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Human Kinetics
BRIEF REPORT

International Swimming League: Do Successive Events Lead to Improve Swimming Performance?

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Purpose: To quantify the impact of successive competitions on swimming performance in world-class swimmers. ***Methods:*** An entire data set of all events swum during a new competition named the International Swimming League was collected. A Bayesian linear mixed model has been proposed to evaluate whether a progression could be observed during the International Swimming League's successive competitions and to quantify this effect according to event, age, and gender. ***Results:*** An overall progression of 0.0005 (0.0001 to 0.0010) m/s/d was observed. The daily mean progression (ie, faster performance) was twice as high for men as for women (0.0008 [0.00 to 0.0014] vs 0.0003 [–0.0003 to 0.0009] $m \cdot s^{-1}$). A tendency toward higher progression for middle distances (200 and 400 m) and for swimmers of a higher caliber (above 850 FINA [Fédération Internationale de Natation] points) was also observed. Swimmers between 23 and 26 years of age seemed to improve their swimming speed more in comparison with the other swimmers. ***Conclusions:*** This new league format, which involves several competitions in a row, seems to allow for an enhancement in swimming performance. Coaches and their support staff can now adapt their periodization plan in order to promote competition participation.

Keywords: training periodization, swimmers, competition, Bayesian mixed models

In 2019, a new international competition circuit was born: the International Swimming League (ISL), including the world's best swimmers. During the second edition, the circuit consisted of 13 meets in 5 weeks, allowing the swimmers to swim up to 7 meets during that period (if the swimmers have participated in all the meets of their team until the final, then they will have swum for 7 meets). It could induce a new way to consider swimming training periodization where swimmers need to adopt appropriate training periodization to multiply high-level performances.[1]

In this context, the debate on the quantity or quality of training has never been more topical, both in terms of training culture[2] and science.[3] Some studies underlined the potential positive effects in an accumulation of races and competitions throughout the season in world-class swimmers.[1,4,5] In so-called block training,[1] the accumulation of competitive events at maximum intensity over a concentrated period of time corresponds to the transmutation phase of block training that follows a general orientation accumulation phase. Such competitive shock microcycles during which the training volume is greatly reduced and the intensity is pushed to the extreme level constitute specific overload periods promoting a high positive transfer from general physiological capacities to highly specific neuromuscular, energetic, and technical capacities.[1,4,5] However, during the ISL, the competitions are separated by only a few days, which does not offer the possibility of providing a full restoration, which could lead to a state of overtraining[6] and impact the recovery capacities. Depending on the periodization plan, it is also possible that training practices in between meets could differ, where some swimmers may prefer to train hard throughout the entire ISL tournament while others may plan a taper for the semifinals and finals. In that sense, it seems important to monitor the evolution of the performances throughout the specific competitive periods, such as the ISL, in order to better calibrate the competitive training phases and adjust the recovery means.

Therefore, the aim of this brief report is to describe the variations of swimming performance of international ranked swimmers during the ISL.

Methods

Participants

A total of 309 world-ranked swimmers (males and females) from 45 countries participated in the ISL. They could be specialists in one or more distances ranging from 50 to 400 m. It is also important to note that swimmers' participation was dependent on the choice of teams (some swimmers raced nonspecialist events). The research protocol is qualified as noninterventional (article L1121-1 of the French Public Health Code). Therefore, the study did not require informed consent from individual athletes.

Performance Data Collection

All the results were collected for both genders for all swimming events. Name, height, mass, wingspan, age, country, date, and time performance were recorded for each swimmer. All data were collected from the website of the ISL.

Statistical Analysis

A statistical analysis has been performed to evaluate whether a progression could be observed during the ISL successive competitions and to quantify this effect. To this purpose, a Bayesian linear mixed model has been proposed and applied to various situations,[7,8] to account for possible differences in progression trends in subgroups of swimmers. Considering the variable *Speed* as the performance during an ISL race (in meters per second), the variable *Date* counting the number of days spent

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since the beginning of the competition, and a random effect (1|*Swimmer*) to account for the fact that each swimmer may appear several times in the data and thus introduce dependencies, the model can be expressed as

$$\text{Speed} = \beta_0 + \beta_1 \text{Date} + (1|\text{Swimmer}) + \varepsilon,$$

where ε is a Gaussian error term, while β_0 and β_1 represent the coefficients of interest. For computing the posterior distribution of these coefficients, the Stan software (https://github.com/stan-dev) was used along with the R software to derive the complete analysis. The coefficient β_1 can be interpreted as the gain (in meters per second) that one may expect for each passed day since the ISL began. Therefore, the posterior distribution over β_1, as displayed in Figure 1, represents the range of values that are the most probable for β_1, according to the observed data. Although this distribution accounts for a complete uncertainty quantification, we solely provided mean values along with 95% CIs in subsequent tables of results for the sake of concision. Then, this model was applied and the coefficients estimated for each event and gender, to determine how much the swimmers changed daily throughout the ISL, regarding their specificities.

Results

Description of the Data Set

In total, the data set has 3681 observations, including 309 swimmers (158 males and 151 females). The physical characteristics of the participants are presented in Table 1.

Performance Progression Results

The posterior probability distribution resulting from the statistical model is presented in Figure 1. This estimation is based on the full database and indicates an overall performance progression (ie, a faster performance) of 0.0005 (0.0001 to 0.0010) m/s/day.

The coefficients (mean [95% CI]) for each event (males and females) are presented in Table 2 and are expressed in absolute times (in seconds). For 50-m events, a small improvement was observed, while larger improvements were observed for 100- and 200-m events, regardless of stroke or gender. The daily mean progression for men was 0.0008 (0.00 to 0.0014) m/s, and for women, it was 0.0003 (–0.0003 to 0.0009) m/s. These results indicate that men progressed twice as much as women throughout the competition.

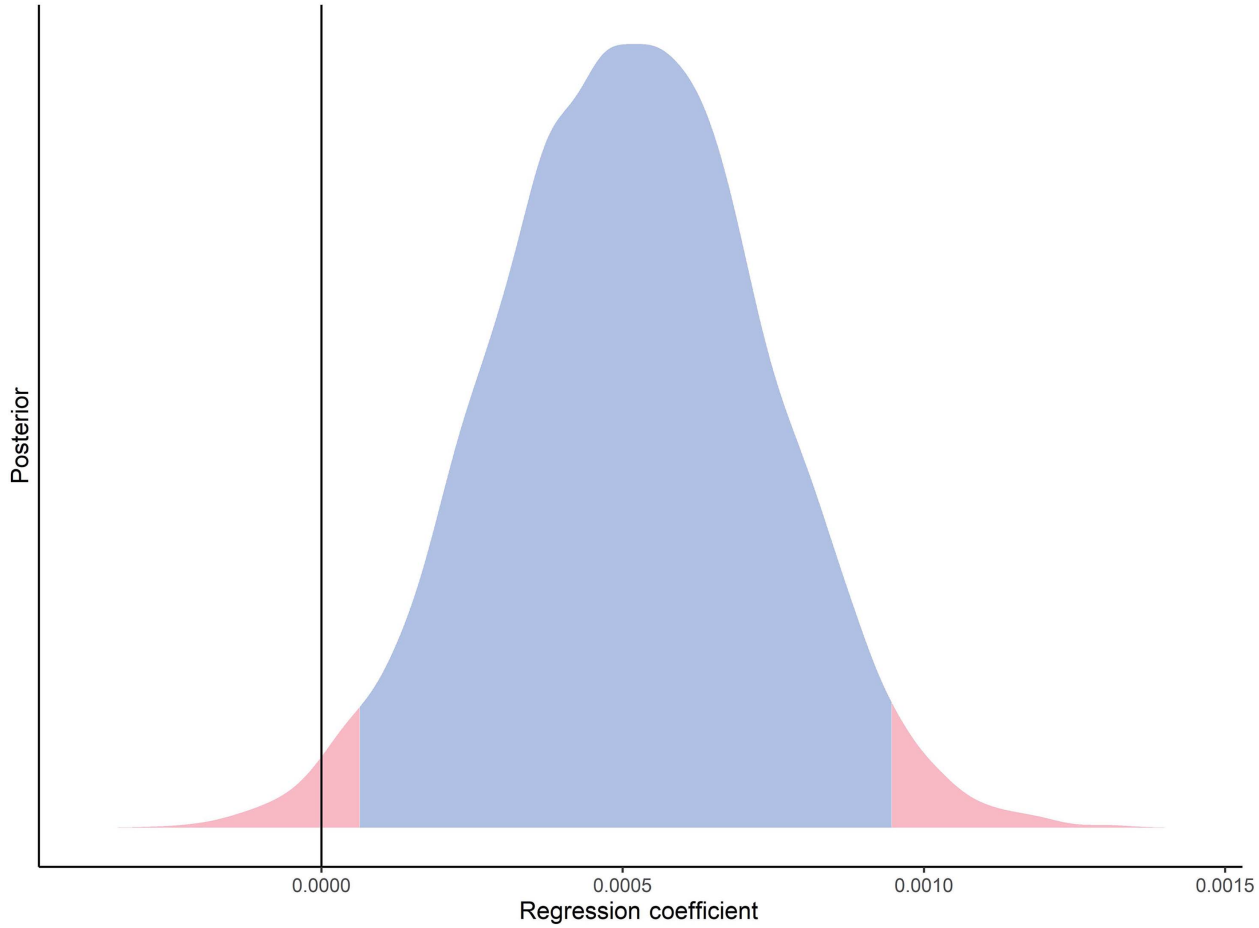

Figure 1 — Posterior distribution of the regression coefficient β_1 indicating how much speed gain can be expected for 1 more day of the International Swimming League competition. This estimation is based on the full database and indicates an overall progression around 0.0005 $m \cdot s^{-1} \cdot d^{-1}$, no matter the discipline or gender. The central part of the distribution represents the values within the 95% credible interval, and values below 0 indicate a decrease in racing time.

Table 1 Characteristics of the Participants (Performance, Age, Height, Body Mass, and Wingspan) According to Swimming Event

	Males					Females				
Event	Time, s	Age, y	Wingspan	Height	Body mass	Time, s	Age, y	Wingspan	Height	Body mass
50 backstroke	23.56 (0.57)	25.9 (4.1)	194 (7)	190 (8)	87 (11)	26.76 (0.53)	24.6 (3.1)	180 (7)	177 (5)	68 (5)
100 backstroke	50.69 (0.98)	25.9 (4.3)	196 (7)	190 (7)	85 (10)	57.60 (1.30)	25.0 (2.7)	179 (8)	177 (6)	67 (6)
200 backstroke	111.95 (3.17)	24.8 (3.2)	196 (7)	187 (7)	81 (8)	125.12 (2.73)	24.4 (3.0)	177 (9)	175 (6)	66 (6)
50 breaststroke	26.45 (0.55)	26.6 (3.7)	200 (9)	190 (6)	87 (6)	30.15 (0.69)	25.4 (2.7)	176 (8)	173 (6)	67 (7)
100 breaststroke	57.52 (1.06)	26.5 (3.6)	200 (10)	189 (6)	87 (6)	65.11 (1.24)	25.3 (2.9)	177 (7)	174 (5)	68 (7)
200 breaststroke	125.42 (2.46)	25.9 (3.2)	196 (7)	187 (5)	83 (6)	140.71 (3.34)	24.7 (2.1)	177 (9)	174 (6)	67 (7)
50 butterfly	22.86 (0.49)	26.3 (4.5)	197 (6)	190 (5)	88 (7)	25.64 (0.63)	24.2 (3.1)	181 (7)	177 (5)	68 (6)
100 butterfly	50.53 (1.12)	25.9 (4.3)	195 (6)	189 (5)	86 (7)	57.07 (1.13)	23.8 (3.3)	181 (8)	177 (6)	67 (7)
200 butterfly	113.44 (2.33)	24.6 (3.5)	192 (8)	185 (7)	81 (8)	127.82 (2.17)	25.1 (3.9)	174 (9)	172 (6)	63 (6)
50 freestyle	21.27 (0.38)	25.4 (3.6)	201 (9)	194 (6)	90 (8)	24.21 (0.46)	25.6 (3.7)	183 (8)	178 (7)	68 (7)
100 freestyle	46.93 (0.63)	24.8 (3.4)	200 (8)	193 (6)	88 (7)	52.64 (0.96)	25.4 (3.6)	183 (8)	179 (6)	69 (6)
200 freestyle	103.82 (1.58)	23.6 (2.5)	197 (7)	189 (5)	83 (5)	115.42 (2.15)	24.2 (3.7)	181 (8)	177 (7)	67 (7)
400 freestyle	223.53 (3.98)	24.3 (2.9)	195 (8)	188 (6)	81 (6)	245.51 (4.66)	24.5 (3.3)	177 (8)	175 (6)	65 (6)
100 medley	52.56 (1.09)	25.1 (3.6)	197 (7)	190 (6)	86 (7)	59.23 (1.42)	23.4 (3.6)	178 (7)	176 (6)	67 (7)
200 medley	115.19 (2.21)	23.6 (3.0)	194 (8)	187 (6)	82 (5)	128.38 (2.95)	24.1 (3.8)	177 (7)	174 (4)	65 (6)
400 medley	248.12 (4.06)	23.9 (3.3)	195 (8)	188 (6)	82 (5)	273.78 (6.44)	25.1 (3.9)	175 (9)	173 (7)	64 (6)

Note: Values are presented as mean (SD).

Table 2 β_1 Coefficients From the Bayesian Linear Mixed Model for Each Event for Both Males and Females, Mean (95% CI)

Event	Males	Females
50 freestyle	.0004 (.0001 to .0008)	.0004 (.0001 to .0007)
100 freestyle	.0003 (.0000 to .0006)	.0002 (–.0001 to .0004)
200 freestyle	.0004 (.0000 to .0007)	.0004 (.0002 to .0007)
400 freestyle	.0002 (–.0002 to .0006)	.0004 (.0002 to .0007)
50 backstroke	.0001 (–.0003 to .0006)	.0003 (–.0001 to .0006)
100 backstroke	.0005 (.0002 to .0007)	.0002 (.0000 to .0005)
200 backstroke	.0004 (.0000 to .0008)	.0005 (.0002 to .0007)
50 breaststroke	.0006 (.0003 to .0009)	.0002 (–.0001 to .0004)
100 breaststroke	.0004 (.0001 to .0007)	.0003 (.0001 to .0005)
200 breaststroke	.0005 (.0002 to .0008)	.0003 (.0002 to .0005)
50 butterfly	.0006 (.0002 to .0009)	.0001 (–.0002 to .0005)
100 butterfly	.0008 (.0005 to .0011)	.0004 (.0002 to .0006)
200 butterfly	.0003 (.0001 to .0006)	.0004 (.0002 to .0006)
100 individual medley	.0004 (.0001 to .0008)	.0001 (–.0001 to .0003)
200 individual medley	.0006 (.0003 to .0008)	.0004 (.0002 to .0006)
400 individual medley	.0006 (.0003 to .0008)	.0002 (.0000 to .0005)

Abbreviation: CI = credible interval.

The daily mean progression for 23 years or younger swimmers was 0.0003 (–0.0004 to 0.0010), and for swimmers between 23 and 26 years, it was 0.0009 (0.0000 to 0.0020), whereas 0.0005 (–0.0002 to 0.0012) was observed for swimmers above 26 years. These results indicate a lower overall progression for the youngest swimmers and a higher progression for the swimmers with an age between 23 and 26 years.

The daily mean progression for swimmers who reached (on average) more than 900 FINA points was 0.0003 (–0.0007 to 0.0013) m/s; for swimmers between 850 and 900 points, it was 0.0007 (0.0001 to 0.0013), for swimmers between 800 and 850 points, it was 0.0002 (–0.0002 to 0.0012), and for swimmers under 800 points, it was 0.0001(–0.0021 to 0.0023).

Discussion

The present study describes swimming performance variations during the 2020 ISL competitions held in Budapest. The overall variation showed an improvement of 0.0005 m/s/d in swimming

speed. This general progression of swimmers (~1.0% of speed) from the start to the end of this 5-week period seems to be higher than previous reports which demonstrated 0.8% in an entire season in elite swimmers.[9] It also appears higher than previous studies which compare the progression between Olympic trial and Olympic game performances.[9,10] The progression was of an equivalent magnitude to that observed between intensive training periods and competitive peaks (1%–5%).[11] But our results can also be interpreted as being due to the beneficial effects of a competitive transmutation phase catalyzing the transformation of general capacities into specific capacities (transmutation phase).[1,11]

Swimmers in the 23- to 26-year age range showed a higher progression compared with the youngest (<23 y) and oldest (>26 y) swimmers. This 23- to 26-year age range is higher compared with the peak swimming time performance observed by Berthelot et al[12] (20.99 [1.55]), ranging from 18.36 (1500 m male) to 23.14 years of age (50 m male). Potentially, the ability to repeat high performances over a 5-week period results from the trade-off between the peak of physiological capacities and the acquisition of competition experience at the highest level.[5] These authors show that swimmers at the highest European level achieve a higher number of races swum per year throughout their career compared with lower-level swimmers.

This hypothesis of a link between the ability to progress during a 5-week competitive period and experience at the highest competitive level is confirmed by the greater progression during the ISL period of swimmers at the highest level (between 850 and 900 points compared with <850 points). These swimmers are likely to be able to better manage their fitness and recovery over a 5-week period as well as make match-to-match improvements to ensure progression.

An important finding of this study is that men swimmers made twice as much progress as women swimmers over the entire 5-week period. Previous work has shown greater stability of performance[9] and commitment to competitive practice[13] for female swimmers compared with male swimmers. Female swimmers have also been characterized by shorter taper periods, which may explain why they could perform at a level closer to their best performances at the beginning of the ISL circuit.[14]

Then, the progress gains were higher for the longer events, such as the 200 and 400 m compared with the 50-m events, suggesting that, over a 5-week period, there are more areas of progress in these events (eg, management of the different parts of the race, starts, and turns). It is also likely that middle-distance swimmers (200- and 400-m events) maintained a higher training volume until the beginning of the ISL period and even within the circuit for some swimmers. The maintenance of the training volume compared with a classic training period could explain a better progression in the middle-distance events.

It would have been interesting to look at the evolution of performance within this 5-week period, in order to propose an optimal competitive cycle time. The impact of number of events swum during each competition may also provide some insights to understand performances changes throughout the 5-week period. It would also have been important to obtain information on the swimmers' activity during the COVID-19 lockdown to better interpret their progressions and possible regressions during the ISL.

Conclusions

During the ISL, the swimmers improved their performance on average, with the greatest improvements observed for top-level swimmers in the 23- to 26-year age group, in the 100- to 200-m events, and for men compared with women.

Practical Applications

The results should help coaches to gain a sharper understanding of how to integrate competition cycles into periodization plans. This periodization should be planned according to the profile of the swimmers.

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