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Research article

How Much the Swimming Performance Leading to Tokyo 2020 Olympic Games Was Impaired Due to the Covid-19 Lockdown?

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Abstract
The aim of this study was to analyze the progression and stability in the performance of world-ranked swimmers from 2015 to 2020, and the impairment induced by the COVID-19 lockdown. An observational retrospective design over five consecutive competitive seasons was selected. FINA´s male Top-50 who were qualified for the Tokyo Olympic Games were considered in freestyle, backstroke, backstroke, and butterfly events. A total of 515 male swimmers and 2060 season-best performances were analyzed. All data was retrieved from two open-access and public websites (Swimrankings and Swimcloud). Repeated measures ANOVA followed by the Bonferroni *post-hoc* test was performed to analyze the variation between seasons. Stabilization in performance was assessed using spearman correlation coefficients. A significant improvement in performance ≈0.5-2.5% was found in most of the strokes and race distances until the 2018-2019 season. The 2020 lockdown impaired the performance by 1-2%. Moderate to high associations were found in the 2017-2018 season when considering the 2019-2020 performance. The breaststroke was the only stroke with a moderate-high stability ($r > 0.40$) in all race distances considering the overall time period. It can be concluded that world-ranked swimmers' performance was impaired by 1-2% due to the COVID-19 lockdown, returning to levels that were reached two years earlier.

Key words: Stability, performance, swimmers, training cessation, COVID-19 lockdown.

Introduction

The annual performance progression of the world-ranked competitors is an important topic to be studied. This information can be used to describe and estimate the performance progression during and between seasons, in order to get a fairly annual enhancement in performance or to be at the top in the most important competitions. This was done in the past leading to several Olympic events. While swimmers improved their performance by 1% within the year leading up to the Sydney's 2000 Olympic Games, an additional enhancement of 0.4 % increased substantially their chances to reach a medal in that specific event (Pyne et al., 2004). The performance trajectories may also help to find hypothetical chronological points where each swimmer needs to achieve their highest level of performance to be qualified. The overall performance improvement during an Olympic cycle is around 3-4%; but the third season leading to the Olympics should be taken as a milestone where a deceleration in race times' improvements is observed (Costa et al., 2010). Although there is some evidence regarding the Olympic Games past editions, there is a lack of research on how performance trends in the various swimming strokes changed through the most recent years, and mostly, how those were affected towards Tokyo 2020, postponed to 2021.

The 2020 swimming year stands out as one of the most unforeseen years justified by the emergence of the global pandemic. The outbreak of the COVID-19 pandemic was a worldwide phenomenon that forced a general lockdown. This led to many restrictions on multiple sports, including swimming. While decisions were made to postpone or cancel major swimming events, the athletes were not allowed to train regularly in their "normal environment". As such, dry-land strength training, plyometrics, or the use of several home-work machines were suggested as useful alternatives to avoid a complete training cessation (Haddad et al., 2021). Although there is evidence that reports positive effects of this kind of training (e.g., Sadowski et al., 2020; Pinos et al., 2020), it is clear that the in-water training cessation would compromise the swimmers' full capacity and, as a consequence, affect their performance (Moreira et al., 2014; Zacca et al., 2019). Thus, there is an opportunity to understand and quantify how the swimming performance was affected during these last years due to the unexpected lockdown.

The aim of this study was to analyze the progression and stability in the performance of world-ranked swimmers already qualified for the Tokyo 2020 Olympic Games during five consecutive seasons, namely from 2015 to 2020. It was hypothesized that the performance would show a significant improvement by the year 2019, and a setback would be expected thereafter.

Methods

Participants

The FINA´s Top-50 male swimmers qualified to Tokyo 2020 Summer Olympic Games (postponed to 2021) in freestyle, backstroke, butterfly, and breaststroke long-course events were analyzed. The original FINA´s qualification time frame, from the 1st of March 2019 until the 29th of June 2020, was considered as an inclusion criteria. Swimmers were excluded if the official season-best performance data in long course (50-m pool) events was not available since 2015-2016 (Rio 2016 Summer Olympic Games) and if they had not swum at least once per season. Hence, 515

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male swimmers qualified for the Olympic Games in the Top-50 were included for further analysis.

Design and procedures

An observational retrospective design over five consecutive competitive seasons was selected for the present study. A "competitive season" was considered from the 1st of October of each year to the 30th of September of the consequent year (e.g., 1st October 2015 to 30th September 2016). The best-season performances (swimmers' official times) between 2015-2016 (Rio 2016 Summer Olympic Games) and 2019-2020 (Tokyo 2020 Summer Olympic Games) in freestyle (50-m, 100-m, 200-m, 400-m, 800-m, and 1500-m), backstroke (100-m and 200-m), butterfly (100-m and 200-m), and breaststroke (100-m and 200-m) long-course events were retrieved. A total of 2060 season-best performances for all events were analyzed. All data was obtained from two open-access and public websites (Swimrankings and Swimcloud). The Institutional Ethics Committee stated that ethics approval was not required for this type of study design.

Statistical analysis

The Shapiro-Wilk was used to assess the normality of distribution. Descriptive analyses included mean and one standard deviation (1 SD). The mean ± 1 SD and quartiles were considered for the mean stability of each competitive season at a given event in all four strokes. Repeated measures ANOVA followed by the Bonferroni *post-hoc* test was performed to analyze the variation between seasons. The assumptions of an ANOVA were tested, and Greenhouse-Geisser correction was considered if the assumption of sphericity was violated. Partial Eta Squared (η_p^2) was calculated as an effect size and interpreted according to Ferguson (2009): no effect if $0 < \eta_p^2 \leq 0.04$; a minimum effect if $0.04 > \eta_p^2 \leq 0.25$; a moderate effect if $0.25 > \eta_p^2 \leq 0.64$; and a strong effect if $\eta_p^2 > 0.64$. The relative frequency of performance variation (i.e., percentage of performance improvement, %) between seasons was reported.

Regularly the performance stability is used as a measure to detect decelerations in race times' improvement and/or to quantify associations between pairwise seasons (Costa et al., 2011). The stability was analyzed using the Pearson Correlation Coefficient (*r*) and interpreted as high if $r \geq 0.60$, as moderate if $0.30 \geq r < 0.60$, and as low if $r < 0.30$ (Malina, 2001). All statistical procedures were performed in the SPSS software (v.27, IBM, SPSS Inc., Chicago, IL, USA) and statistical significance was set at $p \leq 0.05$. Thresholds for assigning qualitative terms to the chance of a substantial improvement were as follows: < 0.5 %, most unlikely; 0.5-5 %, very unlikely; 6-25 %, unlikely; 26-75 %, possibly; 76-95 %, likely; 96-99.5 %, very likely; and > 99.5 %, most likely (Hopkins, 2007).

Results

The variation of season-best and performance trends during the five competitive seasons in all events are shown in Figure 1 and Figure 2. A significant and moderate effect of competitive seasons in the 50-m ($F_{4,152} = 14.60$; $p < 0.01$; $\eta_p^2 = 0.28$), 100-m ($F_{2.66,106.32} = 18.48$; $p < 0.01$; $\eta_p^2 = 0.32$), 800-m ($F_{1.76,58.05} = 16.69$; $p < 0.01$; $\eta_p^2 = 0.34$) and 1500-m ($F_{1.71,54.89} = 12.83$; $p < 0.01$; $\eta_p^2 = 0.29$) freestyle events was observed. The 200-m ($F_{2.5,98.79} = 9.19$; $p < 0.01$; $\eta_p^2 = 0.19$), and 400-m ($F_{1.83,67.72} = 9.07$; $p < 0.01$; $\eta_p^2 = 0.20$) freestyle

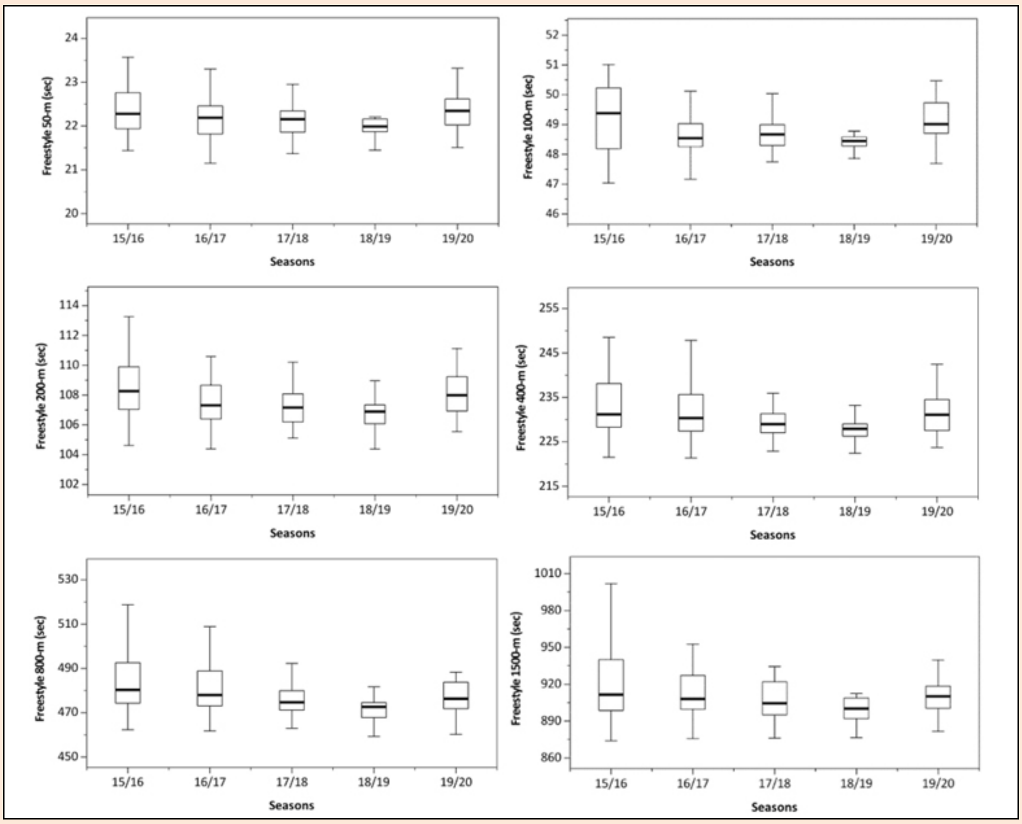

Figure 1. Variation of season-best performances during five competitive seasons in the freestyle events.

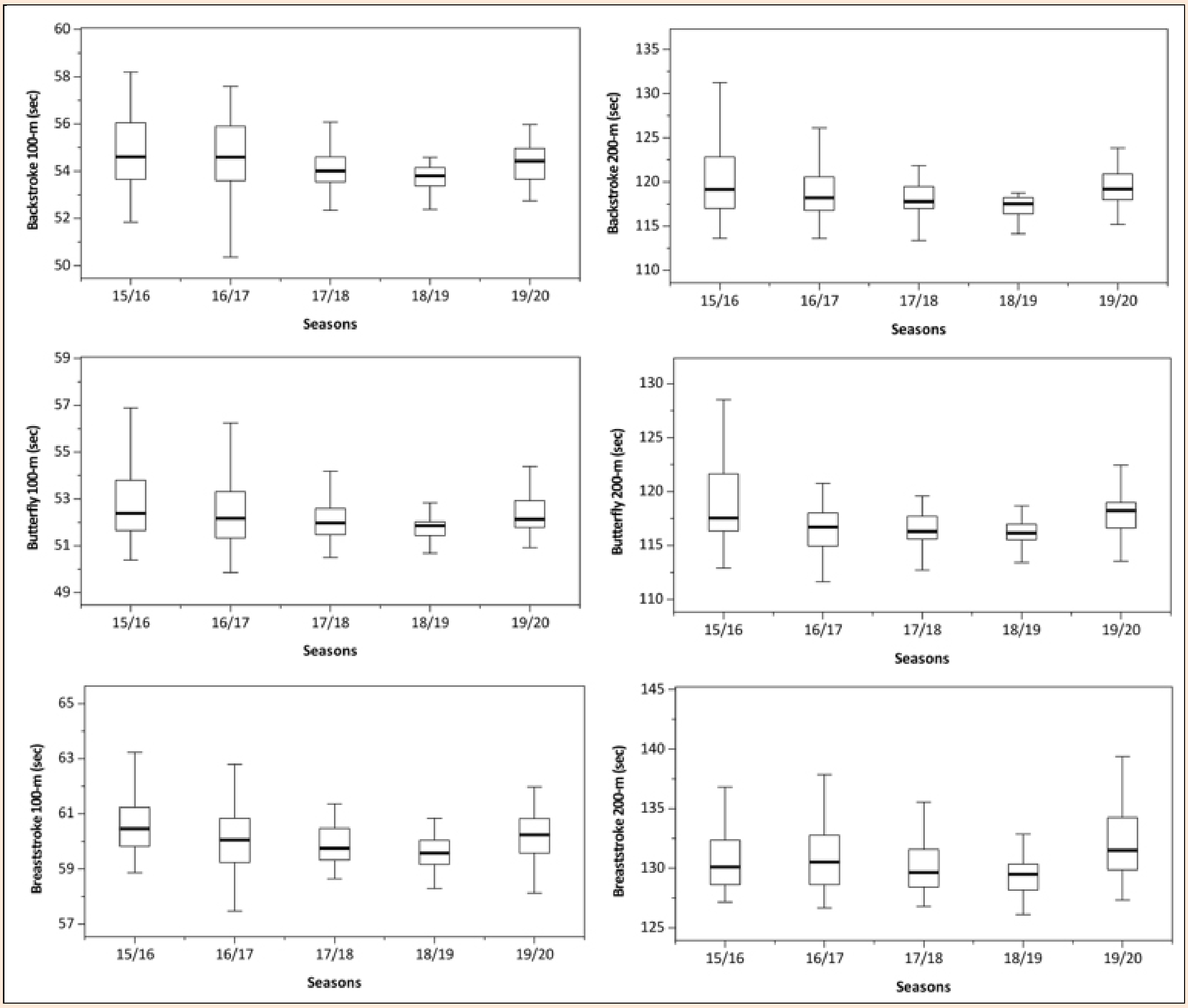

Figure 2. Variation of season-best performance during five competitive seasons in the backstroke, butterfly, and breaststroke events.

events showed significant differences with a minimum effect. Significant differences (Bonferroni *post-hoc*) were found between most of the seasons in freestyle events ($p \leq 0.05$): (i) 50-m and 100-m (15/16 vs 16/17; 17/18 vs 18/19; 18/19 vs 19/20); (ii) 200-m (15/16 vs 16/17; 18/19 vs 19/20); (iii) 400-m and 1500-m (16/17 vs 17/18; 18/19 vs 19/20); (iv) 800-m (15/16 vs 16/17; 16/17 vs 17/18; 17/18 vs 18/19; 18/19 vs 19/20).

The variation of performance in backstroke, butterfly and breaststroke events is shown in Figure 2. As for backstroke, repeated-measures ANOVA showed significant differences in the 100-m ($F_{1.82,72.94} = 14.45$; $p < 0.01$; $\eta_p^2 = 0.27$) and 200-m ($F_{1.47,47.08} = 9.27$; $p < 0.01$; $\eta_p^2 = 0.23$) backstroke events with a moderate and minimum effect, respectively. The Bonferroni *post-hoc* revealed differences in the following seasons: (i) 100-m (16/17 vs 17/18; 17/18 vs 18/19; 18/19 vs 19/20); (ii) 200-m (15/16 vs 16/17; 17/18 vs 18/19; 18/19 vs 19/20). Considering butterfly, there were significant differences between seasons in the 100-m ($F_{1.65,59.40} = 10.80$; $p < 0.01$; $\eta_p^2 = 0.23$) and 200-m ($F_{1.96,64.77} = 13.10$; $p < 0.01$; $\eta_p^2 = 0.28$). Moderate effect size was found only in the 200-m butterfly event. The seasons 18/19 vs 19/20 were significantly different for both events, and seasons 17/18 vs 18/19 showed differences in the 100-m butterfly event (Bonferroni *post-hoc*). Regarding the variation of performance in breaststroke events, significant differences were found between seasons in the 100-m ($F_{2.63,86.72} = 8.53$; $p < 0.01$; $\eta_p^2 = 0.21$) and 200-m ($F_{2.10,71.48} = 9.87$; $p < 0.01$; $\eta_p^2 = 0.23$). Furthermore, the Bonferroni *post-hoc* showed differences in seasons 18/19 vs 19/20 for both events.

Table 1 shows the percentage (%) of performance improvement (variation) between seasons. The seasonal performance improvements ranged from 0.16% in 50-m freestyle to 2.03% in 100-m butterfly and it was around 2-4% up to the 18-19 season. A negative variation from approximately 1 to 2% (depending on the event) was observed for all races between the 18/19 and the 19/20 season. The overall performance improvement was around 0.02% (100-m freestyle) to 2.67% (800-m freestyle).

Table 2 displays the Pearson Correlation Coefficients between 15/16 and 19/20 at a given event. Most of the events showed significant correlations ($p \leq 0.05$) considering the Olympics season. In most of the strokes the moderate-high association coefficients considering the 19/20 performance were seen in the 17/18 season. Interestingly, the breaststroke was the stroke with the highest stability in performance through the overall time period.

Table 1. Percentage (%) of performance improvement between the competitive seasons.

Event	15/16 – 16/17	16/17 – 17/18	17/18 – 18/19	18/19 – 19/20	Overall variation (%) 15/16 – 19/20
Freestyle					
50-m	0.98 ± 1.61	0.16 ± 1.59	0.90 ± 1.66	-1.94 ± 1.82	0.09 ± 2.28
100-m	1.02 ± 1.58	0.16 ± 1.22	0.79 ± 1.23	-2.06 ± 1.95	0.02 ± 2.58
200-m	1.33 ± 2.20	0.73 ± 2.99	0.57 ± 2.27	-1.57 ± 2.09	1.10 ± 3.50
400-m	0.91 ± 2.19	1.20 ± 2.58	1.37 ± 4.27	-2.06 ± 3.42	1.55 ± 4.91
800-m	1.28 ± 2.43	1.46 ± 2.15	0.85 ± 1.38	-1.02 ± 1.69	2.67 ± 4.20
1500-m	1.21 ± 2.27	0.77 ± 1.56	0.66 ± 1.28	-1.11 ± 1.64	1.66 ± 3.44
Backstroke					
100-m	0.93 ± 2.43	1.18 ± 1.87	0.79 ± 1.39	-0.90 ± 1.76	2.00 ± 3.74
200-m	1.25 ± 2.24	0.86 ± 1.63	0.56 ± 1.25	-1.62 ± 2.06	1.39 ± 4.39
Butterfly					
100-m	2.03 ± 3.65	0.44 ± 1.84	0.98 ± 1.83	-1.36 ± 1.90	2.05 ± 4.88
200-m	1.40 ± 2.09	0.75 ± 1.93	0.53 ± 1.26	-2.03 ± 2.21	0.73 ± 3.99
Breaststroke					
100-m	0.82 ± 1.93	0.85 ± 1.80	0.40 ± 1.42	-1.13 ± 1.57	0.89 ± 2.60
200-m	0.68 ± 1.74	0.55 ± 1.38	0.61 ± 1.09	-1.99 ± 1.94	-0.09 ± 2.97

Table 2. Pearson Correlation Coefficients for all competitive seasons and events.

Freestyle	**50-m**	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**	**100-m**	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**
	15/16	1					15/16	1				
	16/17	0.75*	1				16/17	0.68*	1			
	17/18	0.58*	0.74*	1			17/18	0.29	0.64*	1		
	18/19	0.54*	0.61*	0.63*	1		18/19	0.38*	0.33*	0.29*	1	
	19/20	0.52*	0.53*	0.64*	0.50*	1	19/20	0.21*	0.42*	0.44*	0.25	1
	200-m	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**	**400-m**	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**
	15/16	1					15/16	1				
	16/17	0.79*	1				16/17	0.86*	1			
	17/18	0.41*	0.52*	1			17/18	0.66*	0.71*	1		
	18/19	0.21	0.30	0.35*	1		18/19	-0.27	0.00	-0.13	1	
	19/20	0.26	0.33*	0.55*	0.21	1	19/20	0.03	0.13	0.09	0.13	1
	800-m	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**	**1500-m**	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**
	15/16	1					15/16	1				
	16/17	0.79*	1				16/17	0.85*	1			
	17/18	0.75*	0.73*	1			17/18	0.63*	0.71*	1		
	18/19	0.50*	0.40*	0.51*	1		18/19	0.63*	0.58*	0.68*	1	
	19/20	0.13	0.17	0.47*	0.30	1	19/20	0.47*	0.69*	0.57*	0.46*	1
Backstroke	**100-m**	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**	**200-m**	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**
	15/16	1					15/16	1				
	16/17	0.81*	1				16/17	0.89	1			
	17/18	0.76*	0.79*	1			17/18	0.70*	0.80*	1		
	18/19	0.59*	0.61*	0.73*	1		18/19	0.39*	0.48*	0.75*	1	
	19/20	0.38*	0.67*	0.54*	0.52*	1	19/20	0.03	0.10	0.34*	0.38*	1
Butterfly	**100-m**	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**	**200-m**	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**
	15/16	1					15/16	1				
	16/17	0.68*	1				16/17	0.78*	1			
	17/18	0.44*	0.72*	1			17/18	0.50*	0.78*	1		
	18/19	0.13	0.47*	0.43*	1		18/19	0.13	0.46*	0.67*	1	
	19/20	0.05	0.17	0.41*	0.16	1	19/20	0.19	0.20	0.22	0.30	1
Breaststroke	**100-m**	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**	**200-m**	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**
	15/16	1					15/16	1				
	16/17	0.73*	1				16/17	0.85*	1			
	17/18	0.62*	0.64*	1			17/18	0.64*	0.81*	1		
	18/19	0.46*	0.57*	0.63*	1		18/19	0.38*	0.58*	0.76*	1	
	19/20	0.40*	0.42*	0.54*	0.44*	1	19/20	0.44*	0.54*	0.55*	0.46*	1

* $p \leq 0.05$

Discussion

The aim of this study was to analyze the performance progression of world-ranked swimmers already qualified for the Tokyo 2020 Olympics during a five consecutive seasons time period. There was a performance improvement in most of the strokes and race distances until the last season as a consequence of the COVID-19 lockdown. The overall loss in performance capacity was around 1-2% with a setback in performance at levels near those reached two years before.

The degree of overall performance improvement during the five consecutive seasons was ≈0.5-2.5% and was dependent on the stroke and race distance. In fact, there was a fairly good improvement of ≈2-4% until the 2018-2019 season. Improvements of ≈2.5-4.5% were already observed in freestyle events leading to previous games, namely the 2008 Olympic Games (Costa et al., 2010). However, in this study, the restrictive procedures applied due to the COVID-19 affected how the swimmers were preparing to Tokyo 2020. This led to a setback in performance of ≈1-2% in the 2019-2020 season, influencing the overall sum in performance progression. This was a disappointment to the swimmers who would be at the most important event of their career, having dedicated the last few years working on it. The confidence interval limits of means also show a curious trend. While at the beginning of the Olympic cycle the heterogeneity in race times is noticeable, this seems to diminish through the cycle. This phenomena denotes some kind of intra-individual response and was already reported in previous studies related to performance progression during an Olympic cycle (e.g. Costa et al., 2010) or career trajectory (Costa et al., 2011).

The lockdown had a substantial impact on the daily routines of the athletes reducing both training hours and weekly training frequency (da Silva et al., 2021). There was a reduction in the physical training levels from vigorous to moderate intensity facing a more sedentary behavior (da Silva Santos et al., 2021). A significant increase in total sleep time (Facer-Childs et al., 2021) and increased anxiety symptoms (Soares et al., 2021) were found as well. To overcome these constraints, and to minimize fitness losses, several strategies were proposed. The use of real-time video conferencing was intensified in a variety of sports (Bobo-Arce et al., 2021; Schüttler et al., 2021). Home training provided the maintenance of some degree of aerobic capacity at least for soccer players (Rampinini et al., 2021). However, this is more difficult for swimmers as the absence of water training is a major problem to overcome. Water training cessation is expected to increase the swimmers' body fat and decrease VO_{2peak} and metabolic rate (Ormsbee and Arciero, 2012). To avoid it, the swimmers were advised to use when possible flume swimming, tethered swimming in private pools or dry-land training (Haddad et al., 2021). While flume or tethered swimming are methods that work and yield identical VO2 effort (Bonen et al., 1980), the dry-land training can help maintaining integrity in muscle ratio considered important for swimming performance (Batalha et al., 2014).

Finally, and "within normal conditions", the qualified swimmers for Tokyo 2020 would reach similar overall performance progressions as those seen in previous Olympic cycles at least in freestyle events (nearly 4%) (e.g., Costa et al., 2010). The swimmers who qualified for the 2000 Olympic Games were able to show a 2.2% improvement in their final 3 weeks of preparation (Mujika et al., 2002). However, in this study, those final weeks of preparation never happened due to the COVID-19 lockdown. Because none of the available training strategies would be suitable to replace the in-water training gains, the postponement of the Tokyo event was a fair and reasonable decision, at least for swimmers.

When dissecting the performance by stroke and distance there was a curious trend. In most of the strokes, the moderate-high association coefficients considering the 2019-2020 performance were seen in the 2017-2018 season. Here, there was a setback in performance to levels near those attained two years earlier. This means that the loss in performance due to a lockdown phenomenon was faster and greater than the gains in performance reached year by year. In fact, several coaches and athletes from a variety of sports questioned the impact of this postponement, highlighting the opportunity for further performance improvements as one of the main concerns (Oblinger-Peters and Krenn, 2020). With this in mind, we may argue that one year of postponement would not be enough to return to previous performance levels close to the Olympics year.

The breaststroke was the stroke with the highest stability in performance through the overall time period. These swimmers were unable to achieve as great improvements as the remaining strokes. Indeed, the 200-m breaststroke performance showed a negative variation denoting a total loss of gains reached in the previous years. It is known that breaststroke displays a more complex swimming pattern than the other competitive swimming strokes (Bartolomeu et al., 2018). The breaststroke is also the stroke inducing the highest energy cost at various swimming speeds (Barbosa et al., 2006). To achieve long world-class standards the elite breaststrokers must explore strategies to optimize their technique (Seifert et al., 2011). Probably, those swimmers need longer time periods to adjust in a more accurate way the relationship between technical capacity and energy requirement in order to reach the desired performance year by year. Thereby, the ultimate breaststroke performance will come later in the Olympics cycle compared to the remaining swimming strokes.

Practical implications

As this study indicates, it seems important to have different alternatives to decrease the effects of the lockdown in the athletes' performance. Available training facilities prepared to be used with strict sanitary procedures should be provided by all countries, especially with the cooperation of the national Olympic committees, supplying "minimal services" for high-level athletes. On the other hand, the cancellation and postponement of the main international events should be avoided, allowing for a training and competition plan.

Conclusion

An unexpected lockdown seems to impair the performance of world-ranked swimmers by approximately 1-2%. This means a setback of almost two years of performance improvements. So, some kind of preventive procedures should be considered if a new lockdown happens in the future. Decision-makers should be careful about postponing dates because athletes may not reach their previous fitness level to compete at their highest expected level.

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are not publicly available, but are available from the corresponding author who was an organizer of the study.

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Key points

- Swimming performance losses due to the lockdown were around 1-2%.
- There was a setback in performance at levels near those reached in 2017-2018 season.
- The breaststroke was the stroke with the highest stability in performance through the overall cycle.

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