Rev Andal Med Deporte.. 2024; **17(3-4)**

Junta de Andalucía
Consejería de Turismo, Cultura y Deporte

Revista Andaluza de
Medicina del Deporte

https://www.juntadeandalucia.es/deporte/ramd

Originales

Has COVID-19 pandemic influenced the performance of top-class athletes in the ITU World Duathlon and World Aquathlon Championship?

P. García-González[a,*], J.A. Gonzalez-Jurado[a]

[a] *University Pablo de Olavide, Spain.*

ABSTRACT

Objective: The influence of COVID-pandemic on these sports 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 World Duathlon and World Aquathlon Championships focusing on the male and female categories. Methods: Individual discipline times and overall times from 2018 to 2022 Aquathlon and Duathlon World Championship were collected for analysis, excluding 2020 due to the non-celebration caused by the COVID-19 pandemic outbreak. The dataset for this study was obtained from the ITU World Triathlon Series website (http://wts.triathlon.org/). 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. Results: The analysis of the duathlon revealed significant changes in many studied variables for either sex. Of those, cycling performance had greater values after COVID-19 pandemic for either sex. In this sport, female's performance decreased less than male's in second running performance and final performance (p values <0.01; <0.001). The aquathlon displayed several significant changes in performance after COVID-19 pandemic. Females showed greater change values in running and final performance, although the changes were not significant (p values 0.180; 0.602). The analysis of relative changes for common variables across the different sports revealed significant differences in all the analyzed variables except for the final performance in females. Conclusions: Overall, aquathlon shows better values of changes than duathlon in second running performance for each sex and when both were included in the analysis. These findings validate the necessity of considering each discipline when assessing the impact of the COVID-19 pandemic on the performance of elite duathlon and aquathlon athletes in the World Championship.

Keywords: pandemics; exercise; swimming; running.

¿Ha influido la pandemia COVID-19 en el rendimiento de los atletas de élite en el Campeonato Mundial de Duatlón y Acuatlón de la ITU?

RESUMEN

Objetivo: La influencia de la pandemia de COVID-19 en estos deportes aún no está clara. El objetivo del presente estudio es proporcionar un análisis exhaustivo del efecto de la pandemia de COVID-19 en el rendimiento en los Campeonatos Mundiales de Duatlón y Acuatlón, centrándose en las categorías masculina y femenina. Métodos: Se recopilaron los tiempos de cada disciplina y los tiempos totales del Campeonato Mundial de Acuatlón y Duatlón de 2018 a 2022 para su análisis, excluyendo 2020 debido a la cancelación provocada por la pandemia de COVID-19. El conjunto de datos para este estudio se obtuvo del sitio web de la Serie Mundial de Triatlón de la ITU (http://wts.triathlon.org/). 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. Resultados: El análisis del duatlón reveló cambios significativos en muchas de las variables estudiadas para ambos sexos. De ellas, el rendimiento en ciclismo mostró mayores valores después de la pandemia de COVID-19 en ambos sexos. En este deporte, el rendimiento de las mujeres disminuyó menos que el de los hombres en el segundo tramo de carrera y en el rendimiento final (valores de p <0.01; <0.001). El acuatlón mostró varios cambios significativos en el rendimiento tras la pandemia de COVID-19. Las mujeres presentaron mayores valores de cambio en la carrera y en el rendimiento final, aunque estos cambios no fueron significativos (valores de p 0.180; 0.602). El análisis de los cambios relativos en las variables comunes entre los diferentes deportes reveló diferencias significativas en todas las variables analizadas, excepto en el rendimiento final de las mujeres. Conclusiones: En general, el acuatlón muestra mejores valores de cambio que el duatlón en el segundo segmento de carrera para cada sexo y

* Contact author: Pablo García González / +4915737800099 / pablogartri@gmail.com / University Pablo de Olavide. Seville, Spain. (P. García-González)

https://doi.org/10.33155/ramd.v17i3-4.1177
ISSN-e: 2172-5063/

cuando ambos se incluyeron en el análisis. Estos hallazgos validan la necesidad de considerar cada disciplina a la hora de evaluar el impacto de la pandemia de COVID-19 en el rendimiento de los atletas de élite de duatlón y acuatlón en el Campeonato Mundial.

Palabras clave: Pandemias; ejercicio; natación; carrera.

A pandemia de COVID-19 influenciou o desempenho dos atletas de elite no Campeonato Mundial de Duatlo e Aquatlo da ITU?

RESUMO

Objetivo: A influência da pandemia de COVID-19 nesses esportes ainda não está clara. O objetivo do presente estudo é fornecer uma análise abrangente do efeito da pandemia de COVID-19 no desempenho nos Campeonatos Mundiais de Duatlo e Aquatlo, com foco nas categorias masculina e feminina. Métodos: Os tempos individuais de cada disciplina e os tempos gerais do Campeonato Mundial de Aquatlo e Duatlo de 2018 a 2022 foram coletados para análise, excluindo 2020 devido ao cancelamento causado pelo surto de COVID-19. O conjunto de dados para este estudo foi obtido no site da Série Mundial de Triatlo da ITU (http://wts.triathlon.org/). O teste t de Student para amostras independentes comparando sexo e distâncias foi utilizado para variáveis normais, enquanto o teste U de Mann-Whitney foi utilizado para variáveis não normais. Resultados: A análise do duatlo revelou mudanças significativas em muitas variáveis estudadas para ambos os sexos. Dentre elas, o desempenho no ciclismo apresentou maiores valores após a pandemia de COVID-19 para ambos os sexos. Nesse esporte, o desempenho das mulheres diminuiu menos que o dos homens no segundo percurso de corrida e no desempenho final (valores de p <0,01; <0,001). O aquatlo exibiu várias mudanças significativas no desempenho após a pandemia de COVID-19. As mulheres mostraram maiores valores de mudança na corrida e no desempenho final, embora as mudanças não tenham sido significativas (valores de p 0,180; 0,602). A análise das mudanças relativas para variáveis comuns entre os diferentes esportes revelou diferenças significativas em todas as variáveis analisadas, exceto no desempenho final das mulheres. Conclusões: No geral, o aquatlo apresenta melhores valores de mudanças do que o duatlo no segundo percurso de corrida para ambos os sexos e quando ambos foram incluídos na análise. Esses achados validam a necessidade de considerar cada disciplina ao avaliar o impacto da pandemia de COVID-19 no desempenho dos atletas de elite de duatlo e aquatlo no Campeonato Mundial.

Palavras-chave: Pandemias; exercício; natação; corrida.

Introduction

The International Triathlon Union (ITU) is the organizing body for world competitions in a variety of combined sports. Among these sports are triathlon, duathlon and aquathlon. Duathlon is a multi-sport event consisting of the sequential performance of running, cycling, and running (1). The configuration for the ITU World Duathlon Championship is a 10 km run, a 40 km cycle and a further 5 km run and the configuration for the ITU World Aquathlon Championship is a 1 km swim, a 5 km run. These championships, held annually as singular events, differ from triathlon as they do not employ a scoring system. Instead, results in these championships are determined based on a single race. World Championships are attractive to the scientific community and have been investigated in a wide range of sports (2–4). This is sometimes related somehow to duathlon (5) or aquathlon (6). The World Duathlon Championship has been also studied (7,8) whereas World Aquathlon Championship has not been included in the scientific literature as of now.

One of the main topics that has shaken the scientific community, and the world in general, is the global outbreak of the COVID-19 pandemic. In the sports and scientific world, the virus has been widely analyzed from several perspectives, such as psychological or behavioral (9). In addition, it has also been studied practically in all sports modalities such as swimming (10), or tennis (11) among many others. The academic world of multi-sports has not been greatly impacted by the COVID-19 pandemic. Some studies have been conducted on triathletes, (12), but only one of them focuses on the impact of the virus on a multi-sport performance (13). 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. (14) previously highlighted the substantial impact that the COVID-19 pandemic has had on the running community. 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 virus caused to endurance athletes (15), 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 a time for rest and recovery (16). 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 (17). 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 (18). 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. A recent study (19) investigated the impact of confinement on emotional wellbeing and athletic performance. Their findings indicated that there was a difference in the emotional influence of confinement between male and female athletes. This study provided evidence that males and females may experience different levels of performance after confinement, which may be attributed to the emotional impact of confinement on the individuals. 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 Olympic distance (20). These disparities in performance levels have also been observed to change over time, highlighting the need for continued research and examination in this area.

Although there is a lack of scientific literature specifically studying aquathlon, some studies have included aquathlon as part of their research (21). Furthermore, there are several studies available that primarily focus on duathlon. A peak of performance age has been

Table 1. Description of the races and participants (N=546).

Year	Race	Duathlon (n=265)		Aquathlon (n=281)	
		Male	Female	Male	Female
2018	Fyn	49	26	37	19
2019	Pontevedra	39	16	56	36
2021	Aviles / El Anillo	46	23	28	17
2022	Tagu Mures / Samorin	43	23	55	33

found in duathlon (22) and it has also been investigated how this has changed throughout years (8). Several studies have examined the differences between males and females in various duathlon distances. Specifically, some studies (23,24) have explored these differences within duathlon distances. Additionally, the studies conducted by Nikolaidis et al. (7) (25) analyzed this gap throughout several years. In those studies, the authors found that the differences between males and females, as indicated by the males to females ratio, decreased over the years in longer distances. However, this reduction in sex gap was not observed in the context of short distance races.

Despite the extensive literature search conducted, no wide range of articles analyzing either duathlon or aquathlon 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 duathlon or aquathlon. Although many events have been cancelled or postponed, the impact of the virus on sports performance is still not well understood. In the case of duathlon or aquathlon, the limited number of studies available makes it difficult to determine the exact impact of the virus on performance. Thus, this study tries to fill the gap in the literature by analyzing the effect of COVID-19 pandemic on performance in the World Duathlon and World Aquathlon Championships. It is hypothesized that the performance of the best athletes in duathlon and aquathlon in the world will have been significantly impacted by the COVID-19 pandemic.

Therefore, the aim of the present study is to provide a comprehensive analysis of the effect of COVID-19 pandemic on performance in the World Duathlon and World Aquathlon Championships focusing on the male and female categories.

Methods

Participants

The dataset for this study was obtained from the ITU World Triathlon Series website (http://wts.triathlon.org/). Individual discipline times and overall times from 2018 to 2022 Aquathlon and Duathlon World Championship were collected for analysis, excluding 2020 due to the non-celebration caused by the COVID-19 pandemic outbreak. The total number of included athletes in this study was 546. This is divided into 265 (177 males and 88 females) for duathlon and 281 (176 males and 105 females) for aquathlon. The mean age of subjects was 27.01 years for males and 29.11 years for females in duathlon, and 23.20 years for males and 22.44 years for females in aquathlon. Table 1 details the number of participants included per year and competition.

Due to dropouts, disqualifications, and non-starting athletes, the sample size was reduced to 502 (225 athletes for duathlon and 277 cases for aquathlon). The final sample size for the analyses was determined based on the minimum number of athletes who completed the race in each sex and sport category. For the duathlon, the sample consisted of 33 males and 12 females (minimum number of finishing athletes for both sexes reached at the 2019 World Championships). Similarly, for aquathlon, the sample included 28 males and 17 females (minimum number of finishing athletes for both sexes reached at the 2021 World Championships). Therefore, a total of 45 athletes of both sexes were included in the analyses of both sports.

Outcomes

The analyzed variables were as follows:

- Swimming time (ST): average time of the swimming time for each position analyzed.
- First running time (RT1): average time of the first running time for each position analyzed.
- First transition phase (T1): average time of the first transition phase time for each position analyzed.
- Cycling time (BT): average time of the cycling time for each position analyzed.
- Second transition phase (T2): average time of the second transition phase time for each position analyzed.
- Second running time (RT2): average time of the second running time for each position analyzed. In aquathlon, this refers to the single race time.
- Final time (FT): Overall performance. Average time of the final time for each position analyzed.

The variables T2, RT2, and FT are common to both sports, while the variable ST is exclusive to aquathlon. On the other hand, the variables RT1, T1, and BT are specific to duathlon.

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 running time (RRT1).
- Relative difference of first transition phase (RT1).
- Relative difference of cycling (bike) time (RBT).
- Relative difference of second transition phase (RT2).
- Relative difference of second running time (RRT2).
- 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 sports 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). Moreover, the magnitude of differences was assessed using Cohen's d (effect size; ES). The ES were classified 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 (26).

Results

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 sports 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). Moreover, the magnitude of differences was assessed using Cohen's d (effect size; ES). The ES were classified 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 (26).

The total number of athletes per continent is shown in Figure 1 and Figure 2. In duathlon, European males were 72.9% of the total amount of participants, while European females were the 75%. In aquathlon, these percentages were 83.5% for males and 91.5% for females. Non-African females participated in aquathlon.

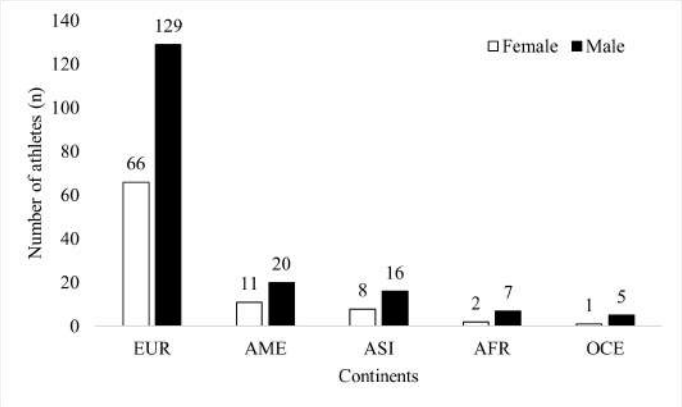

Figure 1. The total number of athletes in duathlon per continent included in the present study (n = 265).

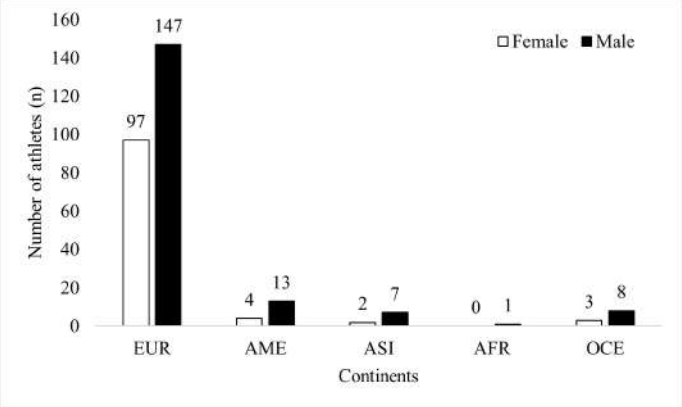

Figure 2. The total number of athletes in aquathlon per continent included in the present study (n = 280).

The analysis of the duathlon revealed significant changes in absolutely all the studied variables for either sex (Table 2). The COVID-19 pandemic had a significant influence on the performance of the top male athletes at the World Duathlon Championship. BT, RT1 and RT2 showed the most significant differences in the three analyzed cases (p values <0.001). BT and T1 increased for male (p values 0.034; <0.001) and only BT for females (p value <0.001) whereas almost the rest of the variables decreased their performance for each sex and both together (Table 2). When examining the relative changes for the duathlon between sex, two significant differences were found in RRT2, (p value <0.01) and RFT with a larger decline in performance observed in males (p value <0.001) (Figure 3). The aquathlon displayed several significant changes in performance after the COVID-19 pandemic. For males, two significant differences were found in ST and FT, enhancing the first one and worsening the second one (p values 0.010; 0.027) (Table 3). Females experienced a 3.65% improvement in ST (p value 0.001) (Table 3). When all participants were analyzed irrespective of sex, only ST and T1 displayed significant differences (p values 0.045; <0.001) (Table 3). When comparing the relative changes between sexes in aquathlon, two significant differences were observed in both RRT1 and RFT (p values 0.014; <0.001), with females showing better results in performance changes (Figure 4). The analysis of relative changes for common variables across the different sports revealed significant differences in all the analyzed variables except for the RFT in females (Table 4). Aquathlon shows better values for the RRT2 for each analysis (p values <0.001) (Table 4).

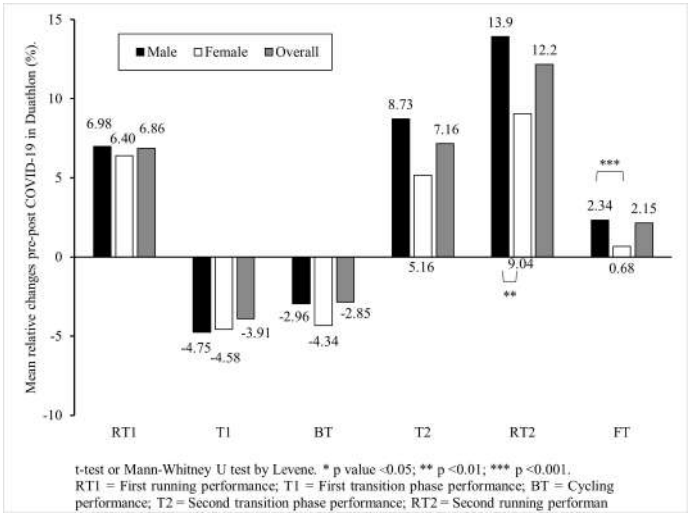

Figure 3. Performance relative changes pre-post COVID-19 pandemic in duathlon and comparison between sexes.

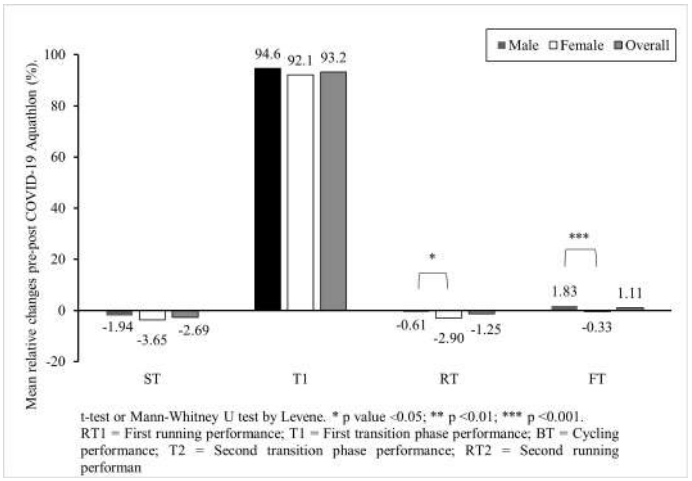

Figure 4. Performance relative changes pre-post COVID-19 pandemic in aquathlon. Comparison between sexes.

Discussion

The present study aimed to provide a comprehensive analysis of the effect of COVID-19 pandemic on performance in the World Duathlon and World Aquathlon Championships focusing on the male and female categories. Females reacted better than males to the second running and final performance after COVID-19 pandemic in both sports. Aquathlon shows better values for the second running performance for each analysis. It is the same case for the final performance, but it is not significant for females.

The analysis of the duathlon revealed significant changes in absolutely all the studied variables for either sex (Table 2). Cycling and first transition phase performance increased for males and only cycling performance for females (Table 2). 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 (27). Nevertheless, almost the rest of variables decreased their performance for each sex and both together (Table 2). These findings differ from another study (12) which observed no changes in the fitness of national and international triathletes. The main cause of this might be that their participants were self-tested at home and not at the World Championships. Moreover, the previous study's design had a study design (12) was based on questionnaires. Additionally, the average ages of the participants align well with previous studies that have examined peak performance ages (22). In that study, it was

Table 2. Pre and post COVID-19 pandemic influence on duathlon performance.

Variable	Pre	Post	Difference (C.I. 95%)	Change (%)	*p**	ES$
Overall						
RT1	1,851.7 ± 108.6	1,977.4 ± 112.8	125.7 (79.3; 172.1)	6.86	<0.001	-1.135
T1	35.4 ± 2.49	33.8 ± 3.47	-1.64 (-2.91; -0.38)	-3.91	0.011	0.545
BT	3,641.2 ± 210.4	3,519.3 ± 181.6	-121.9 (-204.2; -39.5)	-2.85	<0.001	0.620
T2	37.4 ± 4.44	40 ± 3.72	2.51 (0.79; 4.22)	7.16	0.005	-0.613
RT2	946.4 ± 78.3	1,061.7 ± 62.5	115.3 (85.6; 144.9)	12.2	<0.001	-1.627
FT	6,511.2 ± 372	6,632.2 ± 333	120 (-26.97; 268.9)	2.15	0.033	-0.343
Male						
RT1	1,795.5 ± 52.8	1,920.7 ± 68.7	125.2 (95.1; 155.3)	6.98	<0.001	-2.045
T1	34.7 ± 2.41	33.1 ± 3.57	-1.62 (-3.12; -0.12)	-4.75	0.034	0.532
BT	3,522.5 ± 65.9	3,419.6 ± 80.8	-1023 (-139.2; -66.7)	-2.96	<0.001	1.397
T2	37 ± 4.92	39.7 ± 3.86	2.7 (0.52; 4.87)	8.73	0.002	-0.610
RT2	921.4 ± 71.8	1,045.4 ± 60.2	124 (91.4; 156.6)	13.9	<0.001	-1.872
FT	6,310.3 ± 161.4	6,458.5 ± 186.8	148.2 (62.3; 234.1)	2.34	0.002	-0.849
Female						
RT1	2,006.3 ± 59.8	2,133.3 ± 31.5	127 (85.4; 168.3)	6.40	<0.001	-2.660
T1	37.3 ± 1.62	35.6 ± 2.48	-1.71 (-3.5; 0.08)	-4.58	0.075	0.815
BT	3,967.5 ± 78.2	3,793.6 ± 29.9	-173.9 (-225.7; -122)	-4.34	<0.001	2.935
T2	38.7 ± 2.52	40.7 ± 3.35	2 (-0.51; 4.51)	5.16	0.112	-0.676
RT2	1,015.1 ± 49.8	1,106.5 ± 46.1	91.3 (50.7; 131.9)	9.04	<0.001	-1.905
FT	7,063.9 ± 153.3	7,109.9 ± 51.3	46 (-54.5; 146.5)	0.68	0.335	-0.403

***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. RT1 = First running performance; T1 = First transition phase performance; BT = Cycling performance; T2 = Second transition phase performance; RT2 = Second running performance; FT = Final performance (all data are time in seconds). Data is presented as time in seconds. Data is presented as (Mean ± Deviation Standard).

Table 3. Pre and post COVID-19 pandemic influence on aquathlon performance.

Variable	Pre	Post	Difference (C.I. 95%)	Change (%)	*p**	ES$
Overall						
ST	783 ± 46.8	760.6 ± 36.4	-22.4 (-41.88; -2.95)	-2.69	0.045	0.534
T1	58.8 ± 4.25	113.4 ± 6.07	54.5 (52.1; 57)	93.2	<0.001	-10.405
RT	1,076.5 ± 93.9	1,057.4 ± 79.6	-19.2 (-59.5; 21.2)	-1.25	0.347	0.220
FT	1,918 ± 138	1,932.2 ± 115.1	14.2 (-44.7; 73.1)	1.11	0.405	-0.112
Male						
ST	746 ± 14.8	730.9 ± 18.3	-15.1 (-25.7; -4.4)	-1.94	0.010	0.907
T1	56.4 ± 3.10	109.2 ± 4.55	52.8 (50.3; 55;3)	94.6	<0.001	-13.561
RT	1,004.5 ± 35.3	998.6 ± 45.7	-5.95 (-32.1; 20.2)	-0.61	0.647	0.146
FT	1,806.5 ± 39.5	1,839.4 ± 50.4	33 (4; 61.9)	1.83	0.027	-0.728
Female						
ST	826.6 ± 30.8	795.5 ± 13.9	-31.1 (-48.1; -14.1)	-3.65	0.001	1.301
T1	61.7 ± 3.56	118.3 ± 3.3	56.5 (54.1; 58.9)	92.1	<0.001	-16.467
RT	1,161.3 ± 65	1,126.6 ± 48.7	-34.7 (-74.8; 5.39)	-2.9	0.087	0.605
FT	2,049.1 ± 84.9	2,041.2 ± 58.4	-7.9 (-58.8; 43)	-0.33	0.754	0.108

***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 = transition phase performance; RT = Running performance; FT = Final performance. Data is presented as time in seconds. Data is presented as (Mean ± Deviation Standard).

determined that athletes between 20 and 24 years old exhibited the highest performance levels in short duathlon distances, while athletes between 25 and 29 years old displayed the highest performance levels in long distances. This may be caused by several reasons. One of these reasons could be the neuromuscular fatigue and recovery, as this may differ in master versus younger athletes following muscle damaging exercise which may cause a delay in overall recovery from prior exercise, as suggested by (28). A higher aerobic capacity has also been suggested as a reason, but in other sports (29).

Females reacted better than males to the second running (RT2/RT) and FT after the COVID-19 pandemic in both sports. The importance of running performance in determining the final result has been established in multi-sport scientific literature (30), with other variables such as transitions being of secondary importance (31). On the other hand, sex differences in multi-sport performance have been found to depend on discipline and distance, as previous studies have shown (32). While the present study does not explore the differences in performance between sexes, it examines the differences in the relative changes undergone by athletes during the COVID-19 pandemic. It is quite clear that females adapted better than males in terms of performance in these two sports. This indicates that males and females were affected differently by the COVID-19 pandemic in

Table 4. Relative changes comparisons between sports.

Variables	Duathlon (%)	Aquathlon (%)	Difference changes (%)	*p**	*ES*$
Overall					
RT2	*7.16 ± 10.67*	*93.2 ± 11.9*	*-92.01*	*<0.001*	*-7.629*
RRT2	*12.2 ± 4.8*	*-1.25 ± 2.92*	*-852.88*	*<0.001*	*3.473*
RFT	*2.15 ± 1.18*	*1.11 ± 1.62*	*129.31*	*<0.001*	*0.767*
Male					
RT2	*8.73 ± 12.1*	*94.6 ± 13*	*-91.21*	*<0.001*	*-6.912*
RRT2	*13.9 ± 4.99*	*-0.61 ± 2.77*	*-2401.04*	*<0.001*	*3.335*
RFT	*2.34 ± 0.64*	*1.83 ± 0.83*	*29.07*	*0.012*	*0.738*
Female					
RT2	*5.16 ± 4.73*	*92.1 ± 10.8*	*-94.39*	*<0.001*	*-9.865*
RRT2	*9.04 ± 1.61*	*-2.90 ± 2.65*	*-411.72*	*<0.001*	*5.243*
RFT	*0.68 ± 1.49*	*-0.33 ± 1.56*	*-304.87*	*0.066*	*0.661*

***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. RT2 = Change of performance in the second transition phase; RRT2 = Change of performance in running discipline; RFT = Change of final performance. Data is presented as (Mean ± Deviation Standard).

both sports with females having better results in most of the significant as RT2/RT and FT. In fact, the study by Jaenes-Sánchez et al. (19) have previously suggested that females and males may respond differently in terms of fitness levels following a period of confinement. This supports the notion that sex should be considered when assessing the impact of confinement on athletic performance. These authors pointed as a possible reason that, in females, the increase in the use of coping activities was an attempt to reduce their elevated negative moods. Another study (33) found that, during the COVID-19 pandemic, healthcare workers who screened positive for stress and depressive symptoms reported engaging in more coping behaviors. In this sense, a sex gap in performance has been found by other authors (24,25). A recent study (34) has asserted that the sex gap is narrower in the short distance of duathlon when compared to other larger distances, which may suggest that in the unanalyzed long distance, the differences could be different. This finding proposes that there may be a reduction in the performance gap between males and females. However, further research using updated data is necessary to substantiate this claim, since this gap might have changed throughout the years. Our study findings are consistent with this assertion.

The analysis of relative changes for common variables across the different sports revealed significant differences in all the analyzed variables except for the RFT in females (Table 4). Aquathlon shows better values for the RRT2 for each analysis (Table 4). Comparing the relative changes in performance across different sports with other studies is not possible due to the lack of previous analysis of the impact of the COVID-19 pandemic on multi-sports performance, particularly in duathlon and aquathlon, which is not very interesting for the scientific community.

The COVID-19 pandemic did have a negative impact on RT after cycling in duathlon, for both sexes and when both were analyzed together. These findings do not match with another research paper (35) that claim that evidence has not shown conclusive physiological effects of cycling on an immediately following run. This phenomenon could be attributed to the possibility that the decline in running performance after cycling might be specific to the duathlon and influenced by factors unrelated to physiological aspects. These findings align with the results obtained by (36), who observed that the COVID-19 pandemic had an impact on athletic performance. However, the change experienced by aquathletes and duathletes does not appear to have been as positive as that observed in triathletes.

In general, our study differs from the findings of the study by Muriel et al. (15) in that, it was not found any significant performance decline in BT in duathlon. BT demonstrated superior results after COVID-19 pandemic for both sexes. Particularly, this previous study (15) collected data during a 7-week period in the middle of a lockdown, while 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. However, it aligns with (36), as the cycling time was reduced, so the performance was improved, in sprint and olympic triathlon after the COVID-19 pandemic. The decrease in the workload might be a potential explanation for this better performance.

The results of the present study will be of great interest to triathletes, coaches, and researchers alike, and will provide valuable insight into the impact of the COVID-19 pandemic and associated lockdown on the performance of the best athletes in duathlon and aquathlon in the world. Coaches will be able to understand better the long-term effects on the performance of their athletes, particularly 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. On the other hand, this study has limitations, including the scarcity of relevant literature on duathlon and the complete absence of research on aquathlon, which complicates the comparison and interpretation of the results within the broader context of sports research. Moreover, this study adopts a quantitative approach, which implies a lack of consideration for physical or other nature-related variables, such as circuit layout or climatic conditions. Similarly, 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.

There are several areas that require further investigation in future research. Firstly, it would be necessary to determine whether the observed sex differences in performance after the COVID-19 pandemic increase or decrease as the duathlon or aquathlon distance races gets longer. Moreover, exploring the effects of the COVID-19 pandemic on other multi-sport events such as the ITU European Championships for duathlon, triathlon or aquathlon, which share common disciplines the sports here analyzed, 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. Finally, the results of this article provide an interesting perspective for analyzing whether the performance gap between males and females has decreased compared to previous studies.

It can be concluded that the COVID-19 pandemic did have a significant impact on the performance of the top athletes at the World Duathlon and Aquathlon Championship. There is a necessity for considering each discipline when assessing the impact of the

COVID-19 pandemic on the performance of elite duathlon and aquathlon athletes in the World Championship. Females reacted better than males to the second running and final performance after COVID-19 pandemic in both sports. Lastly, aquathlon shows better values for the second running performance for each analysis. It is the same case for the final performance, but it is not significant for females. These findings highlight the importance of considering specific variables, distances, and sex when assessing the impact of the pandemic on multi-sport performance.

References

1. Sparks SA, Cable NT, Doran DA, Maclaren DPM. The influence of environmental temperature on duathlon performance. Ergonomics. 2005;48(11–14):1558–67.
2. De La Rubia A, Bjørndal CT, Sánchez-Molina J, Yagüe JM, Calvo JL, Maroto-Izquierdo S. The relationship between the relative age effect and performance among athletes in World Handball Championships. PLoS One. 2020;15(3):1–22.
3. Finlay MJ. World Heavyweight Championship boxing: The past 30+ years of the male division. PLoS One. 2022;17(1 January):1–12.
4. Hébert-Losier K, Platt S, Hopkins WG. Sources of variability in performance times at the world orienteering championships. Med Sci Sports Exerc. 2015;47(7):1523–30.
5. Haupt S, Knechtle B, Knechtle P, Rüst CA, Rosemann T, Lepers R. The age-related performance decline in ultraendurance mountain biking. Research in Sports Medicine. 2013;21(2):146–58.
6. Knechtle B, Dalamitros AA, Barbosa TM, Sousa CV, Rosemann T, Nikolaidis PT. Sex differences in swimming disciplines—can women outperform men in swimming? Int J Environ Res Public Health. 2020;17(10).
7. Nikolaidis PT, Villiger E, Knechtle B. Participation and performance trends in the ITU Duathlon World Championship from 2003 to 2017. J Strength Cond Res. 2018;00(00):1–7.
8. Rüst CA, Knechtle B, Knechtle P, Pfeifer S, Rosemann T, Lepers R, et al. Gender difference and age-related changes in performance at the long-distance duathlon. J Strength Cond Res. 2013;27(2):293–301.
9. Karrer Y, Fröhlich S, Iff S, Spörri J, Scherr J, Seifritz E, et al. Training load, sports performance, physical and mental health during the COVID-19 pandemic: A prospective cohort of Swiss elite athletes. PLoS One. 2022;17(12):e0278203.
10. Fülöp GA, Gógl Á, Lakatos B, Sydó N, Csulak E, Mester B, et al. Swimming competitions in the era of COVID-19: Lessons from successfully hosting the International Swimming League. Physiol Int. 2022;109(4):511–23.
11. Ishihara T, Robin N, Naito T, Murata M, Crespo M. Effects of the COVID-19 pandemic on professional tennis players' match statistics: A large-scale population-based study. Scand J Med Sci Sports. 2022;32(10):1516–8.
12. Shaw KA, Bertrand L, Deprez D, Ko J, Zello GA, Chilibeck PD. The impact of the COVID-19 pandemic on diet, fitness, and sedentary behaviour of elite para-athletes. Disabil Health J [Internet]. 2021;14(3):101091. Available from: https://doi.org/10.1016/j.dhjo.2021.101091
13. Poczta J, Almeida N, Paczyńska-Jędrycka M, Kruszyńska E. The Impact of COVID-19 Incidence on Motivation to Participate in a Triathlon. Int J Environ Res Public Health. 2022;19(9).
14. Robinson JN, Fontana MA, Metzl JD, Dixit S, Kliethermes SA, Quijano B, et al. Running races during the COVID-19 pandemic: a 2020 survey of the running community. BMJ Open Sport Exerc Med. 2021;7(4):1–5.
15. Muriel X, Courel-Ibáñez J, Cerezuela-Espejo V, Pallarés JG. Training load and performance impairments in professional cyclists during COVID-19 lockdown. Int J Sports Physiol Perform. 2021;16(5):735–8.
16. Patel TS, McGregor A, Cumming SP, Williams K, Williams S. Return to competitive gymnastics training in the UK following the first COVID-19 national lockdown. Scand J Med Sci Sports. 2022;32(1):191–201.
17. Radzimiński Ł, Lorenzo-Martinez M, Konefał M, Chmura P, Andrzejewski M, Jastrzębski Z, et al. Changes of physical match performance after the COVID-19 lockdown in professional soccer players according to their playing position. Biol Sport. 2022;40(4):1087–94.
18. Shaw KA, Bertrand L, Deprez D, Ko J, Zello GA, Chilibeck PD. The impact of the COVID-19 pandemic on diet, fitness, and sedentary behaviour of elite para-athletes. Disabil Health J. 2021;14(3):101091.
19. Jaenes Sánchez JC, Alarcón Rubio D, Trujillo M, Peñaloza Gómez R, Mehrsafar AH, Chirico A, et al. Emotional Reactions and Adaptation to COVID-19 Lockdown (or Confinement) by Spanish Competitive Athletes: Some Lesson for the Future. Front Psychol. 2021;12(May):1–15.
20. Lepers R. Sex difference in triathlon performance. Front Physiol. 2019;10(JUL):1–7.
21. Vikmoen O, Rønnestad BR, Ellefsen S, Raastad T. Heavy strength training improves running and cycling performance following prolonged submaximal work in well-trained female athletes. Physiol Rep. 2017;5(5):1–14.
22. Nikolaidis PT, Villiger E, Ardigò LP, Waśkiewicz Z, Rosemann T, Knechtle B. The age of peak performance in women and men duathletes - The paradigm of short and long versions in "Powerman Zofingen"; Open Access J Sports Med. 2018;Volume 9:125–30.
23. Nikolaidis PT, Villiger E, Victor Sousa C, Rosemann T, Knechtle B. The Effect of Aging on Pacing Strategies in Short and Long Distance Duathlon. Exp Aging Res. 2019;45(3):223–33.
24. Nikolaidis PT, Chtourou H, Ramirez-Campillo R, Villiger E, Rosemann T, Knechtle B. The combined effect of aging and performance level on pacing in duathlon - the "ITU Powerman Long Distance Duathlon World Championships." Front Psychol. 2019;10(FEB):1–6.
25. Nikolaidis PT, Villiger E, Vancini RL, Rosemann T, Knechtle B. The Effect of Sex and Performance Level on Pacing in Duathlon. Sports. 2018;6(4):1–8.
26. Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. Med Sci Sports Exerc. 2009;41(1):3–12.
27. Wonerow M, Rüst CA, Nikolaidis PT, Rosemann T, Knechtle B. Performance trends in age group triathletes in the olympic distance triathlon at the world championships 2009-2014. Chinese Journal of Physiology. 2017;60(3):137–50.
28. Borges N, Reaburn P, Driller M, Argus C. Age-related changes in performance and recovery kinetics in masters athletes: A narrative review. Vol. 24, Journal of Aging and Physical Activity. Human Kinetics Publishers Inc.; 2016. p. 149–57.
29. Sandbakk O, Holmberg HC, Leirdal S, Ettema G. The physiology of world-class sprint skiers. Scand J Med Sci Sports. 2011 Dec;21(6):e9–16.
30. In press: García-González P, González-Jurado JA. Analysis and comparison of male triathlon performance at the Olympic Games, International Triathlon Union World Championship, and International Triathlon Union European Championship over a period of twenty-three years, considering both medalists

and overall triathletes participants. Gazzetta Medica Italiana - Archivio per le Scienze Mediche. 2024;183:0–0.

31. Lepers R, Knechtle B, Knechtle P, Rosemann T. Analysis of ultra-triathlon performances. Open Access J Sports Med. 2011; (August):131.
32. Lepers R, Stapley PJ. Differences in gender and performance in off-road triathlon. J Sports Sci. 2010;28(14):1555–62.
33. Shechter A, Diaz F, Moise N, Anstey DE, Ye S, Agarwal S, et al. Psychological distress, coping behaviors, and preferences for support among New York healthcare workers during the COVID-19 pandemic. Gen Hosp Psychiatry. 2020 Sep 1;66:1–8.
34. Nikolaidis PT, Villiger E, Knechtle B. Participation and Performance Trends in the ITU Duathlon World Championship From 2003 to 2017. J Strength Cond Res. 2021;35(4):1127–33.
35. Rico Bini R, Canal Jacques T, Hunter J, Figueiredo P. Biomechanical and physiological implications to running after cycling and strategies to improve cycling to running transition: A systematic review. J Sci Med Sport. 2022;25(10):861–6.
36. García-González P, González-Jurado JA. Has Covid-19 pandemic influenced the performance of top-class triathletes in the Sprint and Olympic distance of the ITU World Triathlon Championship Series? Retos. 2024;57:137–46.