be needed to improve the total time by 0.5% (Sánchez et al., 2021). However, large changes in certain phases (e.g., the swim start) may be useless if performance in others (e.g., the swim phase) is not maintained. Therefore, future studies should explore whether there are specific factors that are modified more when swimmers want to achieve large improvements.

In this study the split times were collected to analyse the process of sports performance. In the case of the 100m events, significant changes in performance were mostly a consequence of improved performance in the first lap of the event (i.e., from 0 to 50m), while the pace of the second lap (i.e., from 50 to 100m) was no different or slightly slower than the previous round (Tables 2 & 3). These trends were repeated in both the semi-finals and finals, although they appeared to be more common in males than females, which would suggest that males adopted a more aggressive strategy to try to get into a more advanced position from the beginning of the race, while females would have pursued the same purpose but more gradually. In the 200m events, the results of the first lap were quite similar to the 100m. In general, swimming the first or second laps faster and holding on for the rest of the race seemed to be the norm for those progressing to the semi-finals and finals; however, while in the semi-finals for some strokes there was also an improvement in the last split of the race (i.e., from 150m to 200m), during the finals there was a general deterioration of performance during the last 50m lap in all strokes (Tables 2 & 3).

This deterioration could be a consequence of performance fatigue and/or lactate accumulation when trying to perform faster in the first part of the middle-distance races (Cuenca-Fernández et al., 2021), supporting the hypothesis that the best swimmers may have tried strategies to avoid this in the previous rounds. However, it is important to mention that visual feedback could also play a relevant role in this performance impairment (Szczepan et al., 2018). For instance, the swimmers during the finals may choose to let it go and slow down at the end of the race if they do not see themselves among the medal contenders. Conversely, swimmers know that it may not be enough to be among all contenders during the semi-finals, but that it would also be necessary to achieve the fastest possible time to beat the performance times achieved in the other semi-final, so they may have opted to attempt an extra effort at the end of the race. In either case, these group values could be largely influenced by significant performance improvements made by a single swimmer. For example, in the men's 200m butterfly, a significant time drop was observed in the last 50m lap between heats and semi-finals, attaining a CV = 1.24% and considerable changes in performance (-0.67%). However, this strategy was not representative of the whole group ($p = 0.07$), but these results were strongly influenced by the astonishing performance shown by one of the swimmers (T.K., HUN), who completed the last lap of the semi-final race with a difference of $\Delta = -8.37\%$ compared to the heats (~2.2s). Therefore, although this study describes the strategies used by elite swimmers to progress between rounds, it is important to note that elite sport performances are often composed of "outliers" and therefore trends will always be somewhat influenced by this.

The second purpose of this study was to explore the competitive level of performance and the CV changes achieved by the finalists as a function of FINA points. Although it has previously been reported that faster swimmers may vary their performance less between competitions than slower swimmers, control their paces better, or be more likely to sustain effort until the end of the race (Mujika et al., 2019; Stewart & Hopkins, 2000), it was hypothesised that a higher CV might be more evident in faster swimmers within competitions. In the present study, no higher or lower CVs were found for the fastest swimmers (i.e., those who scored the highest FINA points) when comparing performance in finals and heats for the 100m races; although associations were found between FINA points and CV for the 200m events ($r = 0.37$, $p = 0.003$), confirmed by the association between FINA points and Δ% ($r = -0.50$, $p < 0.001$). Therefore, this would indicate that the best 200m swimmers varied their performance more, as they did not swim at their maximum during the heats in the middle-distance races, thus saving energy to progressively improve their performance throughout the following rounds. This race strategy may be more relevant and frequent in 200m events than in shorter distance events.

The two-way ANOVA revealed that there were differences for both males and females in the FINA points scored in the finals during the four strokes (Table 5). Specifically, only the finals were considered, as this is the time when swimmers try to perform at their best, regardless of the different tactics chosen during heats or semi-finals. For the 100m events, there were no differences between strokes in FINA points, especially in females, meaning that the level of competition in the finals was quite similar (Figure 2). This was possibly a consequence of the general deterioration in performance from the semi-finals to the finals in butterfly, backstroke, and breaststroke (Table 1), with swimmers more focused on winning the event than on achieving an improvement in performance. In males, although only freestyle and backstroke were observed to visually outperform butterfly and breaststroke ($p = 0.5$), these results were interesting. For example, in the 100m breaststroke final, the current WR holder (A.P., GBR) participated with a worse performance than his best, possibly conditioned by a periodisation of training aimed at reaching the 2021 Olympic Games (Mujika et al., 2019). Thus, this race accumulated fewer FINA points than expected. On the other hand, the swimmer who eventually achieved the fastest time of the Championships during the relays (K.K., RUS: 52.00s) did not participate in the 100m backstroke final. Therefore, these results may not only have been very different, but suggest that sometimes the winner may not be the fastest (See supplemental material).

In the case of the 200m races, other particular examples were observed. For instance, in the men's 200m breaststroke, the FINA points were large and higher than for the other strokes; however, the inter-athlete CV for this event was quite low (Table 4), indicating that the competitive level of the final was high and similar (Chatard et al., 2001), with some swimmers close to WR and others with good medal chances. In the case of the women's butterfly and backstroke, the FINA points appeared to be quite low for success in other major championships such as the Olympic Games. In particular, in the 200m butterfly swimmers were far away from the WR; however, the inter-athlete CV was also low (Table 4), indicating that, at least at present, these European swimmers presented a similar performance, but it is unlikely that one of them could break the 200m butterfly

WR anytime soon. For the 200m backstroke, the FINA points were also low but the differences between athletes were high (Table 4), possibly because as competitors cannot see each other and control the race leaders, this leads to different strategies being chosen among them (Girold et al., 2001), and this caused some swimmers to significantly worsen their performance during the final due to the lack of visual references.

It is important to mention that during a championship, some swimmers have to face several events in the same session (other strokes, distances or relay events). Consequently, their progression between rounds may be compromised by having little rest time between high-demanding events. Obviously, this human variability could have had a direct effect on the results and the CV, as swimmers with serious medal chances possibly performed better during heats, but could not achieve the expected improvements during the following heats. This could be argued as one of the limitations of the results reported in this study, as variations in performance may not be the consequence of a previously deliberate strategy. In any case, all these aspects are part of the competition and give it an unpredictable character that makes it more exciting and open to a wider group of competitors. An interesting approach for future studies should be to observe whether swimmers were slower in the heats by choice by comparing those times with the start list times obtained before this competition.

CONCLUSION

In conclusion, swimmers qualified for the 100, and 200m finals showed performance variations above the 0.5% reported in previous literature, indicating that the changes obtained were possibly the consequence of a tactic chosen not to excel during the heats.

In any case, it is not excluded that reasons other than their own choice (e.g., improper warm-up, waiting time, and/or lower competitive level of the other swimmers in the heat) may have influenced these results. Specifically, there was a trend for the greatest performance improvements during the semi-finals, although some swimmers also made significant improvements during the finals, specifically the medallists. In particular, most of the performance improvements were in the first 50m lap of the races, indicating that increasing the pace at the beginning and trying to maintain it until the end may have been the strategy chosen by the swimmers to qualify for the next rounds. In terms of the competitive level of the Championships, there were some differences in FINA points between strokes, which may suggest that some events could be significantly below world standards. Therefore, even with significant changes in performance, these European swimmers may have little chance of qualifying for the final rounds of major championships, such as the Olympic Games.

DISCLOSURE STATEMENT:

The authors have no conflicts of interest to report.

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TABLES AND FIGURE CAPTIONS

Table 1. Males and females' intra-athlete coefficient of variation (CV).

Table 2. Males' differences in the coefficient of variation (CV) and relative change in performance (%Δ) between race splits in 100 and 200m races.

Table 3. Females' differences in the coefficient of variation (CV) and relative change in performance (%Δ) between race splits in 100 and 200m races.

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Table 5. Results comparison in the FINA points between strokes.

Figure 1. The mean race times achieved for each round, distance and stroke.

Figure 2. The mean FINA points achieved for each round, distance and stroke

Table 2. Males' differences in the coefficient of variation (CV) and relative change in performance (%Δ) between race splits in 100 and 200m races.

100m EVENTS	Split	Heats (n = 16)	Semi-finals (n = 16)	H-SF			Semi-finals (n = 8)*	Final (n = 8)	SF-F		
				CV	p	%Δ			CV	p	%Δ
Freestyle	1st 50m	23.26 ± 0.29	23.25 ± 0.26	0.41 ± 0.29	0.508	-0.05 ± 0.72	23.18 ± 0.28	23.04 ± 0.35	0.56 ± 0.39	0.017	-0.65 ± 0.73
	50 to 100m	25.19 ± 0.41	25.20 ± 0.46	0.42 ± 0.27	0.508	0.05 ± 0.72	24.84 ± 0.20	24.85 ± 0.22	0.17 ± 0.10	0.811	0.03 ± 0.29
Breaststroke	1st 50m	27.78 ± 0.43	27.63 ± 0.40	0.53 ± 0.36	0.003	-0.53 ± 0.74	27.36 ± 0.36	27.30 ± 0.49	0.51 ± 0.47	0.264	-0.21 ± 1.00
	50 to 100m	31.72 ± 0.37	31.72 ± 0.44	0.63 ± 0.55	0.445	-0.01 ± 1.21	31.46 ± 0.35	31.48 ± 0.42	0.35 ± 0.31	0.950	0.07 ± 0.68
Backstroke	1st 50m	26.09 ± 0.27	26.05 ± 0.42	0.81 ± 0.79	0.162	-0.18 ± 1.74	25.76 ± 0.34	25.72 ± 0.28	0.31 ± 0.25	0.291	-0.14 ± 0.57
	50 to 100m	27.66 ± 0.45	27.71 ± 0.43	0.77 ± 0.92	0.781	0.15 ± 1.56	27.35 ± 0.23	27.34 ± 0.27	0.60 ± 0.30	0.387	-0.02 ± 1.01
Butterfly	1st 50m	24.15 ± 0.28	24.02 ± 0.30	0.59 ± 0.44	0.018	-0.58 ± 0.89	24.04 ± 0.30	23.88 ± 0.26	0.48 ± 0.34	0.025	-0.59 ± 0.62
	50 to 100m	27.67 ± 0.49	27.64 ± 0.51	0.62 ± 0.42	0.485	-0.10 ± 1.08	27.23 ± 0.31	27.28 ± 0.50	0.55 ± 0.45	0.378	0.19 ± 1.03

200m EVENTS	Split	Heats (n = 16)	Semi-finals (n = 16)	H-SF			Semi-finals (n = 8)*	Final (n = 8)	SF-F		
				CV	p	%Δ			CV	p	%Δ
Freestyle	1st 50m	25.48 ± 0.30	25.02 ± 0.24	0.64 ± 0.59	0.197	-0.16 ± 1.24	24.94 ± 0.28	24.69 ± 0.35	1.28 ± 1.22	0.010	-1.05 ± 2.38
	50 to 100m	27.16 ± 0.27	27.09 ± 0.16	0.61 ± 0.45	0.114	-0.25 ± 1.06	27.04 ± 0.17	27.01 ± 0.41	0.92 ± 0.48	0.490	-0.13 ± 1.54
	100 to 150m	27.71 ± 0.18	27.58 ± 0.26	0.68 ± 0.52	0.035	-0.47 ± 1.14	27.53 ± 0.29	27.40 ± 0.28	0.51 ± 0.36	0.048	-0.49 ± 0.76
	150 to 200m	27.52 ± 0.56	27.21 ± 0.55	1.35 ± 0.93	0.010	-1.15 ± 2.08	26.81 ± 0.40	26.88 ± 0.48	1.13 ± 0.99	0.286	0.21 ± 2.21
Breaststroke	1st 50m	29.62 ± 0.43	29.60 ± 0.35	0.55 ± 0.38	0.549	-0.06 ± 0.97	29.38 ± 0.33	29.32 ± 0.30	0.32 ± 0.24	0.173	-0.19 ± 0.54
	50 to 100m	29.60 ± 0.45	33.26 ± 0.39	0.78 ± 0.39	0.534	0.34 ± 1.21	33.02 ± 0.34	32.68 ± 0.37	0.73 ± 0.60	0.002	-1.04 ± 0.85
	100 to 150m	33.58 ± 0.39	33.57 ± 0.58	0.96 ± 0.79	0.649	-0.05 ± 1.80	33.23 ± 0.42	33.11 ± 0.47	0.52 ± 0.54	0.155	-0.36 ± 1.04
	150 to 200m	33.91 ± 0.81	33.50 ± 0.62	1.06 ± 1.02	0.004	-1.24 ± 1.73	33.09 ± 0.56	33.41 ± 0.79	0.84 ± 0.79	0.139	0.94 ± 1.32
Backstroke	1st 50m	27.83 ± 0.41	27.67 ± 0.53	0.92 ± 0.85	0.031	-0.58 ± 1.70	27.64 ± 0.44	27.55 ± 0.72	0.95 ± 0.87	0.480	-0.35 ± 1.87
	50 to 100m	29.96 ± 0.55	29.77 ± 0.60	0.69 ± 0.49	0.008	-0.65 ± 1.03	29.41 ± 0.54	29.33 ± 0.50	0.91 ± 0.80	0.213	-0.28 ± 1.77
	100 to 150m	30.11 ± 0.52	30.17 ± 0.59	0.59 ± 0.45	0.979	0.20 ± 1.04	29.70 ± 0.13	29.75 ± 0.38	0.74 ± 0.50	0.541	0.14 ± 1.32
	150 to 200m	29.78 ± 0.50	29.94 ± 0.98	1.07 ± 1.15	0.477	0.49 ± 2.14	29.46 ± 0.19	29.98 ± 0.72	1.58 ± 1.16	0.489	1.68 ± 2.22
Butterfly	1st 50m	25.90 ± 0.41	25.81 ± 0.32	0.55 ± 0.40	0.067	-0.37 ± 0.96	25.61 ± 0.33	25.37 ± 0.39	0.66 ± 0.51	0.002	-0.94 ± 0.72
	50 to 100m	29.47 ± 0.53	29.55 ± 0.37	0.81 ± 0.40	0.806	0.26 ± 1.33	29.32 ± 0.31	28.99 ± 0.44	0.97 ± 0.99	0.007	-1.14 ± 1.67
	100 to 150m	30.24 ± 0.48	30.29 ± 0.20	0.87 ± 0.40	0.769	0.16 ± 1.54	30.23 ± 0.23	29.87 ± 0.59	1.22 ± 1.28	0.016	-1.24 ± 2.27
	150 to 200m	30.93 ± 0.63	30.37 ± 0.77	1.24 ± 0.40	0.072	-0.67 ± 2.70	30.28 ± 0.65	30.52 ± 0.65	1.01 ± 0.62	0.305	0.79 ± 1.52

* Only the swimmers that progressed to the final

Table 3. Females' differences in the coefficient of variation (CV) and relative change in performance (%Δ) between race splits in 100 and 200m races.

100m EVENTS	Split	Heats (n = 16)	Semi-finals (n = 16)	H-SF			Semi-finals (n = 8)*	Final (n = 8)	SF-F		
				CV	p	%Δ			CV	p	%Δ
Freestyle	1st 50m	26.24 ± 0.26	26.06 ± 0.19	0.58 ± 0.44	0.001	-0.67 ± 0.78	25.92 ± 0.14	25.81 ± 0.18	0.40 ± 0.28	0.015	-0.42 ± 0.56
	50 to 100m	28.16 ± 0.19	28.14 ± 0.45	0.69 ± 0.51	0.506	-0.09 ± 1.23	27.77 ± 0.24	27.73 ± 0.31	0.30 ± 0.30	0.270	-0.15 ± 0.60
Breaststroke	1st 50m	31.64 ± 0.31	31.44 ± 0.35	0.65 ± 0.39	0.002	-0.64 ± 0.87	31.31 ± 0.28	31.22 ± 0.24	0.47 ± 0.32	0.264	-0.28 ± 0.79
	50 to 100m	35.30 ± 0.45	35.19 ± 0.43	0.64 ± 0.47	0.078	-0.30 ± 1.10	34.92 ± 0.28	35.09 ± 0.34	0.54 ± 0.49	0.950	0.47 ± 0.93
Backstroke	1st 50m	29.33 ± 0.17	29.15 ± 0.36	0.63 ± 0.57	0.012	-0.60 ± 1.06	29.00 ± 0.36	28.87 ± 0.27	0.56 ± 0.31	0.060	-0.45 ± 0.82
	50 to 100m	30.96 ± 0.53	30.74 ± 0.49	0.56 ± 0.43	0.001	-0.70 ± 0.72	30.43 ± 0.38	30.71 ± 0.55	0.82 ± 0.43	0.045	0.90 ± 0.97
Butterfly	1st 50m	27.20 ± 0.36	27.11 ± 0.25	0.50 ± 0.50	0.097	-0.30 ± 0.96	26.94 ± 0.22	26.81 ± 0.18	0.39 ± 0.20	0.025	-0.47 ± 0.42
	50 to 100m	31.39 ± 0.42	31.16 ± 0.64	0.88 ± 0.64	0.025	-0.65 ± 1.42	30.70 ± 0.28	31.02 ± 0.42	0.97 ± 0.56	0.378	0.99 ± 1.26

200m EVENTS	Split	Heats (n = 16)	Semi-finals (n = 16)	H-SF			Semi-finals (n = 8)*	Final (n = 8)	SF-F		
				CV	p	%Δ			CV	p	%Δ
Freestyle	1st 50m	27.98 ± 0.53	27.74 ± 0.44	0.74 ± 0.46	0.001	-0.85 ± 0.90	27.40 ± 0.30	27.31 ± 0.48	0.45 ± 0.42	0.123	-0.34 ± 0.82
	50 to 100m	30.13 ± 0.35	30.01 ± 0.30	0.56 ± 0.40	0.049	-0.39 ± 0.91	29.86 ± 0.31	29.54 ± 0.46	0.75 ± 0.64	0.002	-1.07 ± 0.92
	100 to 150m	30.67 ± 0.21	30.69 ± 0.32	0.44 ± 0.37	0.892	0.07 ± 0.81	30.52 ± 0.28	30.35 ± 0.28	0.51 ± 0.42	0.026	-0.53 ± 0.79
	150 to 200m	30.64 ± 0.44	30.60 ± 0.66	1.22 ± 0.88	0.383	-0.16 ± 2.18	30.19 ± 0.30	30.39 ± 0.71	1.34 ± 0.63	0.001	0.61 ± 2.11
Breaststroke	1st 50m	33.46 ± 0.40	33.20 ± 0.44	0.73 ± 0.32	0.549	-0.71 ± 0.89	33.07 ± 0.36	32.80 ± 0.31	0.64 ± 0.52	0.013	-0.80 ± 0.86
	50 to 100m	36.95 ± 0.50	36.78 ± 0.50	1.06 ± 0.66	0.534	-0.47 ± 1.74	36.45 ± 0.45	36.29 ± 0.53	0.68 ± 0.72	0.080	-0.44 ± 1.38
	100 to 150m	37.42 ± 0.42	37.02 ± 0.42	0.88 ± 0.71	0.649	-1.09 ± 1.21	36.73 ± 0.28	36.80 ± 0.51	0.61 ± 0.39	0.824	0.18 ± 1.04
	150 to 200m	37.79 ± 0.80	37.58 ± 0.77	0.85 ± 0.65	0.004	-0.57 ± 1.44	37.08 ± 0.70	37.38 ± 0.78	0.89 ± 0.43	0.164	0.78 ± 1.19
Backstroke	1st 50m	31.16 ± 0.43	31.08 ± 0.44	0.67 ± 0.49	0.211	-0.25 ± 1.17	30.95 ± 0.50	30.67 ± 0.33	0.67 ± 0.78	0.014	-0.92 ± 1.15
	50 to 100m	33.21 ± 0.53	33.21 ± 0.67	0.98 ± 0.81	0.472	-0.03 ± 1.82	32.78 ± 0.48	32.56 ± 0.72	0.80 ± 0.75	0.084	-0.67 ± 1.46
	100 to 150m	33.81 ± 0.48	33.81 ± 0.76	0.95 ± 0.62	0.597	-0.01± 1.64	33.19 ± 0.45	33.10 ± 0.70	0.53 ± 0.19	0.228	-0.26 ± 0.80
	150 to 200m	33.63 ± 0.90	33.53 ± 1.03	1.17 ± 0.85	0.202	-0.34 ± 2.06	32.67 ± 0.54	32.75 ± 0.64	1.01 ± 0.68	0.750	0.21 ± 1.78
Butterfly	1st 50m	29.54 ± 0.46	29.52 ± 0.46	0.34 ± 0.40	0.579	-0.07 ± 0.75	29.27 ± 0.22	29.30 ± 0.30	0.38 ± 0.29	0.897	0.10 ± 0.69
	50 to 100m	33.24 ± 0.50	33.34 ± 0.40	0.42 ± 0.33	0.107	0.31 ± 0.68	33.07 ± 0.19	32.96 ± 0.38	0.46 ± 0.42	0.096	-0.36 ± 0.84
	100 to 150m	33.77 ± 0.60	33.80 ± 0.74	0.75 ± 0.54	0.962	0.07 ± 1.33	33.31 ± 0.39	32.20 ± 0.45	0.63 ± 0.41	0.189	-0.35 ± 1.05
	150 to 200m	34.58 ± 1.33	34.18 ± 1.34	1.02 ± 0.70	0.002	-1.17 ± 1.34	33.34 ± 0.43	33.35 ± 0.58	0.71 ± 0.46	0.859	0.02 ± 1.26

* Only the swimmers that progressed to the final

Table 4. Inter-athlete coefficient of variation (CV).

EVENT	100m Races					
	Males			Females		
	Heats	Semi-finals	Final	Heats	Semi-finals	Final
Freestyle	3.6%	1.1%	0.8%	4.3%	1.1%	0.6%
Breaststroke	2.9%	1.2%	1.1%	2.5%	0.8%	0.5%
Backstroke	3.2%	1.3%	0.4%	3.3%	1.1%	1.2%
Butterfly	3.5%	0.9%	1.0%	3.4%	1.4%	0.7%
MEAN	3.3%	1.1%	0.8%	3.4%	1.1%	0.7%
EVENT	200m Races					
	Males			Females		
	Heats	Semi-finals	Final	Heats	Semi-finals	Final
Freestyle	3.1%	0.7%	1.0%	3.8%	1.1%	1.1%
Breaststroke	3.7%	1.2%	0.9%	2.4%	1.1%	1.2%
Backstroke	2.3%	1.6%	1.3%	3.2%	1.8%	1.6%
Butterfly	2.9%	1.0%	1.5%	3.7%	1.9%	0.9%
MEAN	3.0%	1.1%	1.2%	3.3%	1.5%	1.2%

Table 5. Results comparison in the FINA points between strokes.

			Males		Females	
Distance	Stroke		Difference [95%CI]	p	Difference [95%CI]	p
100m	Freestyle	Butterfly	34 [−7, 76]	0.187	18 [−20, 56]	1
		Backstroke	7 [−34, 49]	1	-1 [−40, 37]	1
		Breaststroke	34 [−8, 76]	0.195	-3 [−42, 35]	1
	Breaststroke	Butterfly	0 [−41, 42]	1	21 [−17, 60]	0.81
		Backstroke	-26 [−68, 15]	0.572	2 [−36, 40]	1
		Freestyle	-34 [−76, 8]	0.195	3 [−35, 42]	1
	Backstroke	Butterfly	26 [−15, 68]	0.553	19 [−19, 58]	1
		Breaststroke	26 [−15, 68]	0.572	-2 [−40, 36]	1
		Freestyle	-7 [−49, 34]	1	1 [−37, 40]	1
	Butterfly	Backstroke	-26 [−68, 15]	0.553	-19 [−58, 19]	1
		Breaststroke	0 [−42, 41]	1	-21 [−60, 17]	0.81
		Freestyle	-34 [−76, 7]	0.187	-18 [−56, 20]	1
200m	Freestyle	Butterfly	-7 [−49, 34]	1	41 [2, 80]	0.03
		Backstroke	6 [−35, 48]	1	34 [−4, 73]	0.109
		Breaststroke	-52 [−95, −10]	0.007	-28 [−67, 10]	0.294
	Breaststroke	Butterfly	45 [3, 87]	0.027	70 [31, 108]	<0.001
		Backstroke	59 [17, 101]	0.002	63 [24, 101]	<0.001
		Freestyle	52 [10, 95]	0.007	28 [−10, 67]	0.294
	Backstroke	Butterfly	-13 [−55, 28]	1	6 [−31, 45]	1
		Breaststroke	-59 [−101, −17]	0.002	-63 [−101, −24]	<0.001
		Freestyle	-6 [−48, 35]	1	-34 [−73, 4]	0.109
	Butterfly	Backstroke	13 [−28, 55]	1	-6 [−45, 31]	1
		Breaststroke	-45 [−87, −3]	0.027	-70 [−108, −31]	<0.001
		Freestyle	7 [−34, 49]	1	-41 [−80, −2]	0.03

Table 1. Males and females' intra-athlete coefficient of variation (CV).

MALES

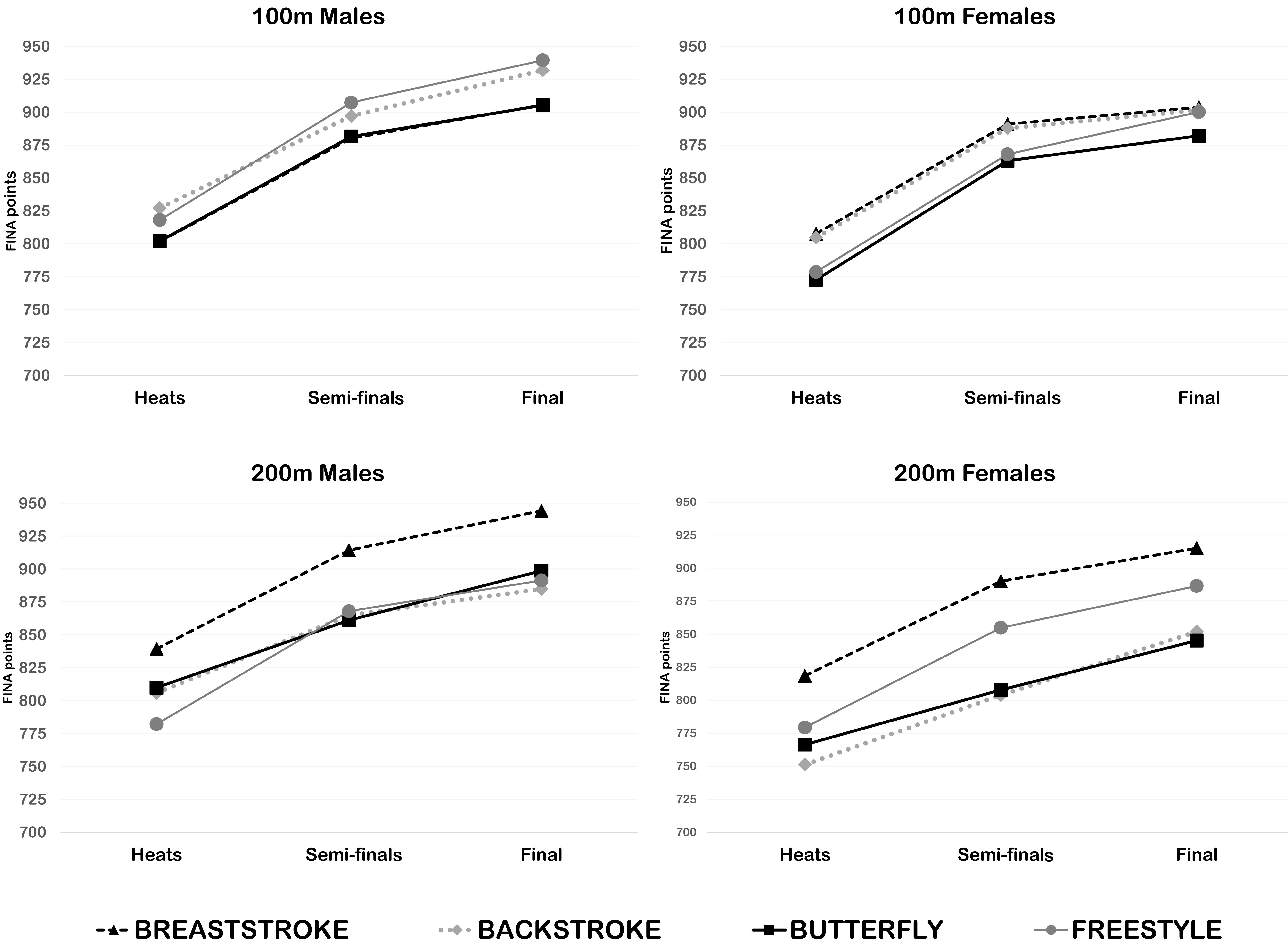
EVENT	H-SF-F			H-SF			SF-F		
100m Races	CV	p	%Δ	CV	p	%Δ	CV	p	%Δ
Freestyle	0.39 ± 0.15	0.010	-0.60 ± 0.34	0.32 ± 0.16	0.821	0.01 ± 0.51	0.28 ± 0.19	0.029	-0.29 ± 0.38
Breaststroke	0.55 ± 0.27	0.045	-0.53 ± 0.83	0.39 ± 0.26	0.053	-0.25 ± 0.62	0.38 ± 0.28	0.436	-0.05 ± 0.67
Backstroke	0.45 ± 0.14	0.307	-0.78 ± 0.20	0.53 ± 0.80	0.479	0.01 ± 1.32	0.30 ± 0.16	0.357	-0.08 ± 0.48
Butterfly	0.53 ± 0.25	0.003	-0.81 ± 0.66	0.39 ± 0.35	0.018	-0.36 ± 0.08	0.25 ± 0.25	0.203	-0.14 ± 0.48
MEAN	0.48 ± 0.21		-0.68 ± 0.55	0.41 ± 0.46		-0.15 ± 0.83	0.30 ± 0.22		-0.14 ± 0.49

EVENT	H-SF-F			H-SF			SF-F		
200m Races	CV	p	%Δ	CV	p	%Δ	CV	p	%Δ
Freestyle	0.64 ± 0.22	0.001	-1.10 ± 0.71	0.46 ± 0.21	0.001	-0.51 ± 0.49	0.48 ± 0.19	0.001	-0.34 ± 0.67
Breaststroke	0.48 ± 0.33	0.040	-0.64 ± 0.84	0.41 ± 0.34	0.104	-0.25 ± 0.72	0.23 ± 0.17	0.186	-0.15 ± 0.42
Backstroke	0.61 ± 0.31	0.207	-0.39 ± 1.16	0.49 ± 0.49	0.105	-0.28 ± 0.95	0.41 ± 0.43	0.576	0.28 ± 0.81
Butterfly	0.78 ± 0.55	0.009	-1.31 ± 0.99	0.51 ± 0.40	0.300	-0.14 ± 0.92	0.58 ± 0.78	0.026	-0.78 ± 1.12
MEAN	0.63 ± 0.36		-0.86 ± 0.96	0.47 ± 0.36		-0.30 ± 0.78	0.43 ± 0.44		-0.25 ± 0.76

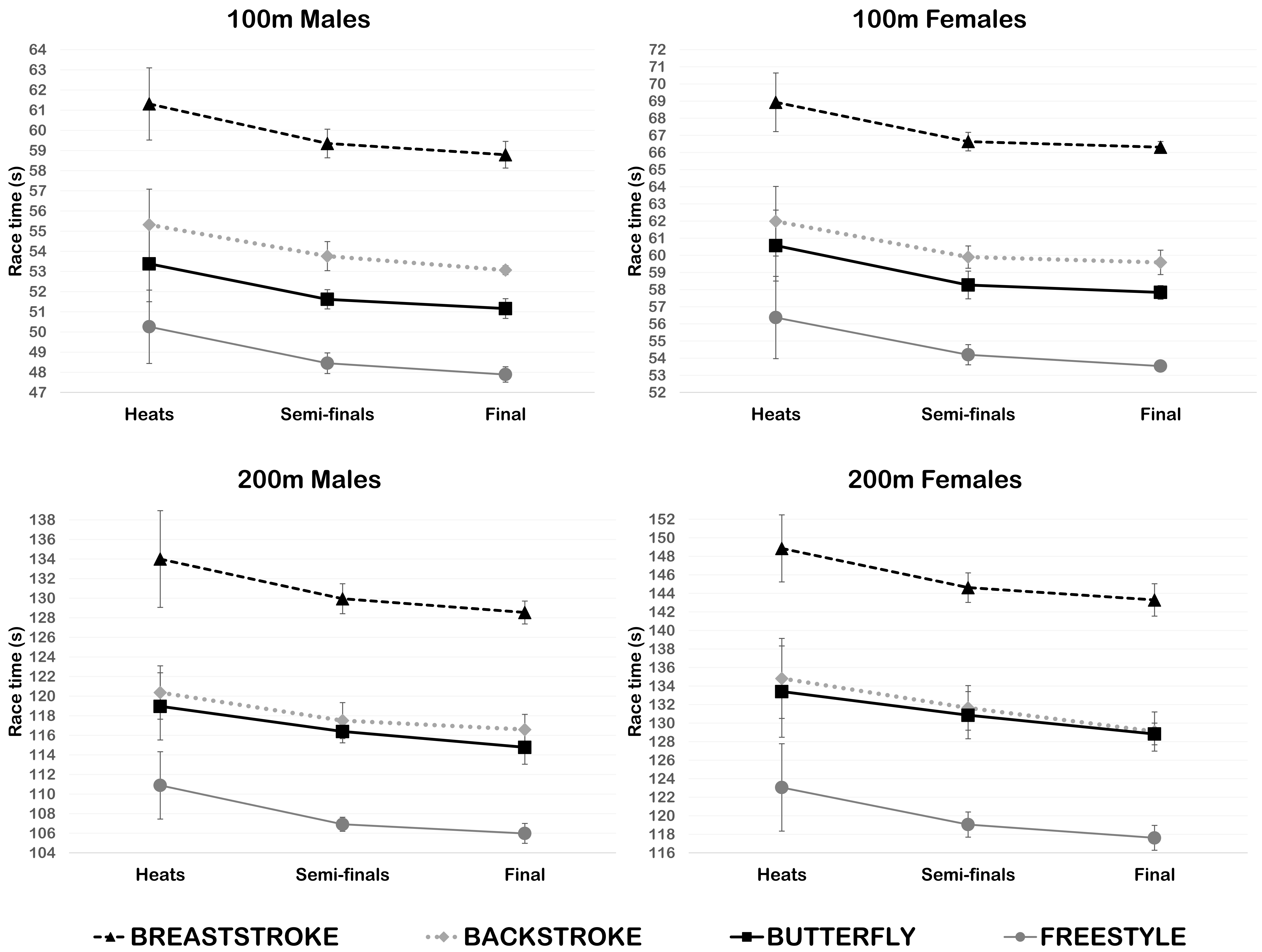
FEMALES

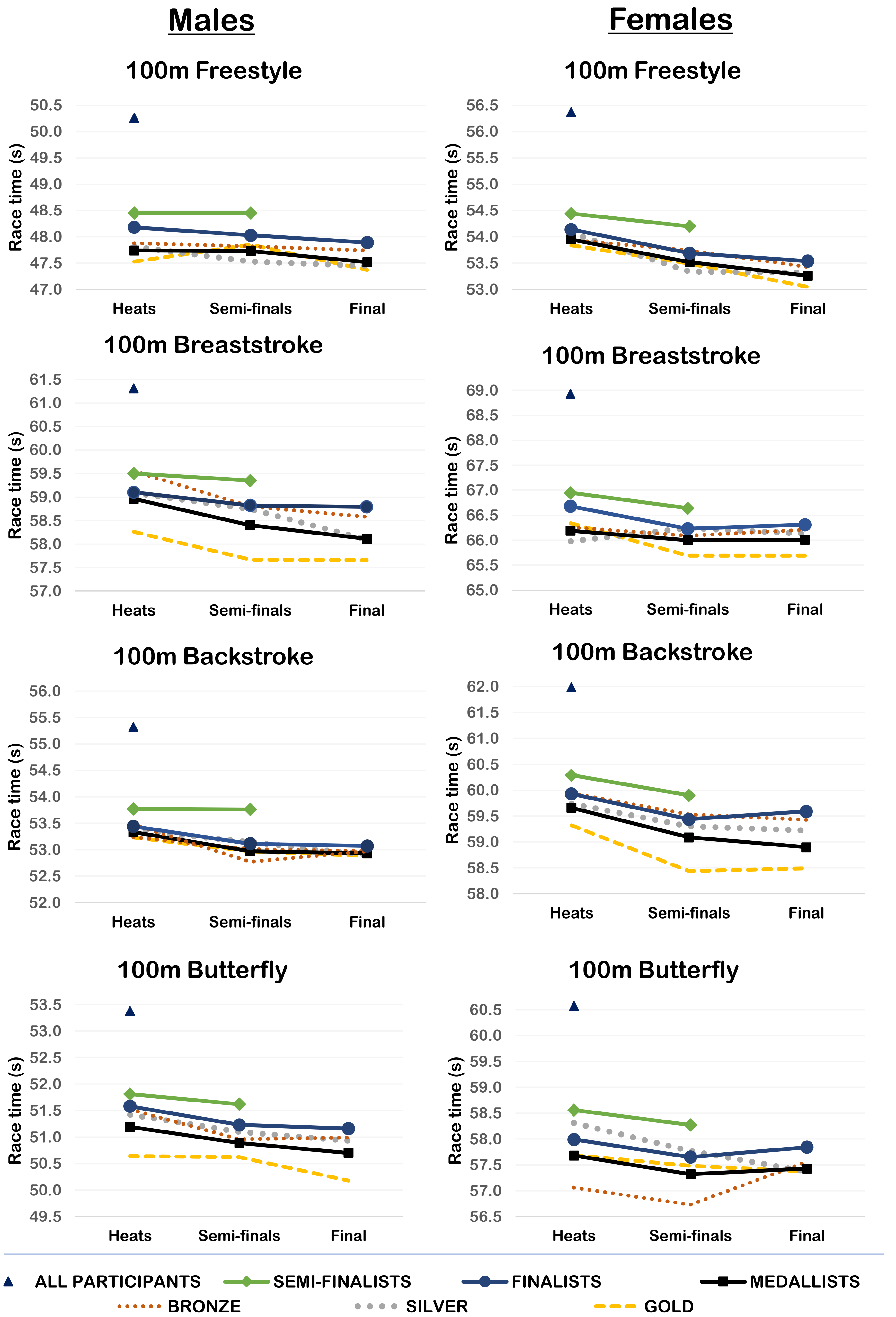
EVENT	H-SF-F			H-SF			SF-F		
100m Races	CV	p	%Δ	CV	p	%Δ	CV	p	%Δ
Freestyle	0.60 ± 0.15	0.001	-1.10 ± 0.31	0.39 ± 0.29	0.012	-0.37 ± 0.57	0.23 ± 0.24	0.027	-0.28 ± 0.36
Breaststroke	0.41 ± 0.19	0.004	-0.54 ± 0.42	0.65 ± 0.67	0.006	-0.46 ± 0.77	0.14 ± 0.11	0.236	0.12 ± 0.22
Backstroke	0.55 ± 0.24	0.001	-0.58 ± 0.72	0.48 ± 0.30	0.001	-0.66 ± 0.43	0.38 ± 0.36	0.696	0.24 ± 0.72
Butterfly	0.45 ± 0.20	0.026	-0.26 ± 0.76	0.56 ± 0.35	0.011	-0.48 ± 0.80	0.36 ± 0.31	0.358	0.32 ± 0.63
MEAN	0.50 ± 0.20		-0.62 ± 0.63	0.52 ± 0.43		-0.49 ± 0.66	0.28 ± 0.28		0.10 ± 0.55

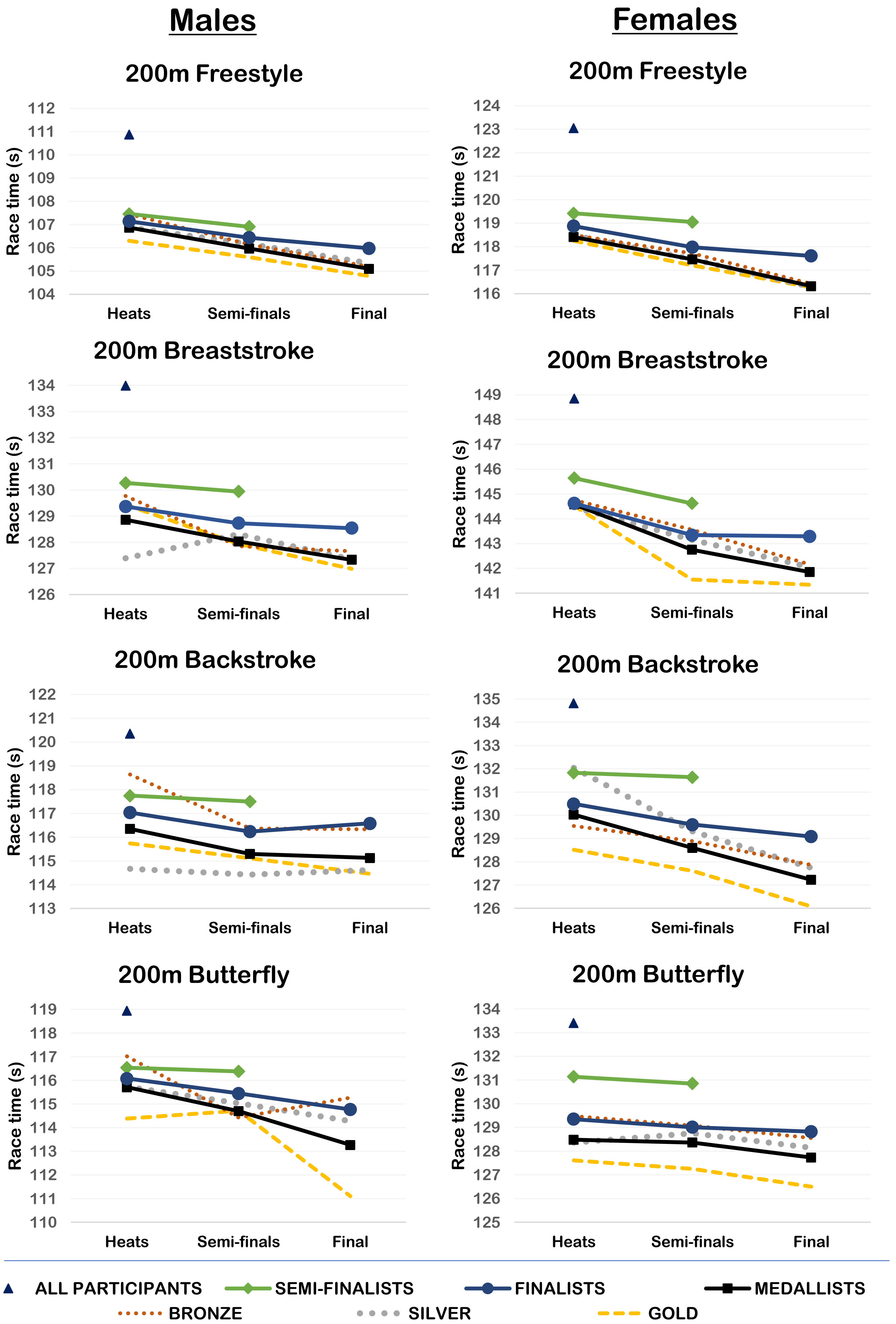
EVENT	H-SF-F			H-SF			SF-F		
200m Races	CV	p	%Δ	CV	p	%Δ	CV	p	%Δ
Freestyle	0.64 ± 0.25	0.002	-1.08 ± 0.70	0.45 ± 0.27	0.050	-0.31 ± 0.68	0.48 ± 0.23	0.083	-0.31 ± 0.68
Breaststroke	0.70 ± 0.28	0.001	-0.93 ± 1.02	0.50 ± 0.36	0.001	-0.70 ± 0.54	0.49 ± 0.25	0.390	-0.04 ± 0.80
Backstroke	0.74 ± 0.48	0.034	-1.09 ± 1.27	0.53 ± 0.50	0.337	-0.15 ± 1.02	0.50 ± 0.33	0.079	-0.40 ± 0.74
Butterfly	0.31 ± 0.15	0.028	-0.45 ± 0.52	0.31 ± 0.21	0.072	-0.22 ± 0.48	0.21 ± 0.14	0.197	-0.14 ± 0.35
MEAN	0.60 ± 0.34		-0.89 ± 0.92	0.45 ± 0.35		-0.35 ± 0.73	0.42 ± 0.26		-0.22 ± 0.65



100m Males
100m Females
200m Males
200m Females
FINA points
950
925
900
875
850
825
800
775
750
725
700
Heats
Semi-finals
Final
BREASTSTROKE
BACKSTROKE
BUTTERFLY
FREESTYLE


100m Males
100m Females
200m Males
200m Females
Race time (s)
Heats
Semi-finals
Final
BREASTSTROKE
BACKSTROKE
BUTTERFLY
FREESTYLE


Males
Females
100m Freestyle
100m Breaststroke
100m Backstroke
100m Butterfly
Race time (s)
Heats
Semi-finals
Final
ALL PARTICIPANTS
SEMI-FINALISTS
FINALISTS
MEDALLISTS
BRONZE
SILVER
GOLD



Males
Females
200m Freestyle
200m Breaststroke
200m Backstroke
200m Butterfly
Race time (s)
Heats
Semi-finals
Final
ALL PARTICIPANTS
SEMI-FINALISTS
FINALISTS
MEDALLISTS
BRONZE
SILVER
GOLD

MEDALLISTS ONLY

EVENT	100m Races									100m Races								
	H - SF - F			H - SF			SF - F			H - SF - F			H - SF			SF - F		
	CV	p	Δ%	CV	p	Δ%	CV	p	Δ%	CV	p	Δ%	CV	p	Δ%	CV	p	Δ%
Freestyle	0.33	0.151	-0.46	0.33	0.966	-0.01	0.3	0.145	-0.44	0.67	**0.002**	-1.28	0.6	**0.045**	-0.79	0.33	**0.085**	-0.48
Breaststroke	0.8	**0.001**	-1.46	0.67	**0.010**	-0.96	0.37	0.151	-0.49	0.3	**0.499**	-0.27	0.4	0.448	-0.28	0.07	0.955	0.01
Backstroke	0.45	**0.001**	-0.76	0.48	0.021	-0.68	0.2	0.620	-0.08	0.70	**0.002**	-1.29	0.7	**0.019**	-0.97	0.27	0.284	-0.31
Butterfly	0.53	**0.007**	-0.97	0.40	0.100	-0.58	0.27	0.180	-0.38	0.6	0.435	-0.44	0.47	**0.020**	-0.62	0.53	0.748	0.18
MEAN	0.53		-0.91	0.47		-0.56	0.29		-0.35	0.57		-0.82	0.54		-0.67	0.30		-0.15
EVENT	200m Races									200m Races								
	H - SF - F			H - SF			SF - F			H - SF - F			H - SF			SF - F		
	CV	p	Δ%	CV	p	Δ%	CV	p	Δ%	CV	p	Δ%	CV	p	Δ%	CV	p	Δ%
Freestyle	0.83	**0.001**	-1.68	0.63	**0.011**	-0.85	0.57	**0.001**	-0.82	0.87	**0.001**	-1.79	0.57	**0.001**	-0.80	0.7	**0.001**	-1.97
Breaststroke	0.77	**0.040**	-1.20	0.80	0.104	-0.65	0.37	0.186	-0.55	0.97	**0.001**	-1.92	0.90	**0.001**	-1.28	0.43	0.390	-0.63
Backstroke	0.60	0.065	-1.04	0.63	0.131	-0.90	0.17	0.475	-0.14	1.13	**0.004**	-2.20	0.80	0.075	-1.10	0.80	**0.002**	-1.08
Butterfly	1.23	**0.038**	-2.16	0.73	0.255	-0.87	0.93	0.213	-1.28	0.33	**0.012**	-0.59	0.20	0.598	-0.09	0.33	**0.001**	-0.49
MEAN	0.86		-1.52	0.70		-0.82	0.51		-0.70	0.83		-1.63	0.62		-0.82	0.57		-1.04

Significant ($p < 0.05$) improvements in performance
Non-significant ($p > 0.05$) improvements in performance
Deterioration in performance