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Original Article

Origin and age group of the fastest amateur triathletes competing in 'Ironman Hawaii' between 2003 and 2019

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ABSTRACT

Little is known about the prevalent nationalities among the best-placed athletes participating in "Ironman Hawaii." Moreover, the age at which athletes achieve their best performances remains unclear. The present study aimed to compare the prevalent nationalities among the athletes, their respective placement among the top five, and the performance difference between the different age groups in 'Ironman Hawaii' from 2003 to 2019. A total of 30 354 amateur triathletes were selected from the Obsessed Triathlete (OBSTRI) website. A "TOP 5" division filter was applied for further analysis, resulting in 1 851 athletes being included in this study. Among the male runners, Americans participated the most in Ironman events (39%), followed by Germans (10%). Among female runners, Americans participated the most (54%), followed by Australian runners (8%). Male Americans also featured most among the top five (30%), followed by Germans (16%). Female Americans were the most prevalent among the top five (47%), followed by Australian Americans (10%). There were no significant performance differences ($p > 0.05$) between the 25–29 and 40–44 age groups for either sex. The 45–49 age group presented significantly worse performance than the 35–39 age group for both sexes ($p < 0.001$). North Americans were the most performant and frequent participants in "Ironman Hawaii." The expected performance decline due to aging was observed after 45 years in both sexes.

1. Introduction

The IRONMAN® is considered the most popular long-distance triathlon.[1] It covers three sequential activities without intervals,[2] including 3.8 km of swimming, 180 km of cycling, and 42.195 km of running.[3] Every year, an impressively high number of professional and amateur athletes join qualifying races worldwide to participate in the "Ironman Hawaii".[1,4] It is considered the World Championship of Ironman triathlon races 5 and one of the 12 toughest endurance races in the world.[3]

Over the last decades, the number of triathletes and World Championship participants has increased.[2,5] In 1978, 12 competitors finished in the world's first Ironman triathlon event off the beach of Waikiki, in Honolulu, Hawaii[6]; however, the last edition (2019) had over 2100 competitors as official finishers.[7] Currently, there are 53 IRONMAN® races around the world (Africa: one race, Asia: five races, Europe: 22 races, North America: 18 races, Oceania: five races, and South America: two races) featuring amateur athletes from all over the world 9 divided by sex and age groups of 5-year-intervals.

According to the Professional Triathletes Organization, a recent entity consisting of non-drafting professional triathletes, the top 10 elite male triathletes are composed of three athletes from the United States, three from Germany, one from Norway, one from Denmark, one from Great Britain, and one from Canada. The top 10 elite female triathletes consist of three from Great Britain, two from United States, two from Germany, one from Switzerland, one from Canada, and one from South Africa.[8]

Despite the above elite triathlete nationalities data, little is known about the nationalities of the best amateur triathletes participating in the IRONMAN®. Similarly, not much is known about the magnitude of representativeness of each country in the competitions. Another point of interest is the effect of aging on long-distance events. It is known that the physiological functional capacity declines with advancing age and affects sports performance.[9,10] Athletes have been observed to reach peak

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Abbreviation list

e.g.	(exempli gratia)
Vs	(versus)
OBSTRI	(Obsessed Triathlete)
VO_{2max}	(maximal oxygen uptake)

performance in endurance sports just before reaching 30 years.[11,12] However, in the IRONMAN® triathlon, performance seems to plateau after 30 until approximately 40 years. This is followed by a moderately negative slope for the next two decades, with a steep decline afterward.[12–15]

However, whether this occurs similarly in males and females is unknown. The present study aimed to compare the prevalent nationalities among the athletes, their respective placement among the top five, and the performance difference between the different age groups in 'Ironman Hawaii' from 2003 to 2019 for both males and females. Considering the data aggregated for elite runners, we hypothesized that participants from Europe and North America would perform best and be among the top five when observing the overall finish time. We also expected the best race time to be achieved between 30 and 40 years of age for male and female athletes, with a significant drop in performance after this age.

2. Methods

2.1. Ethical approval

The study was approved by the Institutional Review Board of Kanton St. Gallen, Switzerland. Institutional Review Board of Kanton St. Gallen, Switzerland waived the need for informed consent of the participants as the study involved the analysis of publicly available data (EKSG June 01, 2010). The study was conducted following recognized ethical standards according to the Declaration of Helsinki adopted in 1964 and revised in 2013.

2.2. Data collection

The "Ironman Hawaii" data for males and females between 2003 and 2019 were obtained from the Obsessed Triathlete (OBSTRI) website (data publicly available).[7] Since the study involved the analysis of publicly available data, the requirement for informed consent was waived. All data were analyzed according to the principle of respect for persons, which encompasses the guarantee of privacy, confidentiality, and anonymity. All methods were performed in accordance with relevant guidelines and regulations. Only competitors classified as amateur athletes were selected for this study, making 30 354 participants initially available. The exclusion criteria included incomplete data for nationality, sex, overall time, position, or year of edition, and lack of male and female athletes in the same age group. After reviewing this information, 26 participants were excluded from the study, including 15 athletes with incomplete information and 11 male athletes from the last two age groups (80–84 and 85–89 years) with no female athletes in the same age group.

At the end of the initial stage, 30 328 participants from 125 countries were selected. Table 1 shows the five most prevalent nationalities competing in Ironman Hawaii. The five best athletes (TOP 5) from each age group and sex were selected for further analysis, resulting in 1881 athletes (Fig. 1). The five most prevalent nationalities in the top five age groups were selected for further analysis. The remaining countries were divided into six groups (Table 2). After selecting the top five athletes for each age group and sex per year, with the results of 17 years, each age group included 85 athletes per year for analysis. There were a few exceptions in the older age groups that failed to reach this number in two male divisions (70–74 and 75–79 years) and three female divisions (65–69, 70–74, and 75–79 years) due to the lower number of participants.

For investigation purposes, the top five frequencies considered the frequency of each country's athletes in the top five of their respective age groups were analyzed for each of the six selected countries by sex and are presented for male (Fig. 2) and female groups (Fig. 3).

2.3. Statistical analysis

Descriptive data were presented as means and confidence intervals and were displayed by age group. Data were tested for normal distribution and homogeneity and did not succeed according to the Shapiro-Wilk and Levene's tests, respectively. A generalized linear model with a gamma probability distribution and log link function was used to investigate the effects of athlete nationality and variations in overall race time. Moreover, the Kruskal-Wallis non-parametric test with independent variables and pairwise comparison was used to analyze the impact of age group and overall time, aside from the nationality of the selected athletes.

The Akaike Information Criterion was used to select the distribution of the dependent variable and link function, looking for the lowest value found after multiple model testing. Differences were investigated using the post hoc Bonferroni test. The level of significance was set at $p < 0.05$. SPSS version 26.0 (SPSS Inc., Chicago, IL, USA) was used for all statistical analyses.

3. Results

The countries that most frequently participated in male competitions were the United States (n = 7 833; 39%), Germany (n = 2 467; 10%), Australia (n = 1 973; 8%), Belgium (n = 552; 2%), and Canada (n = 1 064; 5%). In female competitions, the most frequently participating countries were the United States (n = 3 760; 54%), Australia (n = 745; 8%), Canada (n = 597; 8%), Germany (n = 593; 6%), and Great Britain (n = 353; 4%), as presented in Table 1. The countries with the highest number of the top five male athletes in "Ironman Hawaii" from 2003 to 2019 were the United States (n = 300; 30%), Germany (n = 161; 16%), Australia (n = 86; 9%), Belgium (n = 45; 4%), and Canada (n = 43; 4%). For female athletes, the United States (n = 412; 47%), Australia (n = 91; 10%), Canada (n = 79; 9%), Germany (n = 73; 8%), and Great Britain (n = 43; 5%) had the highest number of athletes among the TOP

Table 1
Total number of participants in "Ironman Hawaii" from 2003 to 2019 from the most frequent nationalities.

Male athletes			Female athletes		
Nationality	Number of participants	Total frequency	Nationality	Number of participants	Total Frequency
United States	7 833	35%	United States	3 760	47%
Germany	2 467	11%	Australia	745	9%
Australia	1 973	9%	Canada	597	7%
Belgium	552	2%	Germany	593	7%
Canada	1 064	5%	Great Britain	353	4%
Others	8 387	38%	Others	2 004	25%

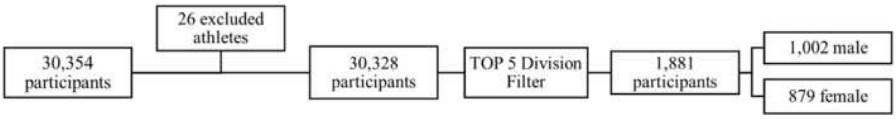

Fig. 1. Briefing of data collection.

Table 2
Countries presenting the greater number of top five athletes in "Ironman Hawaii" from 2003 to 2019.

Male athletes			Female athletes		
Nationality	Number of participants	Total frequency	Nationality	Number of participants	Total frequency
United States	300	30%	United States	412	47%
Germany	161	16%	Australia	91	10%
Australia	86	9%	Canada	79	9%
Belgium	45	4%	Germany	73	8%
Canada	43	4%	Great Britain	43	5%
Others	367	37%	Others	181	21%

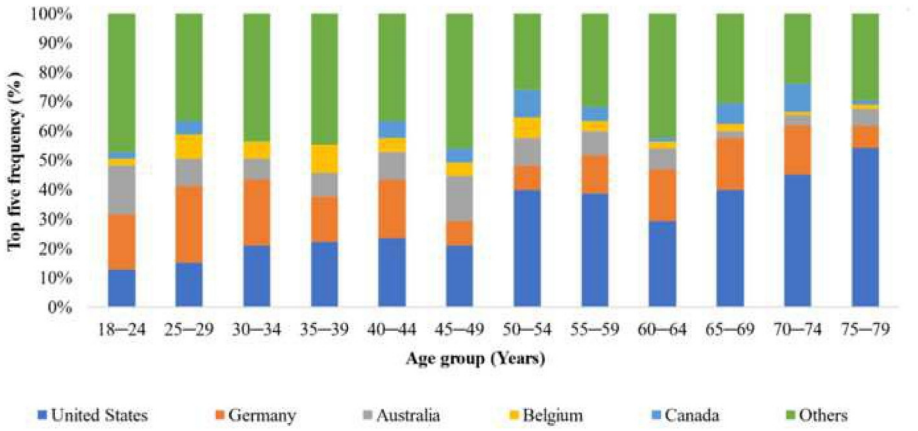

Fig. 2. Nationality frequency of top five male finishers in "Ironman Hawaii" by each age group for the male athletes.

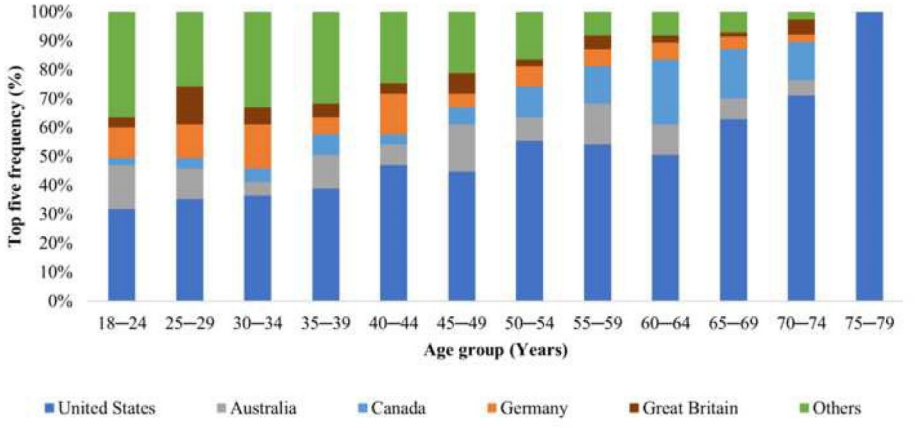

Fig. 3. Nationality frequency of top five female finishers in "Ironman Hawaii" by each age Group for the female athletes.

five (Table 2). Fig. 2 shows the frequency of each country among the TOP five for each male age group. Data showed that in males aged 18–24 and 25–29 years, athletes from Germany were more frequent among the TOP 5 than athletes from the USA. Only after 50–54 years was there a predominance of American athletes among the TOP 5. For the female groups, the predominance of American athletes among the TOP 5 across age groups was manifested from the younger age group (18–24 years old) (Fig. 3).

Fig. 4 compares the mean times for each male age group without considering the country of origin. Further investigation showed that the 18–24 years (10:40:37 ± 03:50:17) age group presented a higher overall mean time than the 25–29 years group ($p = 0.011$). After 25–29 years (10:19:03 ± 04:22:23) and until 40–44 years (11:03:29 ± 04:15:18), the age groups showed no significant differences ($p > 0.05$) in overall race time. After 45–49 years, the plateau trends established by the precluding age groups were broken, and the times progressively increased for older

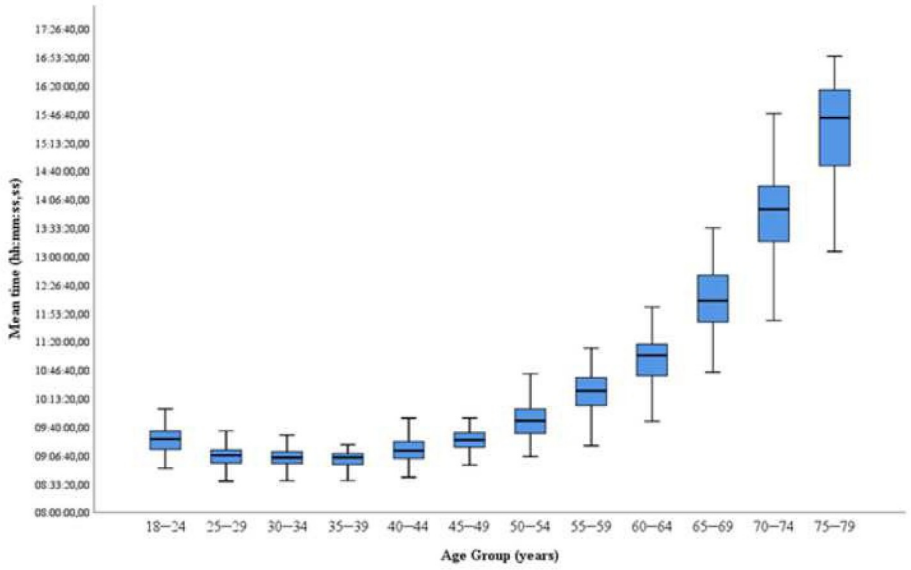

Fig. 4. Overall race time for each age group in "Ironman Hawaii" for the male athletes.

ages (Fig. 4). After 45–49 years, the difference between age groups was significant compared to the previous decade: 45–49 (11:24:37 ± 01:35:28) vs. 35–39 (10:39:09 ± 01:21:46) age groups ($p < 0.001$, mean difference 00:45:29), 50–54 (11:53:28 ± 01:38:41) vs. 40–44 (11:03:29 ± 01:30:42) age groups ($p < 0.001$, mean difference 00:49:59), 55–59 (12:29:08 ± 01:37:24) vs. 45–49 (11:24:38 ± 01:35:28) age groups ($p < 0.001$, mean difference 01:04:31), 60–64 (13:06:44 ± 01:33:50) vs. 50–54 (11:53:28 ± 01:38:41) age groups ($p < 0.001$, mean difference 01:13:16), 65–69 (14:09:22 ± 01:24:54) vs. 55–59 (12:29:08 ± 01:37:24) age groups ($p < 0.006$, mean difference 01:40:14), and 70–74 (15:09:38 ± 01:08:36) vs. 60–64 (13:06:44 ± 01:33:50) age groups ($p < 0.005$, mean difference 02:02:55). After 75–79 (15:35:55 ± 01:00:44) vs. 65–69 (14:09:22 ± 01:24:54) age groups, no significant differences were observed ($p = 0.134$, mean difference 01:26:33) (Fig. 4).

Fig. 5 shows the mean times for each female age group without considering the country of origin. Initial examination showed that women in the 18–24 years (12:10:02 ± 03:42:07 age group seemed to present higher overall race times than those in the 25–29 years (11:31:08 ± 03:36:35) group like their male counterparts ($p < 0.001$). Moreover, in agreement with the pattern observed in the male age groups, the 25–29 and 40–44 years (11:57:44 ± 03:44:15) age groups showed a plateau in performance, and no significant difference was observed ($p > 0.05$). In addition, female triathletes broke this plateau at the same age as males in the 45–49-year age group. As the athletes got older, a significant difference in performance appeared when compared to the previous age decade: 45–49 (12:26:35 ± 01:24:13) vs. 35–39 (11:43:39 ± 01:12:33) age groups ($p < 0.001$, mean difference 00:42:56), 50–54 (13:00:15 ± 01:24:43) vs. 40–44 (11:57:44 ± 01:16:32) age groups ($p < 0.001$, mean difference 01:02:30), 55–59 (13:37:56 ± 01:23:37) vs. 45–49 (12:26:35 ± 01:24:13) age groups ($p < 0.001$, mean difference 01:11:21), 60–64 (14:33:38 ± 01:14:22) vs. 50–54 (13:00:14 ± 01:24:43) age groups ($p < 0.001$, mean difference 01:33:24), and 65–69 (15:22:47 ± 01:07:37) vs. 55–59 (13:37:56 ± 01:23:37) age groups ($p < 0.001$, mean difference 01:44:50). After the 70–74 (15:37:00 ± 00:58:04) vs. 60–64 (14:33:38 ± 01:14:22) age groups, no significant difference was observed ($p = 1$, mean difference 01:03:22) (Fig. 5).

4. Discussion

The main findings of the present study were that (i) North American amateur triathletes dominated the total number of participants and the number of athletes in the top five for male and female categories; (ii) North Americans presented older athletes on the Kona championship than others; (iii) the best overall race times were found in the 25–29, 30–34, 35–39, and 40–44 age groups for males and females; and (iv) after the age of 45–49 years, the overall race times increased with a significant difference in each age decade.

The first important finding was that the North American athletes consecutively achieved the best results and predominantly finished among the "TOP 5." This partially confirms our initial hypothesis that North American athletes will perform among the best and finish in the top ranking. Contrary to our prediction, European athletes did not perform similarly when observing overall race time. This can be explained by the IRONMAN® race distribution worldwide,[9] with the highest number of races occurring in North America. There are 11 IRONMAN® races in the United States of America, whereas there are only 20 in Europe. The number of North American athletes participating in all IRONMAN® races is substantially higher than that of athletes from other countries. Therefore, Americans have become more experienced, which can positively influence the number of Americans participating in the Kona Ironman World Championships.[1,16] It is important to note that there is an established relationship between the number of participants and the frequency of achieving the top five placements. Americans were the most numerous at the starting line, with a significant margin (14% for males and 37% for females), compared to the second most numerous. Despite a significant decrease, they achieved more top-five placements among all the nations represented. In contrast, other nationalities, especially Germany and Australia, achieved an increased percentage of the top five placements with fewer athletes at the starting line. This finding suggests that triathletes who qualify for North American regional races or other events outside their country are better prepared and contribute to a higher percentage of the top five placements with fewer athletes, especially in younger age groups.

When analyzing the participation of the top five age group athletes by nationality, a relevant, progressive increase in Americans participating in older age groups, in both male and female categories, was observed. This was most evident in the 75–79 female age group, where only American amateur triathletes reached the podium. It is essential to highlight the longevity of American triathletes, which may result from successful physical activity programs for older adults.[17,18]

Moreover, by evaluating the last 17 years of the Ironman Kona World Championship mean race times divided by age categories, we recorded similar race times among younger age groups (25–29 to 40–44 years), with a significant decline starting at 45–49 years, imposing a broader age

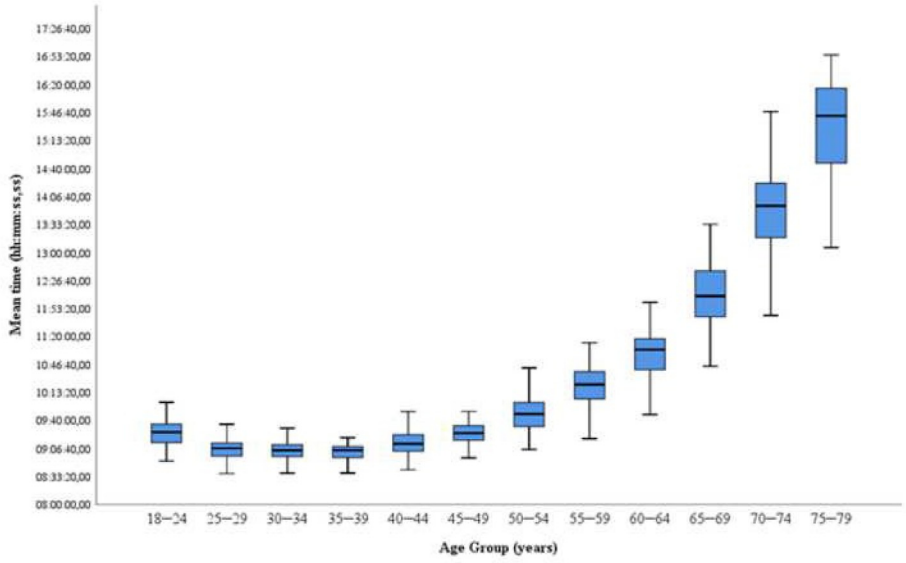

Fig. 5. Overall race time for each age group in "Ironman Hawaii" for the female athletes.

range for the best race times than initially expected in our hypothesis (30–40 years). Nonetheless, the predicted starting age for the decline in performance was correct. The youngest age group (18–24 years) showed significant improvement in performance with age. This reinforces that experience and training[19] contribute significantly to the final performance. No significant differences in mean race times were found between the 25–29, 30–34, 35–39, and 40–44 age groups of males and females. Overall, race times began to decrease after age 45–49 years.

One of the main physiological determinants of aerobic performance is maximal oxygen uptake ($\dot{V}O_{2max}$).[20] $\dot{V}O_{2max}$ has been described as negatively affected by aging,[21] and the decline was 0.65 mL/kg/min per year for males and 0.39 mL/kg/min per year for females.[21] The loss of performance resulting from the $\dot{V}O_{2max}$ decline with aging could be offset by the gain in experience,[20] which positively affects performance,[19] at least up to age 45 years old, when the loss of performance becomes more evident.

After 45–49 until 70–74 years for men and 65–69 age group for women, a significant difference in performance was observed compared with the previous decade. The differences observed up to the 70–74 years age group in men were probably not observed in women, mainly because of the sample size issue. Few women compete in these age groups, making it challenging to observe significant differences.

The observed performance decline with age in males and females followed the expected physiological and functional capacity of aged participants and the peak performance in endurance sports of older male and female athletes.[9–15]

The facts established by this investigation raise a possible discussion on the current division of age groups by 5 years. There was a trend of high proximity between race times in the 25–45 years categories and after 45–49 years of age. A significant difference was established only when comparing categories with 10 years difference. Perhaps age groups with a greater age range would not be disadvantaged in the actual competition and could make the amateur triathlon races even more competitive. The main advantage of this study is that it enrolled a significant sample and is the first to explore the trend of the participants' nationalities among amateur triathletes.

The main limitation includes not evaluating elite athletes that participated and were not included in the "TOP 5" filter. This would increase the sample size and reveal a different pattern. Further studies should be conducted to establish definitive patterns and to compare the best amateur and elite athletes.

5. Conclusion

American athletes have dominated the Ironman Kona World Championship over the last 17 years regarding the number of participants and the number of top five finishers. This dominance was even more evident in older age groups. In addition, the study showed that the decline in performance due to aging occurred significantly only after 45 years of age for both male and female athletes, after which the decline progressed in the older age group. The similar performance of age groups younger than 45 years could question the current age group division of 5 years.

Submission statement

All authors have read and agree with manuscript content. While this manuscript is being reviewed for this journal, the manuscript will not be submitted elsewhere for review and publication.

Ethical approval statement

The study was approved by the Institutional Review Board of Kanton St. Gallen, Switzerland. Institutional Review Board of Kanton St. Gallen, Switzerland waived the need for informed consent of the participants as the study involved the analysis of publicly available data (EKSG June 01, 2010). The study was conducted following recognized ethical standards according to the Declaration of Helsinki adopted in 1964 and revised in 2013.

Authors' contributions

Conceptualization, P·P and M.S.A.; methodology, A.S. and A.N·S.; software, A.S.; validation, P.P. and M.S.A.; formal analysis, A.S. and A.N·S.; investigation, P·P.; data curation, P.P. and M.S.A.; writing—original draft preparation, P.P. and A.N·S.; writing—review and editing, K·W and B. K.; supervision, B.K. and M.S.A. All authors have read and agreed to the published version of the manuscript. All authors contributed equally to the manuscript and read and approved the final version of the manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of interest

Beat Knechtle is an Editorial Board Member for Sports Medicine and Health Science and was not involved in the editorial review or the decision to publish this article. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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