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Has Covid-19 pandemic influenced the performance of top-class triathletes in the Sprint and Olympic distance of the ITU World Triathlon Championship Series?

¿Ha influido la pandemia COVID-19 en el rendimiento de los triatletas de élite en la distancia Sprint y Olímpica de las ITU Series Mundiales de Triatlón?

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Abstract. The ITU World Triathlon Championship Series (WTS) is the top championship for triathlon in Sprint (SPD) and Olympic distance (OD). The influence of COVID-pandemic on triathlon is not yet clear. The aim of the present study is to provide a comprehensive analysis of the effect of COVID-19 pandemic on performance in the WTS focusing on male and female categories and the SPD and OD. The Student's t-test for independent samples comparing sex and distances was used for normal variables, whereas the Mann-Whitney U-test was used for non-normal variables. The analysis of the OD revealed significant changes in all the studied variables for either sex. In this distance, men improved more in cycling performance and final performance than women (p values <0.001). The SPD displayed significant changes in performance in most of the analyzed variables. In this distance, men showed greater change values in swimming and cycling performance (p values <0.001) whereas women showed them in running performance (p value <0.001). The analysis of relative changes across the different distances revealed important significant differences in almost all variables. The variable with a larger effect size was the final performance (3.728; 12.605; 3.006). In overall, SPD shows better values of changes than OD in swimming **performance**, running performance and first transition phase (p values <0.001; 0.001; <0.001) but it is on the **other** way around for the cycling and **final** performance (p values <0.001). These results suggest that triathletes participating in WTS in both sexes were able to not only maintain but also improve their final performance level despite COVID-19 pandemic.
Keywords: SARS-CoV-2, World Championship, swimming, cycling, running, transition.

Resumen. Las ITU Series Mundiales de Triatlón (WTS) es el principal campeonato de triatlón en distancia Sprint (SPD) y Olímpica (OD). La influencia de la pandemia de COVID-19 en el triatlón aún no está clara. El objetivo del presente estudio es proporcionar un análisis integral del efecto de la pandemia de COVID-19 en el rendimiento en las WTS, centrándose en las categorías masculina y femenina y en las distancias SPD y OD. Se utilizó la prueba t de Student para muestras independientes comparando sexo y distancias para las variables normales, mientras que la prueba U de Mann-Whitney se utilizó para las variables no normales. El análisis de la OD reveló cambios significativos en todas las variables estudiadas para ambos sexos. En esta distancia, los hombres mejoraron más en el rendimiento en ciclismo y en el rendimiento final que las mujeres (valores de p <0.001). La SPD mostró cambios significativos en el rendimiento en la mayoría de las variables analizadas. En esta distancia, los hombres mostraron mayores valores de cambio en el rendimiento en natación y ciclismo (valores de p <0.001), mientras que las mujeres los mostraron en el rendimiento en carrera (valor de p <0.001). El análisis de los cambios relativos en las diferentes distancias reveló diferencias significativas importantes en casi todas las variables. La variable con un tamaño de efecto mayor fue el rendimiento final (3.728; 12.605; 3.006). En general, la SPD muestra mejores valores de cambios que la OD en el rendimiento en natación, carrera y primera fase de transición (valores de p <0.001; <0.001; 0.001), pero es al revés para el rendimiento en ciclismo y **rendimiento final** (valores de p <0.001). Estos resultados sugieren que los triatletas de ambos sexos que participaron en la WTS no solo pudieron mantener, sino también mejorar su nivel de rendimiento final a pesar de la pandemia de COVID-19.
Palabras clave: SARS-CoV-2, Campeonato Mundial, natación, ciclismo, carrera, transición.

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Introduction

The International Triathlon Union (ITU) is the organizing body for world competitions in a variety of combined sports. Among these sports are duathlon, aquathlon and the most popular of them all, triathlon. Triathlon combines the sports disciplines of swimming, cycling and running in one single event (Strock, Cottrell, and Lohman, 2006). Furthermore, it is formed by two transition phases in which the athletes change from swimming to cycling and from cycling to running. Triathlon is divided into several disciplines (swimming, cycling and triathlon). These include various distances (Sprint, Olympic, Long distance, Ironman), various sport types (Cross or Winter triathlon), categories (male, female, mixed relay) and age groups. The Olympic distance triathlon (OD) involves a 1,500-meter swim, a 40,000-meter bike ride, and a 10,000-meter run. In contrast, the Sprint distance triathlon (SPD) consists of half the distance of the OD race, meaning a 750-meter swim, a 20,000-meter bike ride, and a 5,000-meter run. One of the most popular triathlon events is the OD World Championship Triathlon, which was previously held as a single event from 1989 to 2009. However, since 2009, the World Triathlon Series (WTS) competition has been introduced, which is based on OD races culminating in a Grand Final event. This competition awards points based on the importance and distance of each race. While the WTS competition primarily focuses on OD races, SPD races may also be held, and the number of such races may vary each year.

World Championships are attractive to the scientific community, and have been investigated in a wide range of sports (De La Rubia et al., 2020; Finlay, 2022; Hébert-Losier, Platt, & Hopkins, 2015), sometimes related somehow to triathlon (Haupt et al., 2013; Knechtle et al., 2020) but also very similar sports as duathlon (P. T. Nikolaidis, Villiger, & Knechtle, 2018; P. Nikolaidis, Villiger, Vancini, Rosemann, & Knechtle, 2018; Christoph Alexander Rüst, Knechtle, et al., 2013).

The study of triathlons has encompassed various perspectives such as anatomy (Landers, Blanksby, Ackland, & Smith, 2000), and biomechanics (Cuba-Dorado et al., 2022). From an analytical point of view, and with an emphasis on the OD, the literature also presents different papers that provide a variety of relevant information, mainly on performance but also other relevant factors (Bernard, Sultana, Lepers, Hausswirth, & Brisswalter, 2010; R. Lepers, Sultana, Bernard, Hausswirth, & Brisswalter, 2010; Quagliarotti, Gaiola, Bianchini, Vleck, & Piacentini, 2022; Christoph Alexander Rüst, Lepers, Stiefel, Rosemann, & Knechtle, 2013). In addition, triathlon performance has been the subject of extensive analysis in other Championships (Etter et al., 2013), as well as in other distances, including Long Distance (Knechtle, Rüst, Rosemann, & Lepers, 2012), Ironman (Gallmann, Knechtle, Rüst, Rosemann, & Lepers, 2014; Jeffery et al., 2012; Meili, Knechtle, Rüst, Rosemann, & Lepers, 2013; Christoph A. Rüst, Rosemann, Lepers, & Knechtle, 2014) or the Triple or Deca Iron, not belonging to ITU the last two (Knechtle, Rosemann, Lepers, & Rüst, 2014; Lenherr, Knechtle, Rüst, Rosemann, & Lepers, 2012; Romuald Lepers, Knechtle, Knechtle, & Rosemann, 2011; Christoph A. Rüst, Knechtle, Knechtle, Rosemann, & Lepers, 2012; Sigg et al., 2013).

One of the main topics that has shaken the scientific community in particular, and the world in general, is the global outbreak of COVID-19 pandemic. In the sports and scientific world, the pandemic has been widely analyzed from several perspectives, such as psychological or behavioral (Karrer et al., 2022; Katanic, Bjelica, Corluka, Preljevic, & Osmani, 2022) or the clinical (Faghy et al., 2020). In addition, it has also been studied in all kinds of sports such as swimming (Fülöp et al., 2022), soccer (Gattoni et al., 2022), tennis (Ishihara, Robin, Naito, Murata, & Crespo, 2022) or taekwondo (Monterrosa Quintero et al., 2023). Studies have also been conducted in the university environment, revealing a decrease in healthy habits such as running or cycling among young individuals (Intelangelo et al., 2022). Considering younger age groups, Villodres, Salvador-Pérez, and Muros (2023) observed that children exhibited lower levels of physical activity after the lockdown.

The academic world of triathlon and its disciplines has not been greatly impacted by the COVID-19 pandemic. There have been several studies conducted on triathletes, (da Costa et al., 2022; Robinson et al., 2021; Shaw et al., 2021), but few of them specifically focus on the impact of the pandemic on triathlon performance (Poczta, Almeida, Paczyńska-Jędrycka, & Kruszyńska, 2022). One of the most significant consequences of the pandemic has been the cancellation of numerous masses racing events, disrupting the training routines and schedules of many runners. Robinson et al. (2021) previously highlighted the substantial impact that the COVID-19 pandemic has had on the running community. Segui-Urbaneja et al. (2021) explored the decrease in participation in running and cycling events, providing a bigger perspective on this trend in specific countries such as Portugal and Spain.

Despite the alarmist feelings of athletes and sportspeople during the lockdown, it has become evident that not all was bad news. Even though there are indeed studies that demonstrate the harm the pandemic caused to endurance athletes (Muriel, Courel-Ibáñez, Cerezuela-Espejo, & Pallarés, 2021), other studies provide overwhelmingly positive evidence regarding the influence of lockdown. For instance, it has been demonstrated that lockdown was beneficial in maintaining the physical fitness of gymnasts in the United Kingdom and was perceived as time for rest and recovery (Patel, McGregor, Cumming, Williams, & Williams, 2022). Furthermore, despite negative results brought up in certain aspects, studies encompassing multiple variables may contain somewhere the effect of lockdown was beneficial or nonexistent. For example, when performance in soccer games was analyzed, it was seen that the Sprint distance covered did not change compared to pre-lockdown (Radzimiński et al., 2022). Additionally, in the population of para-cyclists and para-triathletes, there is evidence indicating that the impact of the lockdown on their physical fitness was negligible (Shaw et al., 2021). The results of this research conducted in this field has shown that these athletes were able to maintain their level of physical condition despite the restrictions imposed during the lockdown period. Research conducted on sports participation among university students suggests that despite a decline in this practice, physical fitness levels were able to be maintained (Alarcón Meza & Hall-López, 2021).

In a different field, with a behavioral approach, Jaenes Sánchez et al. (2021) conducted research to investigate the impact of confinement on emotional wellbeing and athletic performance. Even though this study has a more psychological approach, their findings indicated that there was a difference in the emotional influence of confinement between male and female athletes. This study also provides evidence that men and women may experience different levels of performance after confinement, which may be attributed to the emotional impact of confinement on the individuals. Other authors from the mental health field asserted that the pandemic led to elevated levels of anxiety, stress, and symptoms of depression (Ahsan & Abualait, 2024).

This is further reinforced by the fact that professional male

and female triathletes have different levels of performance in all triathlon distances, with the difference being slightly less pronounced in the OD (Romuald Lepers, 2019; Romuald Lepers & Stapley, 2010). These disparities in performance levels have also been observed to change over time, highlighting the need for continued research and examination in this area.

Despite the extensive literature search conducted, no wide range of articles analyzing triathlon performance in the past 5 years have been found. Furthermore, to date, no article has been found analyzing the effect of the COVID-19 pandemic on triathlon performance in any of its variations. Although many events have been cancelled or postponed, the impact of the pandemic on sports performance is still not well understood. In the case of triathlon, the limited number of studies available makes it difficult to determine the exact impact of the pandemic on performance.

This study tries to fill this gap in the literature by analyzing the effect of COVID-19 pandemic on performance in the WTS.

The aim of the present study is to provide a comprehensive analysis of the effect of COVID-19 pandemic on performance in the World Triathlon Series. The focus of the study will be on the male and female categories, and the Sprint and Olympic distances.

It is hypothesized that the performance of the best triathletes in the world will have been significantly impacted by the COVID-19 pandemic.

Table 1.
Description of the races and participants.

Year	Race	Olympic Distance		Sprint Distance	
		Male	Female	Male	Female
2018	Bermuda	51	32		
	Yokohama	55	53		
	Leeds	54	48		
	Montreal	48	34		
	Gold Coast	65	57		
	Abu Dhabi			55	48
	Hamburg			56	56
	Edmonton			55	55
2019	Bermuda	53	44		
	Yokohama	49	44		
	Leeds	55	35		
	Lausanne	65	61		
	Abu Dhabi			55	55
	Montreal			55	33
	Hamburg			56	53
	Edmonton			54	41
2021	Yokohama	40	38		
	Leeds	55	45		
	Edmonton	60	56		
	Hamburg			56	49
	Abu Dhabi			52	46
2022	Yokohama	53	47		
	Cagliari	56	53		
	Bermuda	50	42		
	Abu Dhabi	65	65		
	Montreal			57	56
	Hamburg			55	55
All by sex		874	754	606	547
All by distance		1,628		1,153	
All		2,781			

Methods

Study design

Quantitative, retrospective, and non-experimental approach descriptive study.

Data sampling

The dataset for this study was obtained from the ITU World Triathlon Championship Series (WTS) website (http://wts.triathlon.org/). Individual discipline times and overall times from 2018 and 2022 were collected for analysis, excluding 2020 due to the COVID-19 outbreak. The total number included athletes in this study was 2,781 (1,480 males and 1,301 females). In the OD, there were 1,628 subjects (874 males and 754 females), while in the SPD, there were 1,153 subjects (606 males and 547 females) (Table 1). The mean age of subjects overall was 26.69 for males and 27.23 for females. In the OD, the mean age was 27.00 for males and 27.59 for females, while in the SPD, it was 26.28 for males and 26.90 for females.

Due to dropouts, disqualifications, and non-starting athletes, the sample size was reduced to 2,330 (1,229 men and 1,101 women). 26 was the minimum number of athletes who finished a worldwide test independently of the distance (OD and SPD) and sex (male and female). Specifically in the OD race in 2018 held in Bermuda for the women's category. To include the 26 best classified athletes is a sufficient sample number to represent that represents the highest-level triathletes; therefore, it was not considered appropriate to differentiate between this number for both distances. Likewise, it was decided not to pick a different number for the male competition in order to produce a more homogeneous analysis when analyzing men and women.

The analyzed variables were as follows:

- Swimming time (ST): mean time of the swimming time for each position (top 26).
- First transition phase (T1): mean time of the first transition phase time for each position (top 26).
- Cycling time (BT): mean time of the cycling time for each position (top 26).
- Second transition phase (T2): mean time of the second transition phase time for each position (top 26).
- Running time (RT): mean time of the running time for each position (top 26).
- Final time (FT): mean time of the final time for each position (top 26).

Next, the relative differences between pre-covid and post-covid years (expressed as change percentages %) were calculated for each of the previous variables, resulting in the following variables:

- Relative difference of swimming time (RST).
- Relative difference of first transition phase (RT1).

- Relative difference of cycling (bike) time (RBT).
- Relative difference of second transition phase (RT2).
- Relative difference of running time (RRT).
- Relative difference of final time (RFT).

Statistical analysis

Results are presented as mean ± standard deviation (SD) in the tables. A Shapiro-Wilk test was used to evaluate the normal distribution and Levene's test was used to evaluate homogeneity of variances.

The Student's t-test for independent samples comparing sex and distances was used for normal variables, whereas the Mann-Whitney U-test was used for non-normal variables. The statistical analysis was performed using IBM SPSS Statistics Version 19. Significance was determined at $P < 0.05$ (two-tailed for t-tests).

The magnitude of differences was assessed using Cohen's d ES. The effects were evaluated according to the following thresholds: <0.2, trivial; 0.2– 0.6, small; 0.6–1.2, moderate; 1.2–2.0, large; >2.0, very large (Hopkins, Marshall, Batterham, & Hanin, 2009).

Results

The total number of triathletes per continent is shown in Figure 1. In the SPD, European men were the 59.57% of the total amount of participants, while European women were the 55.76%. In the OD, these percentages were 59.84% for men and 50.66% for women. Africa is the continent with the least participants.

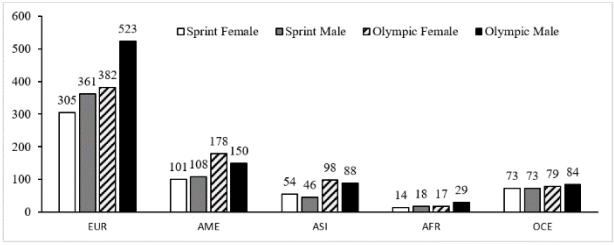

Figure 1. Total number of triathletes per continent included in the present study (N = 2,781).

The analysis of the OD revealed significant changes in all the studied variables for both sexes (Table 2). For men, all the variables increased or decreased with a *p* value lower than 0.001. When examining the relative changes between sexes for the OD, four out of six studied variables showed significant differences, being the cycling and the final performance the most significant (*p* values <0.001) (Figure 2). Additionally, the two other variables (swimming and first transition performance), showed a smaller difference (*p* values <0.05) (Figure 2). The SPD displayed some significant changes in performance in most of the analyzed variables (Table 3). The final performance was reduced significantly for men, women and when both were analyzed (Table 3). When examining the relative changes between sexes for the SPD, five out of six studied variables showed significant differences, being the swimming, cycling and the running performance the most significant (*p* values <0.001) (Figure 2). Nevertheless, the final performance showed a smaller difference (*p* values <0.05) (Figure 3). The analysis of relative changes across the different distances revealed important significant differences in all variables except for the second transition time for male, women and when both were analyzed. The variable with a larger effect size was the final performance in the three cases (3.728; 12.605; 3.006).

Table 2.
Pre and post COVID-19 influence in performance (Mean ± DS). Olympic Distance.

Variable	Pre	Post	Difference (C.I. 95%)	Change (%)	*p**	ES§
			Overall			
ST	1,125.6 ± 47.1	1,129.9 ± 60.8	4.3 (-16.9; 25.5)	0.43	0.037	-0.079
T1	53 ± 3.23	56.1 ± 4.13	3.1 (1.65; 4.54)	5.93	<0.001	-0.835
BT	3,630.7 ± 187.7	3,411.3 ± 244	-219.4 (-304.1; -134.6)	-6	<0.001	1.008
T2	25.8 ± 1.86	23.6 ± 1.74	-2.15 (-2.85; -1.45)	-8.21	<0.001	1.194
RT	2,052.1 ± 158.6	2,028.3 ± 266.8	-23.83 (-109.5; 61.8)	-1.17	0.020	0.109
FT	6,911.3 ± 367.3	6,689 ± 373.8	-222.3 (-366.4; -78.2)	-3.21	<0.001	0.600
			Male			
ST	1,086.5 ± 26	1,096.8 ± 50.2	10.4 (-12.1; 32.8)	1.03	<0.001	-0.259
T1	50.7 ± 1.77	52.5 ± 1.79	1.82 (0.82; 2.81)	3.72	<0.001	-1.018
BT	3,464.9 ± 73.6	3,224.8 ± 142.3	-240.2 (-303.8; 176.5)	-6.88	<0.001	2.120
T2	24.3 ± 1.01	22.5 ± 1.32	-1.83 (-2.49; -1.18)	-7.4	<0.001	1.558
RT	1,907.3 ± 65.4	1,841.5 ± 77.1	-65.8 (-105.6; 25.9)	-3.36	<0.001	0.920
FT	6,560.1 ± 57.3	6,326.8 ± 48.9	-233.3 (-263; -203.6)	-3.56	<0.001	4.379
			Female			
ST	1,164.7 ± 25.8	1,163 ± 52.4	-1.77 (-24; 21.5)	-0.08	0.033	0.043
T1	55.3 ± 2.7	59.6 ± 2.36	4.38 (2.95; 5.8)	8.15	<0.001	-1.711
BT	3,796.4 ± 96.6	3,597.9 ± 169.8	-198.6 (-276; -121.1)	-5.15	<0.001	1.437
T2	27.2 ± 1.33	24.7 ± 1.35	-2.46 (-3.21; -1.71)	-8.77	<0.001	1.836
RT	2,196.9 ± 58.3	2,215 ± 258.4	18.1 (-88.4; 124.6)	0.79	0.003	-0.097
FT	7,262.5 ± 123.6	7,051.2 ± 98.8	-211.3 (-273.7; -148.9)	-2.9	<0.001	1.888

*p = Independent samples t-test or Mann-Whitney U test by Levene.

§ ES = Cohen's effect size. <0.2, trivial; 0.2– 0.6, small; 0.6–1.2, moderate; 1.2–2.0, large; >2.0, very large.
ST = Swimming performance; T1 = First transition phase performance; BT = Cycling performance; T2 = Second transition phase performance; RT = Running performance; FT = Final performance (all data are time in seconds).

Table 3.
Pre and post COVID-19 influence in performance (Mean ± DS). Sprint Distance.

Variable	Pre	Post	Difference (C.I. 95%)	Change (%)	*p**	ES§
			Overall			
ST	563.2 ± 17.2	558.2 ± 23	-5.02 (-12.9; 2.9)	-0.89	0.067	0.247
T1	52.4 ± 2.69	51.5 ± 2.37	-0.95 (-1.94; 0.03)	-1.81	0.023	0.376
BT	1,821.34 ± 77.1	1,784.7 ± 107.7	-36.7 (-73.2; -0.2)	-2.01	0.001	0.392
T2	25.8 ± 1.66	23.6 ± 1.8	-2.15 (-2.83; -1.47)	-8.27	<0.001	1.233
RT	970.4 ± 71.4	955.64 ± 70.56	-14.8 (-42.4; 12.8)	-1.51	0.225	0.209
FT	3,446.9 ± 167.9	3,385.4 ± 166.3	-61.5 (-126.5; 3.53)	-1.78	0.001	0.368
			Male			
ST	547.2 ± 5.38	536.5 ± 3.87	-10.7 (-13.3; 8.08)	-1.95	<0.001	2.283
T1	49.9 ± 0.8	49.4 ± 1.1	-0.47 (-1; 0.07)	-0.91	0.021	0.489
BT	1,747.4 ± 6.18	1,695.4 ± 82.7	-51.97 (-85.44; -18.51)	-2.97	<0.001	0.887
T2	24.4 ± 0.85	22.6 ± 1.8	-1.81 (-2.61; -1.02)	-7.29	<0.001	1.288
RT	903.5 ± 21.7	895.1 ± 46.8	-8.36 (-28.9; 12.2)	-0.9	0.791	0.229
FT	3,285.9 ± 28.1	3,223.7 ± 24.1	-62.2 (-76.8; -47.6)	-1.89	<0.001	2.375
			Female			
ST	579.2 ± 6.8	579.9 ± 9.27	0.67 (-3.86; 5.2)	0.12	0.749	-0.083
T1	54.9 ± 0.98	53.5 ± 1.28	-1.44 (-2.07; 0.8)	-2.58	<0.001	1.258
BT	1,895.4 ± 26.1	1,874 ± 15.6	-21.4 (-33.4; -9.3)	-1.12	0.004	0.994
T2	27.1 ± 1.13	24.6 ± 1.1	-2.48 (-3.10; -1.86)	-9.04	<0.001	2.227
RT	1,037.4 ± 24.5	1,016.1 ± 18.8	-21.3 (-33.5; -9.05)	-2.03	0.002	0.972
FT	3,607.9 ± 52.8	3,547.2 ± 37	-60.7 (-86.2; -35.2)	-1.68	<0.001	1.332

*p = Independent samples t-test or Mann-Whitney U test test by Levene.
§ ES = Cohen's effect size. <0.2, trivial; 0.2– 0.6, small; 0.6–1.2, moderate; 1.2–2.0, large; >2.0, very large.
ST = Swimming performance; T1 = First transition phase performance; BT = Cycling performance; T2 = Second transition phase performance; RT = Running performance; FT = Final performance (all data are time in seconds).

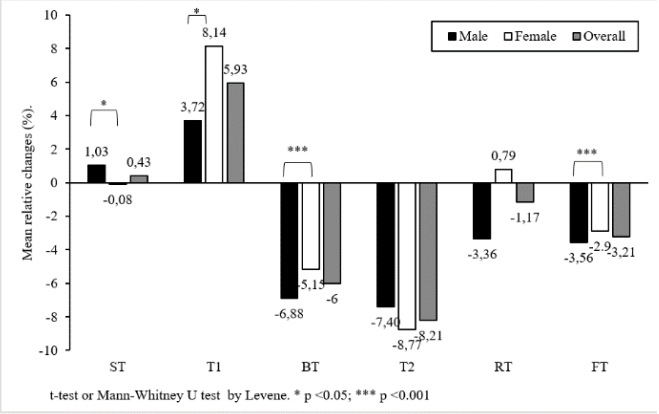

Figure 2. Performance relative changes pre-post COVID-19 in Olympic Distance. Comparison between sexes.

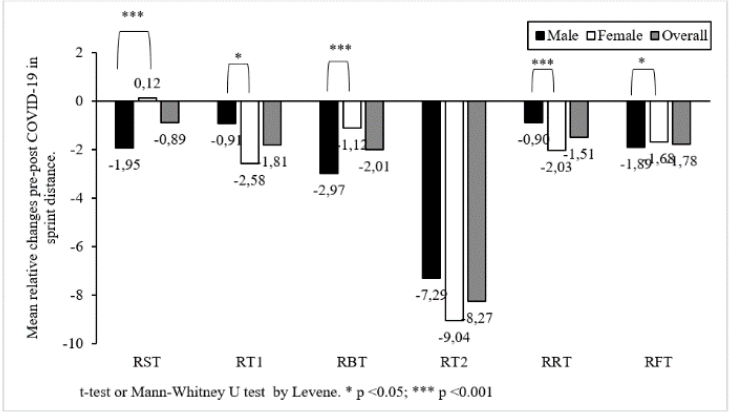

Figure 3. Performance relative changes pre-post COVID-19 in Sprint Distance. Comparison between sexes.

Table 4.
Relative changes comparisons across distances (Mean ± DS).

Variables	Sprint	Olympic	Differences change (%)	*p**	ES§
			Overall		
RST	-0.89 ± 1.59	0.43 ± 5.51	-151.81	<0.001	-0.343
RT1	-1.81 ± 3.050	5.93 ± 6.34	-439.78	<0.001	-1.544
RBT	-2.01 ± 3.48	-6 ± 5.21	193.72	<0.001	0.895
RT2	-8.27 ± 6.711	-8.21 ± 6.98	-1.04	0.455	-0.012
RRT	-1.51 ± 3.722	-1.17 ± 8.68	-12.18	0.001	-0.027
RFT	-1.78 ± 0.347	-3.21 ± 0.43	80	<0.001	3.728
			Male		
RST	-1.95 ± 1.19	1.03 ± 5.57	-152.74	<0.001	-0.738
RT1	-0.91 ± 3.05	3.72 ± 5.48	-509.86	<0.001	-1.044
RBT	-2.97 ± 4.72	-6.88 ± 4.81	131.26	<0.001	0.819
RT2	-7.29 ± 8.21	-7.4 ± 6.40	1.46	0.959	0.014
RRT	-0.9 ± 5.12	-3.36 ± 4.64	275.48	<0.001	0.505

RFT	-1.89 ± 0.14	-3.56 ± 0.13	87.86	<0.001	12.605
			Female		
RST	0.12 ± 1.23	-0.08 ± 5.5	-167.17	0.037	0.049
RT1	-2.58 ± 2.87	8.15 ± 6.46	-415.18	<0.001	-2.147
RBT	-1.12 ± 0.77	-5.15 ± 5.54	359.71	<0.001	1.017
RT2	-9.04 ± 4.78	-8.77 ± 7.58	-3.06	0.875	-0.044
RRT	-2.03 ± 1.19	0.79 ± 11.10	-139.05	0.006	-0.358
RFT	-1.68 ± 0.45	-2.9 ± 0.36	73.24	<0.001	3.006

*p = Independent samples t-test or Mann-Whitney U test by Levene

§ ES = Cohen's effect size. <0.2, trivial; 0.2– 0.6, small; 0.6–1.2, moderate; 1.2–2.0, large; >2.0, very large.

RST = Change of performance in swimming discipline; RT1 = Change of performance in the first transition phase; RBT = Change of performance in cycling discipline; RT2 = Change of performance in the second transition phase; RRT = Change of performance in running discipline; RFT = Change of final performance.

Discussion

The aim of the present study was to provide a comprehensive analysis of the effect of COVID-19 pandemic on performance in the WTS focusing on the male and female categories, and the Sprint and Olympic distances.

COVID-19 pandemic had a significant influence on the performance of the top triathletes in the OD at the WTS (Table 2). For men, it is highlighted the results recorded in the cycling performance and the final time displayed the greatest values of size effect (2.120; 4.379 respectively) These findings do not align with Shaw et al. (2021) which observed no changes in the fitness of national and international triathletes. This is the main finding of this article. The main cause of this might be that their participants were self-tested at home and not at World Championships. Moreover, they had a study design based on questionnaires. The same case applies to women, who also exhibit a decrease in their final time across those same disciplines and during the second transition, thereby improving their performance. Furthermore, these improvements are accompanied by a substantial effect size (1.437; 1.836; 1.888 for BT, T2, and FT, respectively).

When examining the relative changes between sexes for the OD, the cycling and the final performance showed the most significant differences (p values <0.001) (Figure 2). Both variables show a better adaptation to competition after COVID-19 in male. Additionally, the two other variables (swimming and first transition performance), showed a smaller difference (p values <0.05). From those, only swimming performance differences had greater values in women. Regarding the SPD, the importance of running performance in determining the final result has been established in literature, with other variables such as the transition phases being of secondary importance (Romuald Lepers et al., 2011). Rüst, Lepers, et al. (2013) declared that the sex gap is greater in running compared to swimming and cycling. It is reasonable to assume that therefore, there has been a decrease in the sex gap of the running performance in the SPD (Figure 3). However, a specific analysis would be required to validate this assumption, since the authors Lepers et al. (2011) based their result on ultra-endurance triathlon races, which is quite different to the SPD.

Regarding the changes in performance in SPD produced by COVID-19 pandemic, men and women improved all the analyzed variables that showed significant differences. (Table 3). These findings mostly align with those reported in OD, although they demonstrate a more evident improvement in performance. It would be necessary to examine whether the temporary pause caused by the COVID-19 pandemic has a direct positive effect on the results or, on the contrary, follows a pattern of consistent enhancement previously identified (Wonerow, Rüst, Nikolaidis, Rosemann, & Knechtle, 2017).

Sex differences in triathlon performance have been found to depend on discipline and distance, as previous studies have shown (Romuald Lepers, 2019). Lepers & Stapley (2010) have asserted that the sex gap is narrower in the OD when compared to other larger distances. While the present study does not explore the differences in performance between sexes, it examines the differences in the relative changes undergone by triathletes during the COVID-19 pandemic. These differences are more pronounced in SPD when compared to OD, since the analysis has included significant changes in five variables, having three of them a p value <0.001. This indicates that men and women were affected differently to COVID-19 pandemic in both distances, but specially in SPD. Women had worse change performance values in most of the analyzed variables. The cause of this could be the sex gap found by other authors (Lepers, 2019; Lepers & Stapley, 2010, 2011). In fact, Jaenes Sánchez et al. (2021) have previously suggested that women and men may respond differently in terms of fitness levels following a period of confinement. Our study findings are consistent with this assertion, as we observed differences in multiple variables in both distances between the sex. This supports the notion that sex should be considered when assessing the impact of confinement on athletic performance. The analysis of relative changes across the different distances revealed an improvement in swimming performance and first transition phase of the OD compared to SPD for men (p value <0.001), but a decrease in cycling, running and final performance (Table 4). Women exhibited a parallel trend, although with a more pronounced disparity in running time relative to the SPD (Table 4).

In general, our study differs from the findings of Muriel et al. (2021) in that it was not found any significant decline in cycling performance, neither in OD nor in SPD. In fact, cycling performance demonstrated superior results for both

sexes across both distances. It is possible that the discrepancies in our findings are due to differences in the study design. Particularly, Muriel et al. (2021) collected data during a 7-week period in the middle of a lockdown, while at the present article it was analyzed data from the two subsequent years to investigate the effects of long-term performance. Accordingly, the lack of significant declines in our study may be attributed to the differences in data collection and analysis. The comparison with Radzimiński et al. (2022) is subject to the same consideration. In this case, the analysis involves different sports, distances, and time periods for data collection, making the differences in the findings even more noticeable. Similarly happens to other studies such as (García-Tascón, Mendaña-Cuervo, Sahelices-Pinto, & Magaz-González, 2021; Zamarripa, Marroquín-Zepeda, Ceballos-Gurrola, Flores-Allende, & García-Gallegos, 2021). However, the findings of this study are consistent with others (Alarcón Meza & Hall-López, 2021) which assert that among non-beginner athletes, the same level of physical fitness was maintained.

The results of this study will be of great interest to triathletes, coaches, and researchers alike, and will provide valuable insight into the impact of COVID-19 pandemic on the performance of the best triathletes in the world. Coaches will be able to understand better the long-term effects on the performance of their triathletes, particularly taking with regards to the sex of the athletes. Athletes may be able to modulate their risk tolerance during training in situations that are not completely isolated from COVID-19 threat.

There are several areas that warrant further investigation in future research. Firstly, it would be worthwhile to determine how COVID-19 affected the performance of athletes in other triathlon distance races. Moreover, exploring the effects of the COVID-19 pandemic on other multi-sport events such as the ITU World Duathlon and World Aquathlon Championship, which share common disciplines with triathlon, could provide a more comprehensive understanding of the impact of the pandemic on athletic performance. Therefore, future research could aim to address these areas in order to expand our knowledge in the field of multi-sport performance during and post-pandemic.

One limitation of this study is the limited availability of suitable literature on triathlon, which makes it challenging to compare and interpret the obtained results within the wider triathlon research domain.

Conclusions

It can be concluded that the COVID-19 pandemic had a significant impact on the performance of the top triathletes in the World Triathlon Series (WTS). Triathletes participating in WTS in both sexes were able to not only maintain but also improve their final performance level despite COVID-19 pandemic. When men and women changes were analyzed, men showed significant greater values of improvements in the first transition, cycling and final performance of the Olympic distance and the swimming, cycling and final performance of the Sprint distance. On the contrary, women did it in the swimming performance for the Olympic distance and the first transition for the Sprint distance. These findings highlight the importance of considering specific variables, distances, and sex when assessing the impact of the pandemic on multi-sport performance. Sprint distance shows better values of changes than Olympic distance in swimming performance, running performance and first transition phase when both sexes are analyzed together but it is on the other way around for the cycling and final performance

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