

SEX AND AGE-RELATED CHANGES IN PERFORMANCE IN THE DUATHLON WORLD CHAMPIONSHIPS



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SEXO E MUDANÇAS RELACIONADAS COM A IDADE NO DESEMPENHO EM CAMPEONATOS MUNDIAIS DE DUATLO

SEXO Y CAMBIOS RELACIONADOS CON LA EDAD EN EL DESEMPEÑO EN CAMPEONATOS MUNDIALES DE DUATLÓN

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ABSTRACT

Objective: Our study analyses differences in performance between sexes, and changes in performance between age groups at Olympic distance during the ITU Duathlon World Championships, held between 2005 and 2016. During this period, a total of 9,772 duathletes were analysed (6,739 men and 3,033 women). **Methods:** Two-way analyses of variance (ANOVA) were used to examine sex- and age-related differences in performance (time, percentage of time and performance ratio) in the first running and cycling legs, the second running leg, and total race for the top 10 male and female athletes in each age group at the Duathlon World Championships. **Results:** The age group with the highest participation, in both male and female categories, was 40-44 years, and it was found that the mean age of female finisher participants across all age groups was 23.5 ± 12 . With regards to performance, the best results for total race time and the cycling segment were achieved in the 30-34-year age group, for both male and female athletes. With regards to performance in the first and third segments (running legs), the best times were achieved in the 25-29 and 30-34 age groups, for men and women respectively. **Conclusion:** According to the results of our study, the best results in the professional career of a duathlete are achieved at between 30 and 35 years, therefore the athlete should incorporate this factor into their training plan. **Level of evidence III; Retrospective comparative study.**

Keywords: Sports performance; Running; Bicycling; Sex difference; Aging; Physical endurance.

RESUMO

Objetivo: Nosso estudo analisa as diferenças de desempenho entre os sexos e as mudanças do desempenho entre as faixas etárias quanto à distância olímpica durante o Campeonato Mundial de Duatlo da ITU, realizado entre 2005 e 2016. Nesse período, foram analisados 9.772 duatletas (6.739 homens e 3.033 mulheres). **Métodos:** As análises de variância bidirecional (ANOVA) foram usadas para examinar as diferenças de desempenho relacionadas com sexo e idade (tempo, porcentagem de tempo e coeficiente de desempenho) na primeira corrida, ciclismo, segunda corrida e competição total dos 10 melhores atletas do sexo masculino e feminino em cada faixa etária no Campeonato Mundial de Duatlo. **Resultados:** A faixa etária com maior participação, tanto dos homens quanto das mulheres foi de 40 a 44 anos, e verificou-se que a média de idade das participantes do sexo feminino que concluíram a competição em todas as faixas etárias foi de $23,5 \pm 12$. Com relação ao desempenho, os melhores resultados para o tempo total de competição e o segmento de ciclismo foram na faixa etária de 30 a 34 anos, tanto em atletas masculinos quanto femininos. Com relação ao desempenho no primeiro e terceiro segmentos (corridas), o melhor desempenho foi alcançado nas faixas de 25 a 29 e 30 a 34 anos, em homens e mulheres, respectivamente. **Conclusão:** De acordo com os resultados obtidos neste estudo, os melhores resultados na carreira profissional de um duatleta poderiam ser alcançados entre 30 e 35 anos, portanto o atleta deve incorporar esse fator em seu plano de treinamento. **Nível de evidência III; Estudo retrospectivo comparativo.**

Descritores: Desempenho esportivo; Corrida; Ciclismo; Diferenças sexuais; Envelhecimento; Resistência física.

RESUMEN

Objetivo: Nuestro estudio analiza las diferencias de desempeño entre los sexos y los cambios de desempeño entre los grupos de edad con respecto a la distancia olímpica durante el Campeonato Mundial de Duatlón de ITU, realizado entre 2005 y 2016. En ese período, fueron analizados 9.772 duatletas (6.739 hombres y 3.033 mujeres). **Métodos:** Los análisis de variancia bidireccional (ANOVA) fueron usados para examinar las diferencias de desempeño relacionadas con sexo y edad (tiempo, porcentaje de tiempo y coeficiente de desempeño) en la primera carrera, ciclismo, segunda carrera y competición total de los 10 mejores atletas de sexo masculino y femenino en cada grupo de edad en el Campeonato Mundial de Duatlón. **Resultados:** El grupo de edad con mayor participación, tanto de los hombres como de las mujeres, fue de 40 a 44 años y se verificó que la edad promedio de las participantes femeninas que concluyeron la competición en todos los grupos de edad fue de $23,5 \pm 12,5$. Con relación al desempeño, los mejores resultados para el tiempo total de competición y el segmento de ciclismo fueron en el grupo de edad de 30 a 34 años, tanto en atletas masculinos como femeninos. Con relación al desempeño en el primer y tercer segmentos (carreras),



el mejor desempeño fue alcanzado en los grupos de 25 a 29 y 30 a 34 años, en hombres y mujeres, respectivamente. Conclusión: De acuerdo con los resultados obtenidos en este estudio, los mejores resultados en la carrera profesional de un duatleta podrían ser alcanzados entre 30 y 35 años, por lo tanto el atleta debe incorporar ese factor en su plan de entrenamiento. **Nivel de evidencia III; Estudio retrospectivo comparativo.**

Descriptor: Rendimiento deportivo; Carrera; Ciclismo; Diferencias sexuales; Envejecimiento; Resistencia física.

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INTRODUCTION

Participation in multisport races, in their various formats, such as triathlon or duathlon, have seen considerable growth in the number of participants, in age groups (AG) and in elite category in recent decades.^{1,2}

A multitude of studies have been carried out on the triathlon format's various races and distances, analysing changes in performance according to the gender and/or age of the participants. The greatest number of studies have been carried out on long-distance^{3,2} and Olympic distance⁴⁻⁷ in triathlon races. There have been fewer studies of other races and distances, such as cross triathlon⁸ or ultra-triathlon.^{9,10} Only one study analysing changes in performance according to gender and age variables in the duathlon, long-distance, was found.¹¹

Knechtle et al.¹² analyses three distances (Olympic, Half-Ironman and Ironman) while the study by Lepers et al.¹³ analyses two distances, and Lepers et al.¹⁴ examines all distances, including the cross triathlon. Lepers & Stapley¹⁵ which compares performance in conventional Olympic triathlons with the cross triathlon.

Other studies compared these variables with performance in two different sports, such as in a marathon and Olympic triathlon, as a predictor of long-distance triathlon performance.^{16,17} The AG World Championships Olympic triathlon differences are not evident until age 45-40 in men and women respectively.¹⁸ With regards to gender, in triathlons there are differences in performance similar to other sports formats, influenced by distance and type of triathlon.^{9,19}

The purpose of this study was therefore to analyse possible differences in performance among athletes according to gender and age during the Olympic Duathlon World Championships (ODWCH) held between 2005 and 2016.

METHODS

A total of 9,772 duathletes (6,739 men and 3,033 women) from AG categories have been analyzed, at ITU ODWCH, since 2005 to 2016.

The data set of this study were obtained from the results during a 12 years' period in those competitions published by the ITU. It was analyzed the performance of participants in the different AG during the competition, the results in the three segments of the Duathlon and the end time in the top ten men and women from each of the AG. These AG are established by the ITU, in 5 years' periods, discarding the groups of 70-74 years onwards by their low participation rate.

Data were averaged over the top 10 male and female duathletes in each year from 2005 to 2016, and the first running (1R), cycling (C), second running (2R), and total race (TR) performance times were converted to minutes. Then, the percentage of time that athletes spend on the 1R/C/2R relative to the TR time was calculated. Finally, in order to examine the age-related declines in performance in 1R/C/2R, and TR, a performance ratio was calculated as the mean time performance of the best performing AG divided by the individual performance time.¹³

Statistical analysis

Data are reported as mean (standard deviation) in the text and the table, and displayed as mean (standard error) in the figures. Two-way

analyses of variance (ANOVA) were used to examine the sex differences and age-related changes on performance (time, percentage of time and performance ratio) in the 1R/C/2R, and TR. Subsequently, the post-hoc with the Bonferroni adjustment was used for pairwise comparisons. All statistical analyses were performed using the SPSS Version 21.0 for Windows (IBM® SPSS® Statistics). The statistical significance level was set at $p < 0.05$.

RESULTS

From 2005 to 2016, a total of 9,772 duathletes (6,739 men and 3,033 women) participated in the 18-19 to 85-89 AG categories at the ODWCH. Nonfinishers represented $4.0 \pm 1.6\%$ (0.0-8.8%) of the starters for the men and $2.3 \pm 2.3\%$ (2.3-8.3%) for the women. The AG 40-44 years was the one with the largest participation for both males (874) and females (483). Figure 1 shows the number of finishers separately by sex and AG.

Table 1 shows the performance times of the 1R/C/2R, and TR for the top 10 male and female athletes in each AG. Due to the limited valid number of athletes in some AG, analyses were performed with the AG from 20-24 to 65-69 years. On average, men and women respectively, performed the duathlon race on $126.3 \pm 2.5/149.7 \pm 21.4$ min, 1R on $37.2 \pm 4.3/44.6 \pm 7.2$ min, C on 66.7 ± 8.0 min/ 77.9 ± 11.7 and 2R on $20.1 \pm 2.5/24.2 \pm 4.5$ min.

Figure 2 shows the sex differences and age-related changes of the top 10 athletes in performance time in 1R/C/2R, and TR. For both men and women the mean age-related performance time increased in a curvilinear manner with advancing age. The results of the two-way ANOVAs on the average performance time showed a statistically significant interaction effect between sex and AG ($p < 0.001$). Additionally, overall statistically significant differences between both sex and AG separately were also found ($p < 0.001$). Subsequently, the post-hoc pairwise comparisons with the Bonferroni adjustment showed that on average men had a statistically significant better performance than women in all AG ($p < 0.001$).

Regarding the AG analyses, the pairwise comparisons with the Bonferroni adjustment showed that for male athletes the best time was in the AG 25-29 years for 1R and 2R, but not statistically significant differences in performance times were observed between this AG and 20-24, 30-44 years (and 45-49 years for the 2R) ($p > 0.05$). For C and TR the best time in male athletes was in the AG 30-34 years, but not statistically significant differences in performance times were observed between this AG and

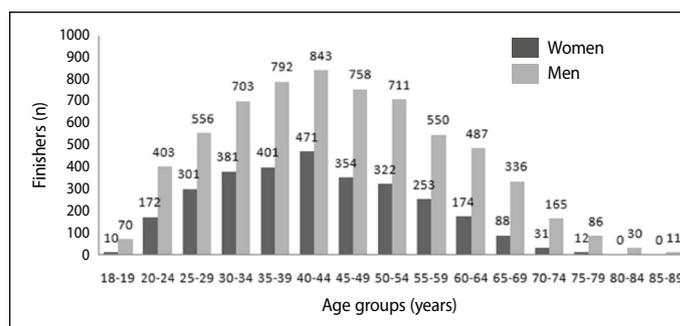


Figure 1. Number of finishers separately by sex and age groups at the Duathlon World Championships from 2005 to 2016.

Table 1. Performance times (minutes) of the first running, cycling, second running, and total race for the top 10 male and female athletes in each age group at the Duathlon World Championships.

Age	Men					Women				
	N	Running	Cycling	Running	Race	n	Running	Cycling	Running	Race
20-24	118	34.9 (2.7)	64.7 (6.3)	19.1 (1.6)	120.7 (8.8)	105	42.5 (4.0)	77.7 (8.5)	23.4 (2.8)	146.2 (12.6)
25-29	120	34.2 (2.1)	64.0 (6.0)	18.5 (1.3)	118.7 (7.8)	119	41.2 (3.3)	74.9 (7.8)	22.4 (2.1)	141.1 (11.3)
30-34	119	34.3 (2.3)	63.3 (6.3)	18.6 (1.3)	118.2 (8.1)	117	39.8 (2.8)	72.2 (6.8)	21.4 (1.7)	135.9 (9.3)
35-39	120	34.7 (2.2)	63.7 (6.5)	18.7 (1.5)	119.1 (8.1)	119	40.5 (2.7)	73.1 (7.3)	21.7 (1.8)	137.8 (9.3)
40-44	120	34.9 (2.2)	64.0 (6.5)	18.7 (1.4)	119.6 (8.2)	119	41.2 (2.8)	73.8 (7.8)	22.1 (1.6)	139.7 (9.7)
45-49	120	36.0 (2.4)	64.8 (6.5)	19.3 (1.5)	122.4 (7.8)	120	41.9 (3.2)	74.9 (8.0)	22.5 (1.9)	141.9 (10.0)
50-54	120	37.5 (2.1)	67.1 (6.9)	20.3 (1.3)	127.2 (8.3)	119	44.2 (3.7)	77.4 (9.1)	23.9 (2.5)	148.4 (12.5)
55-59	119	39.3 (2.4)	68.4 (7.2)	21.1 (1.4)	131.5 (9.3)	111	48.4 (4.4)	81.5 (12.0)	26.4 (3.1)	159.6 (17.6)
60-64	120	41.6 (2.9)	71.4 (8.7)	22.7 (1.9)	138.5 (11.0)	96	55.2 (6.9)	90.7 (16.9)	30.5 (4.4)	180.8 (23.9)
65-69	103	45.4 (3.9)	76.6 (8.8)	24.8 (2.3)	150.3 (11.6)	64	60.1 (8.2)	92.4 (14.3)	33.8 (6.3)	190.9 (23.6)
Total	1,179	37.2 (4.3)	66.7 (8.0)	20.1 (2.5)	126.3 (13.2)	1,089	44.6 (7.2)	77.9 (11.7)	24.2 (4.5)	149.7 (21.4)

Values are reported as mean (standard deviation).

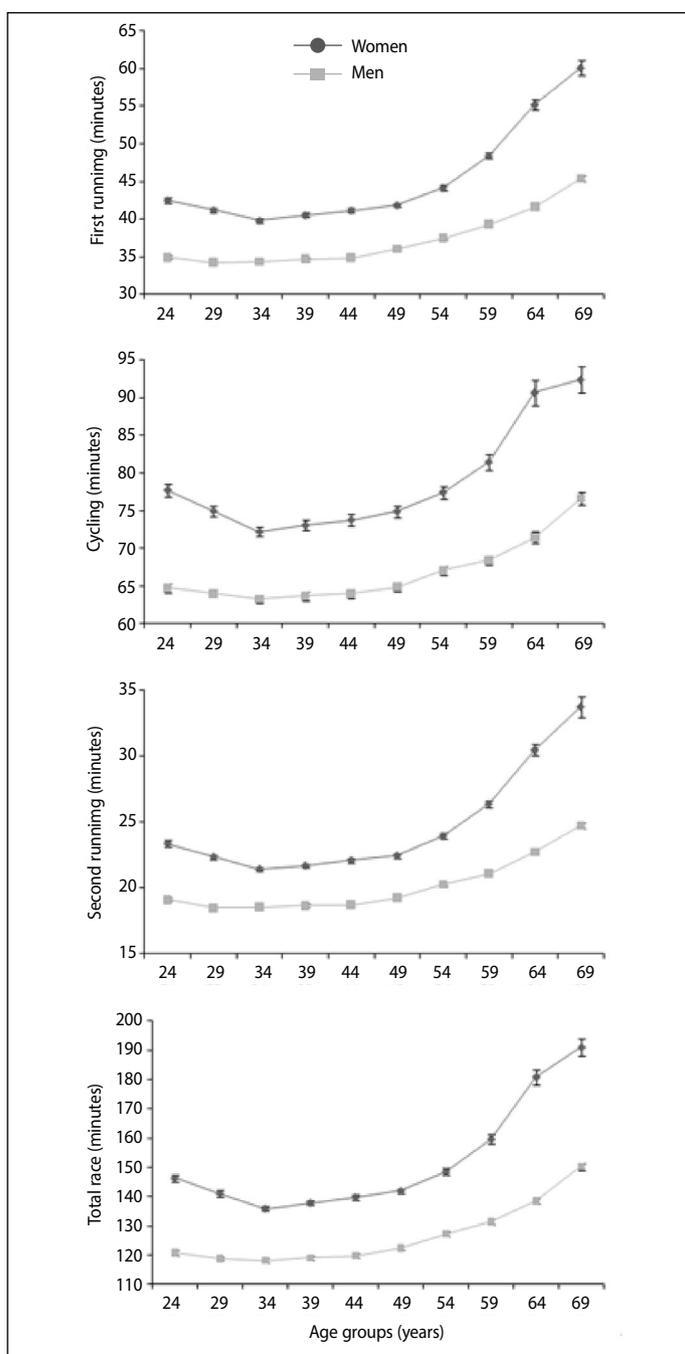


Figure 2. Sex differences and age-related changes of the top 10 athletes in performance time (minutes) in first running, cycling, second running and total race at the Duathlon World Championships (mean \pm standard error).

20-29, 35-49 years ($p > 0.05$). For the female athletes the best time was in the AG 30-34 years, but not differences in performance times were observed between this AG and 25-29, 35-44 years for the 1R and 2R, and 25-29, 35-49 years for C, and 35-44 years for TR ($p > 0.05$).

Figure 3 shows the sex differences and age-related changes of the top 10 athletes in relative performance (percentage of the TR time) in 1R/C/2R and TR. The results of the two-way ANOVAs on the average percentage of the TR time at the C and 2R relative to the TR showed a statistically significant interaction effect between sex and AG ($p \leq 0.001$); for the 1R tend to be significant ($p = 0.098$). Additionally, overall statistically significant differences between both sex and AG separately were also found (1R/C/2R) ($p < 0.001$). Subsequently, the post-hoc pairwise comparisons with the Bonferroni adjustment showed that male and female athletes had a similar relative performance in the 1R/C/2R from the AG 20-24 to 50-54 years (except for the C in the AG 25-29 years that was different, $p = 0.032$) ($p > 0.05$). However, from the AG 55-69 years on average men had a statistically significant better relative performance in the 1R and 2R than females ($p < 0.05$), meanwhile it was better for women in the C ($p < 0.01$). Regarding the AG analyses, the pairwise comparisons with the Bonferroni adjustment showed that for both male and female athletes the relative performance in the 1R/C/2R was similar from the AG 20-24 years to 50-54 years ($p > 0.05$), meanwhile with age the relative time was significantly increasing in the 1R and 2R and decreasing in the C ($p < 0.05$).

Figure 4 shows the sex differences and age-related changes of the top 10 athletes in performance ratio in 1R/C/2R and TR. For both men and women, the mean age-related performance ratio in the 1R/C/2R and TR decreased in a curvilinear manner with advancing age. The results of the two-way ANOVAs on the average performance ratio showed a statistically significant interaction effect between sex and AG ($p \leq 0.001$). Additionally, overall statistically significant differences between both sex and age categories separately were also found ($p < 0.001$). Subsequently, the post-hoc pairwise comparisons with the Bonferroni adjustment showed that on the performance ratio there were not statistically significant differences between male and female athletes in the AG from 30-34 to 50-54 years (and 25-29 in C) ($p > 0.05$). However, for the rest of AG the women's performance ratio was statistically significant lower than men ($p < 0.05$).

DISCUSSION

It was found that from 2005 to 2016, there was a 62% increase in participation rates in all AG.

The AG with the widest participation, in both the male and female categories, was age 40-44. These results differ from those found in different triathlon events, in which the AG with the highest participation

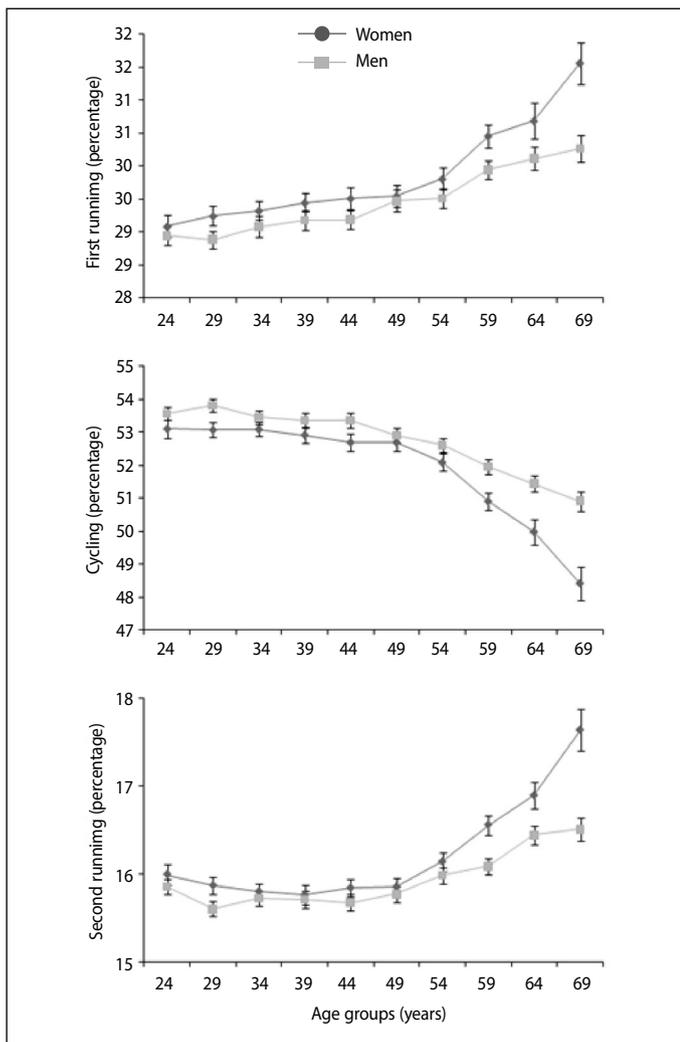


Figure 3. Sex differences and age-related changes of the top 10 athletes in relative performance (percentage of the total race time) in first running, cycling and second running at the Duathlon World Championships (mean \pm standard error).

was 35-39 years for men and 30-34 years for women, at Ironman 70.3¹⁹ distance and Olympic distance.⁴

Among the finisher duathletes, it was found that women were on average 23.5% of participants in the different AG, a percentage that looks similar if it is compared it with 27.2% of women finishers in the Hawaii Ironman and 18% in Ironman qualifiers.²

According to the results of the present study, shown in Table 1, as regards performance in the top 10 male and female athletes in each AG, the percentage differences between gender in the fastest AG in 1R/C/2R and TR were 16.37%, 14.06%, 15.67% and 14.97%, and 32.37%, 20.62%, 36.29% and 27.01% in the slower AG. Of the 10 AG analyzed, the smallest differences between genders in TR time correspond to AG between 30-34 and 50-54. In general, the differences between gender in the different legs and TR time increase with age. C is the segment with the fewest differences in performance between men and women, with running being where the greatest differences occur.

In the Olympic distance on the Zurich triathlon between 2000 and 2010, for elite top five overall triathletes, mean gender differences in swimming, cycling, second running legs and TR were 15.2%, 13.4%, 17.1%, and 14.8%, respectively.⁴ Our gender-based differences in performance in 1R/2R are similar to those obtained in the previous study. In the C, it was found a slight difference that is greater in the duathlon than in the triathlon, possibly linked to the difference in the first leg that precedes C in both events, swimming in the triathlon,

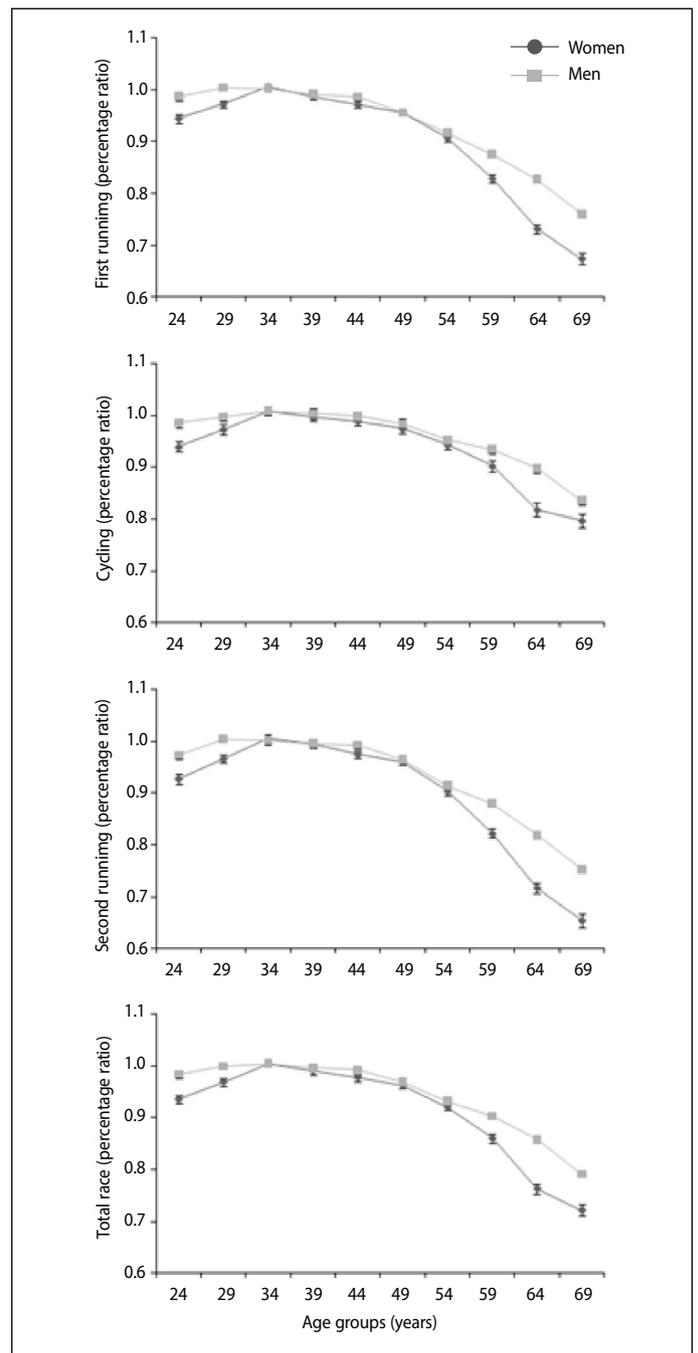


Figure 4. Sex differences and age-related changes of the top 10 athletes in performance ratio in first running, cycling, second running and total race at the Duathlon World Championships (mean \pm standard error).

and running in the duathlon. The TR time could also be affected for this reason, as it has found differences somewhat higher than those established in the previous study.

In our study the peak performance of the top ten competitors in short duathlon from 2005 to 2016 was in the AG 30-34 in both gender. In contrast with Etter et al.,⁴ where the mean age of the top five competitors in short triathlon from 2000 to 2010 was established at 26.8 years in men and 28.4 years in women.

According to the results of Knechtle et al.,¹² the mean ages in which the best results are achieved in the total running time increase as the competition distance increases, and that is 27.1 years in men at Olympic distance, 28.0 years at Half-Ironman and 35.1 years at Ironman distance, and 26.6, 31.6 and 34.4 years respectively in the case of the female category. Our study agrees with the age of TR time of best results in men (25-29 years) but not in woman (30-34 years).

According to the results of our study, shown in Figure 2, gender-related performance differences, for both men and women, the mean age-related performance ratio in the 1R/C/2R and TR decreased in a curvilinear manner with advancing age. Results confirmed in other studies completed on Olympic distance triathlons.²⁰

With regards to the different duathlon legs, in our results the best time for men in the 1R/2R was achieved by the 25-29 AG, although there were no statistically significant differences in race times between this AG and the 20-24, 30-44 year groups (and 45-49 years for the 2R). For women, the best time was in the 30-34 AG, with no significant differences being observed in performance times between this AG and the 25-29, 35-44 AG for the 1R/2R.

The long-distance duathlon study establishes that the best times for men in the 1R/C and TR times are achieved by AG between 25 and 39 years, for the 2R between 25-44 years.¹¹

Studies on international triathlon competitions at Olympic distance put the mean age of the top 10 at 27.1 and 26.6 years in men and women respectively.¹² Although the decline in performance in men does not appear before the age of 45, whereas in women it appears earlier at 40, with no significant reduction until after age 50 in both study populations.¹⁸

In the C, our results show that the best time in male and female athletes is in the 30-34 AG, although there were no statistically significant differences with AG from 20 to 49 years and 25 to 49 years in men and women respectively. These results, as in the previous running legs, partially tally with those found in other studies, principally depending on the competition distance, with the best results in C seen in the AG between 25 and 39 years in the long-distance duathlon.¹¹

Just as in the study conducted on long-distance duathlon,¹¹ in our results it can be seen that changes in performance across the AG are greater in running than in the cycling leg.

A study on Olympic distance triathlons at the World Championships 2009-2014 supports our results, with women being on average slower

than men in swimming, C and TR time in the AG 18-24 to 70-74 years, but not in the 75-79 AG.²¹

Due to these results, it would be interesting to determine whether these changes as a factor in performance in the different AG, and according to gender, are similar in short distance duathlons, as a potential way of establishing our training strategies for the different events and distances. It has therefore analysed the results of participants in the ITU ODWCH event over more than one decade (2005-2016).

According to the results obtained in our study, the best results in the professional career of a duathlete should be planned to be achieved between 30-35 years. Furthermore, based on the results, and in our opinion, results in performance or sporting success in our discipline should not be forced before age 25, after which improvements begin to be consolidated until achieving peak performance in the 30-34 age bracket.

CONCLUSION

According to the results of our study, shown in Table 1, as regards performance in the top 10 male and female athletes in each AG, the percentage differences between gender in the fastest AG in 1R/C/2R and TR were 16.37%, 14.06%, 15.67% and 14.97%, and 32.37%, 20.62%, 36.29% and 27.01% in the slower AG. The smallest differences between gender and the different duathlon legs and TR is in group 30-34. The biggest difference in C and TR are given in the group 60-64. (Table 1) The best time for men in the 1R/2R was achieved by the 25-29 AG, and for women, the best time was in the 30-34 AG. Although in C and TR the best time for both gender was 30-34 AG. Due to the lack of publications on duathlon, and specifically on the performance in the duathlon AG, it has been inevitable to use publications focused on the elite and the triathlon to discuss this article.

All authors declare no potential conflict of interest related to this article

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. ORR: writing the article, reviewing and carrying out the surgeries; EFR: writing and revision of the article as well as all the intellectual content of the article; DMV: statistical and data analysis, surgeries and revision of the article; RMM: analysis of slides and revision of the article; RP: surgery, revision and intellectual concept of the manuscript. All authors reviewed and approved the final manuscript.

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