

Impact of the COVID-19 pandemic on competitive swimming performance

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Abstract. – **OBJECTIVE:** This article aims to conduct a comparison of swimming performance during short course national championships (25-m) from 2019 and 2020 (before and during the pandemic).

MATERIALS AND METHODS: The data points from the championships will be compared for 5 European countries: Poland, Spain, Russia, Turkey, and Denmark. Times achieved in the finals were calculated by the analysis of variance. Post hoc pairwise comparison analysis was performed using Tukey's test. The analysis plan included the assessment of the main effects and the effect of interactions in the groups of women and men. The strength of the effect was expressed by the partial eta-squared ratio.

RESULTS: Two main trends were observed in the results. The first was a greater variation in the results in the group of men than in women (12-5 differences). The second was the development and improvement of sports performance in symmetrical strokes (69% improvement in recorded times measured during the pandemic, e.g., in Poland, women on 50-m breaststroke and butterfly $\Delta = 0.52$, $p < 0.001$ and $\Delta = 0.32$, $p = 0.034$, men on 50-m and 100-m butterfly $\Delta = 0.34$, $p = 0.003$ and $\Delta = 1.21$, $p < 0.001$).

CONCLUSIONS: The main conclusion of our analysis is that the pandemic influenced the development of sports performance in symmetrical techniques, i.e., in breaststroke and butterfly.

Key Words:

Swimming, Symmetrical strokes, Breaststroke, Butterfly, Analysis, Pandemic.

Introduction

In December 2019, in the city of Wuhan (capital city of China's Hubei province), an outbreak was announced of the SARS-COV-2 virus, responsible for COVID-19 infection which caus-

es atypical pneumonia¹. A month later, disease outbreaks were observed in other Chinese cities, such as Beijing and Shanghai, which were global transport hubs². The virus was spreading worldwide with several millions of confirmed cases and deaths in many countries³. This led to the World Health Organisation declaring the COVID-19 pandemic on March 11th, 2020.

The main symptoms of the disease include fever, cough, shortness of breath and fatigue; however, instances of so-called asymptomatic cases have been recorded⁴. The virus affects all people, but there are certain factors that are associated with a higher risk of increased severity of the disease⁵. Preventive measures include thorough hand washing and frequent sanitisation, the use of face masks covering the mouth and nose and social distancing⁶. All of those entail the cancellation of sports and cultural events, and leads to difficulties in education⁷. Also, COVID 19-vaccines are effective and can lower your risk of getting and spreading the virus that causes COVID-19⁸.

The pandemic has left its mark on sports; from the relocation or cancellation of sports competitions⁹, training disruptions, closures of sports facilities, to sports club bankruptcies¹⁰. The largest sports events were cancelled since the participation of many athletes and the presence of crowds of fans could contribute to an increased risk of virus^{11,12}.

Many athletes lost out on training opportunities due to government restrictions. The competitors faced the phenomenon of detraining, i.e., physiological and morphological changes, which are caused by a lack of physical activity and training stimuli¹³. Consequently, athletes returning to systematic training and competition experience a higher likelihood of injury or trauma, have lower training endurance and have a longer training adaptation period¹⁴. Elite athletes have the most

at stake during a sports lockdown, for their highly-developed physical condition is likely to deteriorate fastest¹⁵. The most common consequences of even a short-term cessation of training are morphological changes, decrease in physical capacity, and the rate of strength development^{16,17}.

2020 was supposed to go down in world sports history on account of the Olympic Games that were scheduled to take place in Tokyo, Japan. Organising such a huge event was no small feat¹⁸. Unfortunately, due to the pandemic, the organisers were forced to take an unprecedented step in the history of the modern Olympic Games: they decided to postpone the event until 2021. For many athletes preparing for the quadrennial event, this meant a big change in the training process. Swimming, one of the most popular disciplines in the Olympic program, faced the same problem. As the second-largest sport in terms of the number of participants, swimming competitions are divided into 34 categories. Competitors are split by gender, distance, and stroke¹⁹. Throughout lockdowns, competitive swimmers struggled with even greater difficulties than other athletes due to swimming pool closures and suspended training. There was no way to replace training in the water in 100% with exercising at the gym or on a treadmill. Training on dry land can be beneficial for the athlete but it is not an adequate substitute for the work one needs to put in at the pool²⁰. To the best of our knowledge, no research results have been presented so far of the influence of the COVID-19 pandemic on competitive swimmers' performance in selected European countries' championships.

The study aims to examine whether the results achieved at the national swimming championships during COVID-19 pandemic in 2020 differ significantly from the results from 2019. Assuming that there are differences, we considered which mechanisms may be at the root of these changes and why the changes occurred in those exact instances. We also explored the differences divided categorically by gender, symmetrical and asymmetrical strokes. Knowing the answers to these questions, we can answer whether the COVID-19 pandemic has affected the sports performance of competitive swimmers in Europe.

Materials and Methods

Subjects

The results of men and women from the finals of the national short course (25 m) swimming

pool Nov/Dec championships in 50-m and 100-m events, were downloaded from internet sources (www.swimrankings.net, 04/10/2021). The data comes from Poland, Spain, Russia, Turkey and Denmark. The times of the finalists (places 1 - 8) were analysed, i.e., the most representative and reliable group. Out of 720 results, only 11 times were missing, which resulted from the disqualification or the competitor's failure to start. All the procedures used in the study were approved by the University Bioethics Committee for Scientific Research of the Jerzy Kukuczka Academy of Physical Education in Katowice (No. 8/2018) with the exception of the requirement for informed consent of participants due to the fact that the study included an analysis of publicly available data.

Statistical Analysis

The analyses were performed using Statistica 13.3 software (TIBCO Software Inc., Palo Alto, CA, USA). The normality of the distribution of the tested variables was assessed with the Shapiro-Wilk test. Homoscedasticity and sphericity of data were analysed by Levene's and Mauchly's tests, respectively. In response to the research questions posed, the analysis of variance was used to calculate the differences in the times achieved in the finals, before and during the pandemic. Post hoc pairwise comparison analysis was performed using Tukey's test. A mixed-design analysis of variance distinguished an intergroup variable - strokes, which had four categories: freestyle, backstroke, breaststroke, and butterfly, and an intra-group variable - the pandemic, expressed as a repeated measurement in 2019 and 2020. The 4x2 analysis plan included the assessment of the main effects and the effect of interactions in the groups of women and men of selected European countries: Poland, Spain, Russia, Turkey, and Denmark. The strength of the effect was expressed by the partial eta-squared ratio. The strength of the effect was interpreted as low 0.01, moderate 0.09, and strong 0.25. A p -value of ≤ 0.05 was indicated as statistically significant.

Results

The results of the analysis presented in Table I show that the recorded times for 50-m and 100-m events in females and males in all analysed countries exhibited a statistically significant ($p < 0.001$) strong ($\eta^2 > 0.25$) main effect of the swimming stroke. The main effect of the pan-

Table I. Summarized variance analysis of recorded times in 50-m and 100-m events in women and men, categorized by swimming strokes and pandemic variables in selected European countries.

Sex	Country	Effect	Distance 50 meters				Distance 100 meters			
			<i>F</i>	<i>df</i>	<i>p</i>	η_p^2	<i>F</i>	<i>df</i>	<i>P</i>	η_p^2
Female	Poland	Style	193.69	3.28	<0.001	0.95	136.52	3.28	<0.001	0.94
		Pandemic	13.41	1.28	0.001	0.32	1.82	1.28	0.189	0.06
		Style x Pandemic	16.32	3.28	<0.001	0.64	0.86	3.28	0.475	0.08
	Spain	Style	205.57	3.28	<0.001	0.96	147.41	3.26	<0.001	0.94
		Pandemic	0.26	1.28	0.614	0.01	0.21	1.26	0.649	0.01
		Style x Pandemic	8.19	3.28	<0.001	0.47	1.58	3.26	0.219	0.15
	Russia	Style	342.81	3.28	<0.001	0.97	260.90	3.28	<0.001	0.97
		Pandemic	11.50	1.28	0.002	0.29	4.46	1.28	0.044	0.14
		Style x Pandemic	4.51	3.28	0.011	0.33	4.80	3.28	0.008	0.34
	Turkey	Style	113.17	3.28	<0.001	0.92	72.60	3.27	<0.001	0.89
		Pandemic	0.62	1.28	0.439	0.02	3.51	1.27	0.072	0.11
		Style x Pandemic	0.68	3.28	0.574	0.07	1.37	3.27	0.272	0.13
	Denmark	Style	116.40	3.27	<0.001	0.93	136.45	3.28	<0.001	0.94
		Pandemic	0.94	1.27	0.341	0.03	0.06	1.28	0.813	0.00
		Style x Pandemic	2.00	3.27	0.137	0.18	3.84	3.28	0.020	0.29
Male	Poland	Style	264.14	3.28	<0.001	0.97	235.87	3.28	<0.001	0.96
		Pandemic	16.29	1.28	<0.001	0.37	113.90	1.28	<0.001	0.80
		Style x Pandemic	4.28	3.28	0.013	0.31	4.10	3.28	0.016	0.31
	Spain	Style	290.68	3.28	<0.001	0.97	410.44	3.28	<0.001	0.98
		Pandemic	2.50	1.28	0.125	0.08	9.07	1.28	0.005	0.24
		Style x Pandemic	5.66	3.28	0.004	0.38	0.50	3.28	0.683	0.05
	Russia	Style	318.62	3.27	<0.001	0.97	347.18	3.28	<0.001	0.97
		Pandemic	0.68	1.27	0.416	0.02	16.37	1.28	<0.001	0.37
		Style x Pandemic	16.97	3.27	<0.001	0.65	3.00	3.28	0.047	0.24
	Turkey	Style	47.03	3.28	<0.001	0.83	54.92	3.28	<0.001	0.85
		Pandemic	1.93	1.28	0.176	0.06	0.91	1.28	0.349	0.03
		Style x Pandemic	3.76	3.28	0.022	0.29	12.29	3.28	<0.001	0.57
	Denmark	Style	161.57	3.28	<0.001	0.95	179.07	3.28	<0.001	0.95
		Pandemic	5.30	1.28	0.029	0.16	3.46	1.28	0.073	0.11
		Style x Pandemic	4.63	3.28	0.009	0.33	35.38	3.28	<0.001	0.79

F – results of variation analysis, *df* – degree of freedom, *p* – significance, η_p^2 – strength of the effect partial eta-square

demic variable on the men's 50-m events proved to be strong in Poland ($F_{(1,28)} = 16.29$; $p < 0.001$, $\eta_p^2 = 0.37$) and moderate in Denmark ($F_{(1,28)} = 5.30$; $p = 0.029$, $\eta_p^2 = 0.16$), while in the group of women, the main effect of the pandemic variable proved to be strong in Russia ($F_{(1,28)} = 11.50$; $p = 0.002$, $\eta_p^2 = 0.29$). In the remaining analysed countries, the pandemic variable effect on the 50-m events for men and women was weak ($\eta_p^2 = 0.01 - 0.08$) and statistically insignificant. The main effect of the pandemic variable on the men's 100-m events proved to be strong in Poland ($F_{(1,28)} = 235.87$; $p < 0.001$, $\eta_p^2 = 0.80$), Spain ($F_{(1,28)} = 9.07$; $p = 0.005$, $\eta_p^2 = 0.24$), and Russia ($F_{(1,28)} = 16.37$; $p < 0.001$, $\eta_p^2 = 0.37$), while in the group of women, the main effect of the pandemic variable proved to be moderate in Russia ($F_{(1,28)} = 4.46$; $p = 0.044$, $\eta_p^2 = 0.14$). In the remaining analysed countries, the pandemic variable on the 100-m events for men and women was weak or moderate ($\eta_p^2 = 0.00 - 0.11$) and statistically insignificant.

A strong interaction effect of the swimming strokes and the pandemic variable was noticed in the final results of all the men's 50-m and 100-m events except Spain, where the variance analysis proved to be statistically insignificant. A similarly strong interaction effect of the swimming strokes and the pandemic was noticed in the final results of women's 50-m events in Poland ($F_{(3,28)} = 16.32$; $p < 0.001$, $\eta_p^2 = 0.64$), Spain ($F_{(3,28)} = 8.19$; $p < 0.001$, $\eta_p^2 = 0.47$) and Russia ($F_{(3,28)} = 4.51$; $p = 0.011$, $\eta_p^2 = 0.33$) and 100-m events in Russia ($F_{(3,28)} = 4.80$; $p = 0.008$, $\eta_p^2 = 0.34$) and Denmark ($F_{(3,28)} = 3.84$; $p = 0.020$, $\eta_p^2 = 0.29$).

The results presented in Table II revealed that freestyle race times, before and during the pandemic, in women's 50-m events do not differ significantly in any of the analysed countries. Statistically significant surveys occurred in the women's 50-m event backstroke and breaststroke race time in Poland ($\Delta = -0.34$, $p = 0.015$; $\Delta = 0.52$, $p < 0.001$ – respectively) and the butterfly race time in

Table II. Summarised post hoc pairwise Tukey test analysis of the results in women’s and men’s 50-m events in various strokes between 2019 and 2020, in selected European countries.

Sex	Country	Style	N	2019		2020		Pairwise comparison			
				M	SD	M	SD	Difference	95% CI		p
									LL	UP	
Female	Poland	Freestyle	8	25.17	0.36	24.99	0.35	0.18	0.05	0.31	0.507
		Backstroke	8	27.65	0.76	27.99	0.51	-0.34	-0.65	-0.04	0.015
		Breaststroke	8	31.74	0.54	31.22	0.76	0.52	0.31	0.73	<0.001
		Butterfly	8	26.89	0.52	26.57	0.58	0.32	0.14	0.49	0.034
	Spain	Freestyle	8	25.62	0.65	25.45	0.57	0.17	-0.01	0.33	0.190
		Backstroke	8	28.22	0.45	28.04	0.59	0.18	0.00	0.36	0.125
		Breaststroke	8	31.66	0.59	31.80	0.53	-0.14	-0.26	-0.01	0.427
		Butterfly	8	27.15	0.40	27.29	0.33	-0.14	-0.24	-0.05	0.318
	Russia	Freestyle	8	24.52	0.44	24.56	0.21	-0.04	-0.24	0.16	0.998
		Backstroke	8	27.45	0.42	27.28	0.53	0.17	0.04	0.29	0.133
		Breaststroke	8	30.67	0.38	30.64	0.35	0.03	-0.08	0.14	0.999
		Butterfly	8	26.29	0.47	26.05	0.36	0.24	0.13	0.36	0.008
	Turkey	Freestyle	8	26.12	0.84	26.15	0.69	-0.03	-0.32	0.25	1.000
		Backstroke	8	28.77	0.88	28.82	0.95	-0.05	-0.28	0.18	1.000
		Breaststroke	8	33.32	1.17	33.18	0.80	0.14	-0.29	0.58	0.964
		Butterfly	8	27.84	0.74	27.68	0.36	0.16	-0.17	0.49	0.935
	Denmark	Freestyle	8	25.15	0.37	25.31	0.66	-0.16	-0.41	0.10	0.971
		Backstroke	8	27.92	0.93	28.14	1.22	-0.22	-0.88	0.44	0.879
		Breaststroke	7	31.54	0.63	31.72	0.53	-0.18	-0.50	0.13	0.928
		Butterfly	8	26.68	0.73	26.43	0.78	0.25	0.03	0.47	0.727
Male	Poland	Freestyle	8	21.73	0.36	21.76	0.43	-0.03	-0.19	0.13	1.000
		Backstroke	8	24.08	0.41	23.88	0.38	0.20	0.08	0.33	0.173
		Breaststroke	8	27.34	0.50	27.24	0.26	0.10	-0.13	0.34	0.877
		Butterfly	8	23.52	0.41	23.18	0.54	0.34	0.16	0.52	0.003
	Spain	Freestyle	8	22.26	0.20	22.14	0.31	0.12	0.01	0.24	0.610
		Backstroke	8	24.73	0.35	24.83	0.47	-0.10	-0.26	0.07	0.816
		Breaststroke	8	27.65	0.60	27.71	0.38	-0.06	-0.25	0.14	0.989
		Butterfly	8	24.03	0.29	23.78	0.39	0.25	0.10	0.39	0.021
	Russia	Freestyle	8	21.50	0.21	21.65	0.25	-0.15	-0.24	-0.07	0.120
		Backstroke	8	23.75	0.40	23.57	0.43	0.18	0.00	0.36	0.072
		Breaststroke	7	26.88	0.45	26.72	0.29	0.16	0.00	0.31	0.109
		Butterfly	8	22.69	0.41	22.96	0.38	-0.27	-0.36	-0.18	0.001
	Turkey	Freestyle	8	22.48	0.61	22.60	0.50	-0.12	-0.29	0.05	1.000
		Backstroke	8	24.81	0.78	24.90	0.57	-0.09	-0.36	0.18	1.000
		Breaststroke	8	28.49	1.34	28.12	1.24	0.37	0.25	0.51	0.900
		Butterfly	8	24.00	0.62	24.99	1.99	-0.99	-2.35	0.36	0.040
	Denmark	Freestyle	8	22.43	0.27	22.44	0.46	-0.01	-0.30	0.27	1.000
		Backstroke	8	25.45	0.47	25.31	0.36	0.14	0.01	0.27	0.871
		Breaststroke	8	28.20	0.78	28.28	0.95	-0.08	-0.37	0.22	0.996
		Butterfly	8	24.15	0.57	23.73	0.34	0.42	0.19	0.65	0.007

N – number of pairs of observations, M – mean, SD – standard deviation, CI – confidential interval, LL – lower limit, UP – upper limit.

Poland and Russia ($\Delta = 0.32, p = 0.034$; $\Delta = 0.24, p = 0.008$ – respectively). In men’s 50-m events the results showed no significant differences in the results of freestyle, backstroke and breaststroke in any of the analysed countries’ events between 2019 and 2020. The results of the men’s 50-m butterfly total race times were the only ones that differed significantly. Poland, Spain and Denmark ($\Delta = 0.34, p = 0.003$; $\Delta = 0.25, p = 0.021$; $\Delta = 0.42, p = 0.007$ – respectively) achieved shorter 50-m butterfly race times for men in 2020 than in 2019. During the pandemic, men in Russia and

Turkey ($\Delta = -0.27, p = 0.001$; $\Delta = -0.99, p = 0.040$ – respectively) achieved significantly worse results in the 50-m butterfly finals than before the pandemic.

The results of the detailed comparisons in Table III show that final times differ only in the women’s 100-m backstroke in Russia ($\Delta = -0.61, p = 0.037$), with a worse result during the pandemic than before it. In addition to this comparison, women’s 100-m events do not differ significantly in the times from the 2019 and 2020 finals. In the men’s category, the differences in

Table III. Summarised post hoc pairwise Tukey test analysis of the results in women's and men's 100-m events in various strokes between 2019 and 2020 in selected European countries.

Sex	Country	Style	N	2019		2020		Pairwise comparison			
				M	SD	M	SD	Difference	95% CI		P
								LL	UP		
Female	Poland	Freestyle	8	55.05	0.68	54.63	0.94	0.42	0.12	0.72	0.472
		Backstroke	8	60.25	1.39	60.24	1.50	0.01	-0.42	0.45	1.000
		Breaststroke	8	68.17	1.59	68.13	2.24	0.04	-0.75	0.82	1.000
		Butterfly	8	59.31	1.09	59.22	0.91	0.09	-0.16	0.33	1.000
	Spain	Freestyle	7	55.07	1.34	55.29	1.18	-0.22	-0.62	0.18	0.839
		Backstroke	8	60.44	1.08	60.39	1.09	0.05	-0.11	0.21	1.000
		Breaststroke	7	68.26	1.69	68.06	1.52	0.20	-0.42	0.81	0.910
	Russia	Butterfly	8	60.18	0.73	60.34	0.61	-0.16	-0.33	0.00	0.946
		Freestyle	8	53.73	0.72	53.86	0.46	-0.13	-0.38	0.12	0.995
		Backstroke	8	58.39	0.99	59.00	0.83	-0.61	-0.84	-0.37	0.037
		Breaststroke	8	65.75	0.76	66.08	1.20	-0.33	-0.88	0.21	0.577
	Turkey	Butterfly	8	58.70	0.72	58.39	1.30	0.31	-0.22	0.86	0.630
		Freestyle	8	56.86	2.09	57.01	2.09	-0.15	-0.86	0.55	1.000
		Backstroke	8	62.21	2.29	62.02	1.72	0.19	-0.39	0.77	0.999
		Breaststroke	7	72.71	3.12	71.85	2.00	0.86	-0.55	2.25	0.343
	Denmark	Butterfly	8	61.95	1.83	61.50	1.52	0.45	-0.21	1.11	0.898
		Freestyle	8	55.61	1.00	54.95	1.35	0.66	0.08	1.24	0.210
		Backstroke	8	60.86	1.59	61.03	0.66	-0.17	-1.07	0.73	0.997
	Poland	Breaststroke	8	68.52	1.73	68.59	1.47	-0.07	-0.45	0.32	1.000
		Butterfly	8	59.50	1.34	60.05	1.62	-0.55	-1.00	-0.10	0.432
Freestyle		8	48.21	0.89	47.32	0.44	0.89	0.49	1.29	<0.001	
Backstroke		8	52.59	0.71	51.59	1.23	1.00	0.48	1.52	<0.001	
Spain	Breaststroke	8	59.84	0.75	59.43	0.84	0.41	0.10	0.74	0.219	
	Butterfly	8	52.29	1.28	51.08	1.09	1.21	0.94	1.47	<0.001	
	Freestyle	8	48.70	0.56	48.38	0.53	0.32	0.20	0.43	0.400	
	Backstroke	8	54.00	0.80	53.77	0.59	0.23	-0.03	0.49	0.761	
Russia	Breaststroke	8	60.31	0.95	60.06	0.50	0.25	-0.25	0.77	0.643	
	Butterfly	8	53.13	0.66	53.05	0.88	0.08	-0.29	0.43	1.000	
	Freestyle	8	47.34	0.68	46.99	0.50	0.35	0.12	0.56	0.645	
	Backstroke	8	51.30	0.61	51.03	1.48	0.27	-0.58	1.13	0.841	
Turkey	Breaststroke	8	58.61	0.52	57.74	0.73	0.87	0.67	1.06	0.003	
	Butterfly	8	50.65	0.42	50.57	0.52	0.08	-0.07	0.24	1.000	
	Freestyle	8	49.79	1.71	49.47	1.48	0.32	-0.21	0.84	0.917	
	Backstroke	8	53.47	1.16	53.52	1.32	-0.05	-0.37	0.27	1.000	
Denmark	Breaststroke	8	61.90	3.27	60.71	2.61	1.19	0.38	2.00	0.002	
	Butterfly	8	53.47	1.16	54.44	1.31	-0.97	-1.62	-0.32	0.014	
	Freestyle	8	49.06	0.69	48.98	0.83	0.08	-0.29	0.44	0.998	
	Backstroke	8	54.95	0.57	54.56	0.52	0.39	0.25	0.53	0.056	
Denmark	Breaststroke	8	61.00	1.61	62.17	1.53	-1.17	-1.39	-0.95	<0.001	
	Butterfly	8	53.82	1.24	53.56	1.26	0.26	-0.10	0.60	0.433	

N – number of pairs of observations, M – mean, SD – standard deviation, CI – confidential interval, LL – lower limit, UP – upper limit.

recorded times of freestyle and backstroke are visible only in Poland ($\Delta = 0.89$, $p < 0.001$; $\Delta = 1.00$, $p < 0.001$ – respectively), where better results were achieved in the 100-meter final during the pandemic than before it. The results of the breaststroke finals in men's 100-m events are significantly different in Russia and Turkey ($\Delta = 0.87$, $p = 0.003$; $\Delta = 1.19$, $p = 0.002$ – respectively), where better results were achieved during the pandemic, and in Denmark ($\Delta = -1.17$, $p < 0.001$), where the results of the finals are worse in 2020 than in 2019. The recorded times for

men's 100-m butterfly finals differ in Poland and Turkey between the results before and during the pandemic. Men in Poland ($\Delta = 1.21$, $p < 0.001$) achieved better results, while in Turkey ($\Delta = -0.97$, $p = 0.014$) recorded times for the butterfly finals are much worse in 2020 than in 2019.

Discussion

The results of our analysis conclude that the COVID-19 pandemic has taken its toll on

swimming performance. The first conclusion of the analysis is that the results vary in relation to gender. Significantly less result variation was observed in women than in men. Scientists warn that the COVID-19 pandemic could have a negative impact on mental health^{21,22}. Athletes are already under heavy mental strain on a daily basis²³ and, in the present reality, the pressure is increasing, which might cause a runaway effect on mental health for athletes. Scientific research confirms that women are more prone to mental health problems, such as fear of failure^{24,25}. When combined with the difficulties imposed by the pandemic, women can be affected noticeably more than men. However, when compared with the results of the analysis, female competitive swimmers are not necessarily coping with the pandemic less well than their male counterparts. Interestingly its impact on their results is small. Limitations in training or participation in competitions for women did not contribute to significant changes in results. Men, on the other hand, note a greater differentiation in their performance level, exhibiting a tendency to improve results despite the difficulties and changes in training. This may contradict many forecasts regarding the consequences of the pandemic and its limitations²⁶.

The most important conclusion is that our article demonstrates a clear tendency towards result improvement in symmetrical techniques, i.e., breaststroke and butterfly. The number of significant differences between the 2019 and 2020 total race times for asymmetrical strokes was 1 in 50-m events and 3 in 100-m events. Whereas, in symmetrical strokes, the number of significant differences was 8 in the 50-m events and 5 in the 100-m events. If we only compare the men's results, these dependencies become even more pronounced. In the 50-m category, the ratio of significant differences in the results of asymmetrical vs. symmetrical strokes is 0/5, and in the 100-m category, the ratio is 2/5. Symmetrical stroke results for both men and women in sprint events were 69% better during the pandemic. For the butterfly stroke alone, a 67% change in the results, in 50-m and 100-m categories, meant an improved overall time. Such dependencies are not visible in asymmetrical strokes, where, in the 50-m freestyle category there are no recorded final time differences between 2019 and 2020. The only deviation from this is the Polish men's results in the 100-m category. Butterfly and breaststroke are exceptionally strenuous, both physically and technically^{27,28}, due to being less economical, less

streamlined strokes, resulting in large changes in speed during the stroke cycle²⁹. Difficulties resulting from swimming pool closures and the subsequent inability to train in water forced competitive swimmers to substitute it with gym training. This could be organized and done without the necessity of leaving the house. Competitors performing this type of training focused more on improving strength and power, rather than endurance, due to the nature of the exercises. Strength training, admittedly, improves swimming efficiency^{30,31}, but it can only be utilized in addition to a swimming pool workout. Of all swimming techniques, symmetrical techniques are the ones characterized by greater importance of strength and power during swimming^{32,33}. This may explain why better results were achieved in these categories. The results presented in the study demonstrate conclusively that, mainly in men, there was greater progress in the butterfly and breaststroke styles, than in the freestyle and backstroke. This analysis concludes that the pandemic influenced the development and improvement of symmetrical techniques.

Our analysis examined sprints i.e., 50-m and 100-m events. The results, perhaps not unequivocally but generally, indicate a tendency towards improved performance. In addition to the better-performing, symmetrical technique-using athletes, it was observed that sprinters, in general, exhibited an upward tendency in their performance. Thus, greater work at the gym, despite coming at the expense of swimming pool training, benefited the short distance swimmers as well. When working out at the gym, competitive swimmers hope to form training-induced neural adaptations based on performance, strength, and speed, while limiting muscle hypertrophy and weight gain³⁴. This is confirmed by the fact that strength for sprint events is one of the main and most important factors of success³⁵, and its improvement results in higher swimming speeds, especially at sprint events³⁶. The training of players specializing in longer distances differs in nature and purpose from sprint training. The goal of long-distance swimmers is to improve the maximum oxygen uptake (VO_{2max}), which increases the baseline cardiac output volume but also to raise the number and size of mitochondria and much more^{37,38}. The lack of access to swimming pools and training in water, which is based on oxygen metabolism in natural conditions of competition, could significantly affect the results of medium distances compared to sprint distanc-

es. This presents us with an exciting opportunity for further research on similar issues and connections between the COVID-19 pandemic and the results of professional swimmers.

Competitive swimming performance was steadily increasing before the pandemic^{39,40}. Knowing the effects of the pandemic and the aftermath of it is crucial for athletes, training staff and entire sports organizations. Analyses like these give the opportunity to understand the emerging trends in a given sport. It is worth continuing this type of work and expanding knowledge on this topic. In order for the results to be as reliable as possible, similar analyses should be performed in the future. They could be broadened by comparing them with subsequent observations from the following years or improved further, by juxtaposing current findings with medium or long-distance swimming events.

Conclusions

To sum up, the results in the men group were more influenced by COVID-19 pandemic in comparison with women group. There was a greater differentiation of results than in the group of women, where the differences were much smaller. When comparing the results of symmetrical and asymmetrical techniques, greater variation was clearly visible in the former group. More changes were observed in the symmetrical swimming techniques, with a tendency towards improved athletic performance. The main conclusion of our analysis is that the pandemic influenced the development of sports performance in symmetrical techniques, i.e., in breaststroke and butterfly.

Conflict of Interests

The authors declare that they have no conflict of interest.

Ethical Committee

All the procedures used in the study were approved by the University Bioethics Committee for Scientific Research of the Jerzy Kukuczka Academy of Physical Education in Katowice (No. 8/2018).

Informed Consent

Informed consent of participants was not required due to the fact that the study included an analysis of publicly available data.

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