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The aspect of nationality in participation and performance in ultra-marathon running—A comparison between 'Badwater' and 'Spartathlon'

B Knechtle[1,2]*, CA Rüst[2], T Rosemann[2]

Abstract

Introduction

The aim of the study was to investigate participation and performance trends in relation to the nationality of successful finishers in sing lest age ultra-marathons of more than 200 km.

Materials and methods

The association between sex and nationality with running speed was investigated in 'Badwater' (217 km) held in North America with 208 women and 818 men and 'Spartathlon' (246 km) held in Europe with 206 women and 1,814 men between 2000 and 2012.

Results

In 'Badwater', most of the finishes were achieved by athletes from the USA, followed by athletes from Germany and Great Britain. In 'Spartathlon', the highest number of finishes was obtained by athletes from Japan, followed by athletes from Germany and France, women from Japan, followed by women from Germany and the USA. In men, the fastest finishes were achieved by runners from Greece, followed by athletes

Conclusion

These results show that American ultra-marathoners dominated both participation and performance in 'Badwater' in the USA. In 'Spartathlon' in Europe, however, both female and male runners from Japan were dominating participation whereas male ultra -marathoners from Greece and female ultra-marathoners from Japan dominated performance. Future studies need to investigate participation and performance trends for Japanese ultra-marathoners in other races such as 100 km and 100 miles ultra-marathons.

Introduction

Participation in ultra-marathon running has become increasingly popular in the past years[1–5] and there has been an increased interest in investigating participation and performance trends in ultra-running[2–4]. Participation and performance trends in ultra-marathons have been mainly analysed for 161-km ultra-marathons held in North America[2–4] where Hoffman et al.[3] reported an exponential increase in the annual number of finishers during the past three decades. Although the number of participants increased, the overall number of competitors in ultra-marathons remained low[3] compared with running events of shorter distances such as a marathon[6]. The growth in the number of finishers in 161-km ultra-marathons was mainly due to an increase in the number of finishers older than 40 years and an increasing number of female finishers[3]. The number of female finishers in 161-km ultra-marathons increased from none in the late 1970s to nearly 20% women, where it has remained since 2004[3]. Regarding the increase in the number of older athletes, previous studies demonstrated that nearly 70%–80% of overall finishers in ultra-marathons were middle-aged and older ('master') athletes[3–5].

The performance in ultra-marathon running seemed to be influenced by a variety of different variables. The associations between physiological characteristics[7–9], psychological aspects[10], anthropometric characteristics[11–15], training variables[14,16,17] and the success in different running distances have been reported. Other aspects such as ethnicity and nationality of athletes also appeared to have an essential impact on endurance performance, especially in middle- and long-distance running[18–24]. Since the 1968 Mexico City Olympic Games, Kenyan and Ethiopian runners have dominated the international middle- and long-distance races[24]. Additionally, Kenyan athletes have dominated the International Association of Athletics Federations (IAAF) World Cross-Country Championships and road marathons[19,21,24].

The association between origin and performance in ultra-endurance has been recently investigated for ultra-distance multi-sports athletes[25–30] and multi-stage ultra-marathoners[31,32]. In both long-distance duathlons and triathlons[25–30] and ultra-marathons[31,32], mainly European athletes have dominated both participation and performance. These findings may emphasize the importance of factors such as origin and geography in other endurance sports disciplines such as long-distance running. In running, the majority of the most successful Kenyan runners originated from the Rift Valley province

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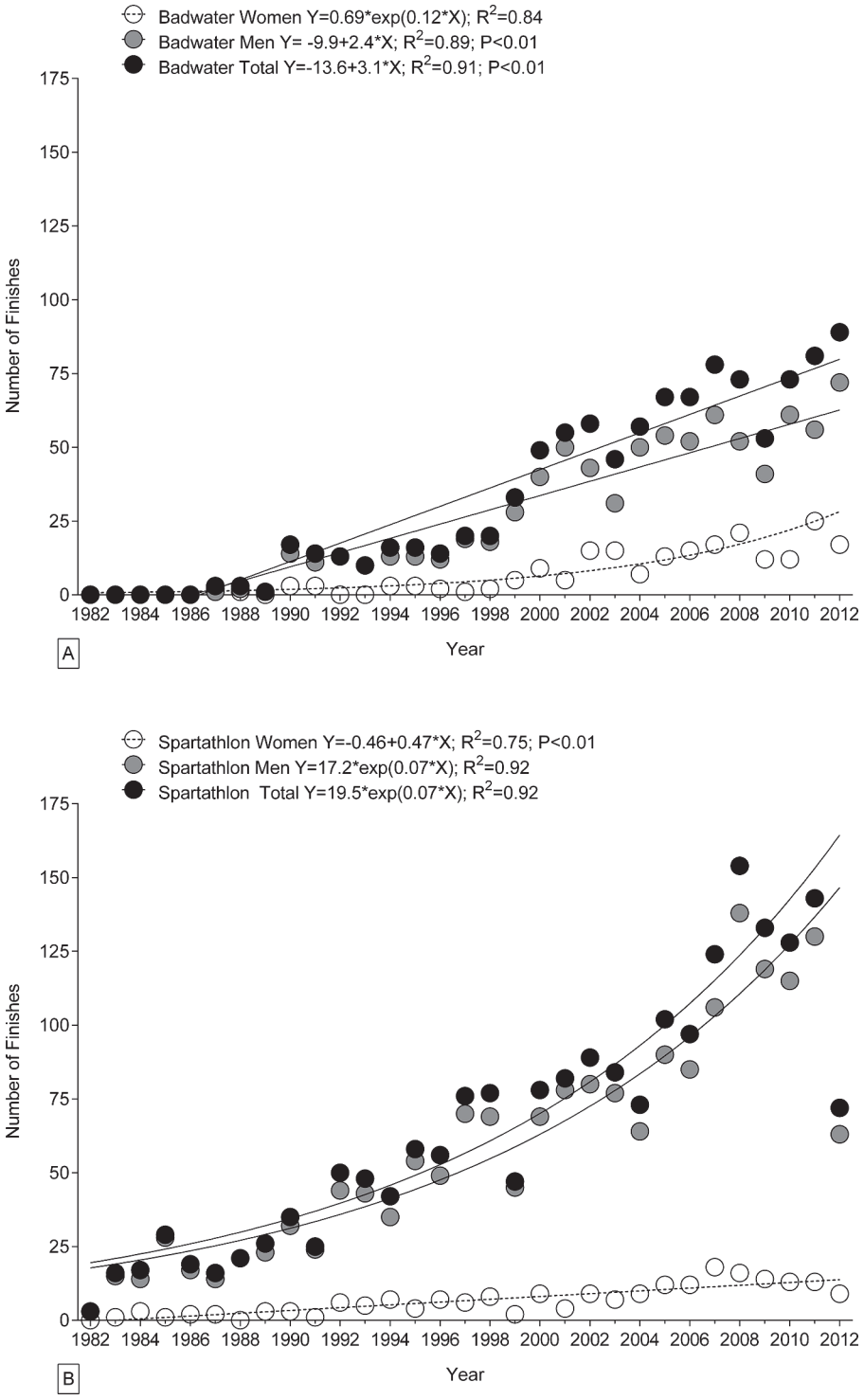

Figure 1: Annual number of female, male and overall finishes in 'Badwater' (panel A) and 'Spartathlon' (panel B).

and belonged to the Kalenjin ethnic group[21]. Kenyan runners, particularly the international athletes, originated from a distinctive environmental background regarding geographical distribution and ethnicity[21]. Living and training in the highlands of the Great Rift Valley may partly contribute to the excellent performance in distance running due to the chronic hypoxic exposure[24,33]. Kenyan runners had additionally to travel far to school when they were children, commonly by running[21]. Elite Kenyan runners seemed to have a very specific motivation to run fast in races. International Kenyan runners stated economic reasons to become a competitive athlete, as success in distance running enables them to advance to the top ranks in their society[21].

There seemed to be a difference between marathon and ultra-marathon running with regard to participation and performance trends. In the multi-stage ultra-marathon the 'Marathon des Sables' held in Northern Africa the men's race was dominated by Moroccan runners whereas the women's race was dominated by European runners[32]. Considering the nationality of athletes competing in ultra-marathon distances, the dominance of Japanese runners in 100-km ultra-marathon races is known. Regarding the world's best list in 100-km events, Japanese ultra-marathoners hold the current world records at 6 h 13 min 33 s for men and 6 h 33 min 11 s for women, respectively[34]. These findings highlight the importance of environmental, geographical and national aspects in ultra-endurance running. Since the dominance of East African runners in long-distance running up to the marathon is well known, the leading nations in ultra-marathon running in single-stage ultra-marathons are not known.

Recent studies suggested that European ultra-endurance athletes dominate participation and performance in races held in both Europe and America[27,28,30]. The present study compared participation and performance trends in ultra-marathoners competing in ultra-marathons of longer than 200 km held in Europe ('Spartathlon') and in the USA ('Badwater') with regard to the nationality of the finishers. These two races are

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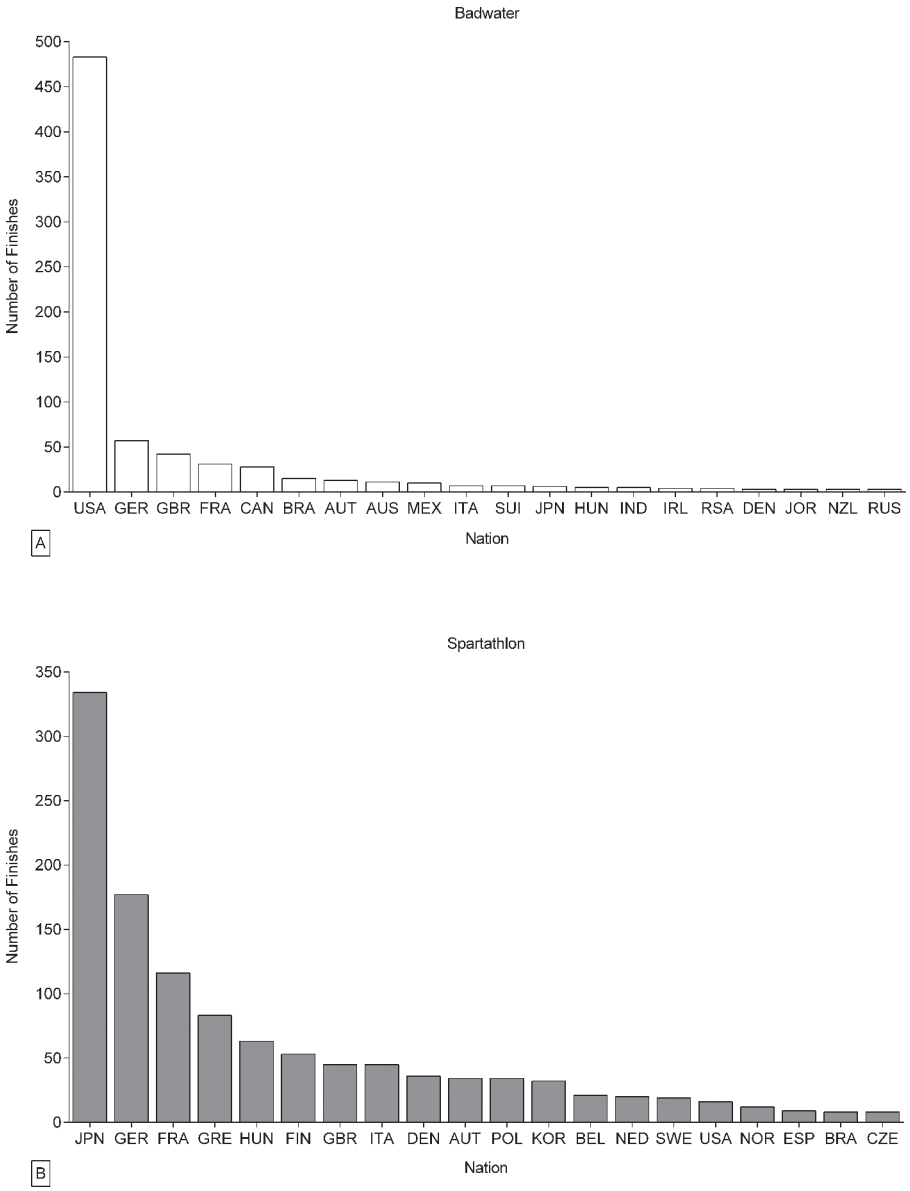

Figure 2: Number of female and male finishes in 'Badwater' (panel A) and 'Spartathlon' (panel B) sorted by the origin of the athletes. Results are sorted for the 20 countries with the overall highest number of finishes.

among the world's toughest races[35,36]. Respecting existing literature investigating the influence of nationality on performance in ultra-distance races, we hypothesized, first, an increase in participation across years where European athletes would participate in both the European and the American races. Second, we hypothesized that Japanese athletes would dominate these two ultra-marathon races even though the Kenyans dominated the Olympic long-distance track events and marathons.

Methods

The present study was approved by the Institutional Review Board of St. Gallen, Switzerland, with a waiver of the requirement for informed consent given that the study involved the analysis of publicly available data. The data set for this study was obtained from the race websites for 'Badwater'[37] and 'Spartathlon'[38]. All finishers in 'Badwater' and 'Spartathlon' between 2000 and 2012 were analysed with regard to the association between sex and age with performance.

The races

The 'Badwater' covers 217 km of highway non-stop across the Death Valley in California. The event was established as an official foot race in 1987 with five successful US participants. Since 1989, the race starts at Badwater, the lowest elevation in the Western Hemisphere at 85 m below the sea level and finishes at the Mt. Whitney Portals at nearly 2,530 m above the sea level. The course includes a total of 3,962 m of cumulative vertical ascent and 1,433 m of cumulative descent. During the race in the Death Valley in mid-July, the average daily high temperature reaches 46.9 °C, and temperatures over 50 °C are common[39]. There are no aid stations present along the 'Badwater' course, so runners mustrely on their own supporter-crew to make the passage across the Death Valley. The number of participants is limited to 90 competitors. The 'Spartathlon' started in 1982 and is a non-stop foot race in Greece covering 246 km from Athens to Sparta. Since 1983, the race has been consistently held every September. The course includes elevations that range from the sea level to 1,200 m above the sea level. The cumulative gain of elevations is approximately 1,650 m and the route runs on tarmac road, trail or mountain footpath. The weather conditions during the race are typically changing between warm temperatures of about 27 °C during the day and cold temperatures of about 5 °C during the night. Aid stations are placed every 3 to 5 km, which provide competitors with water and food. Each of the 75 race control points has its own time limitations and runners arriving later than the official closing time will be eliminated from the race. Nowadays, the number of applicants for the 'Spartathlon' exceeds the limit of 350.

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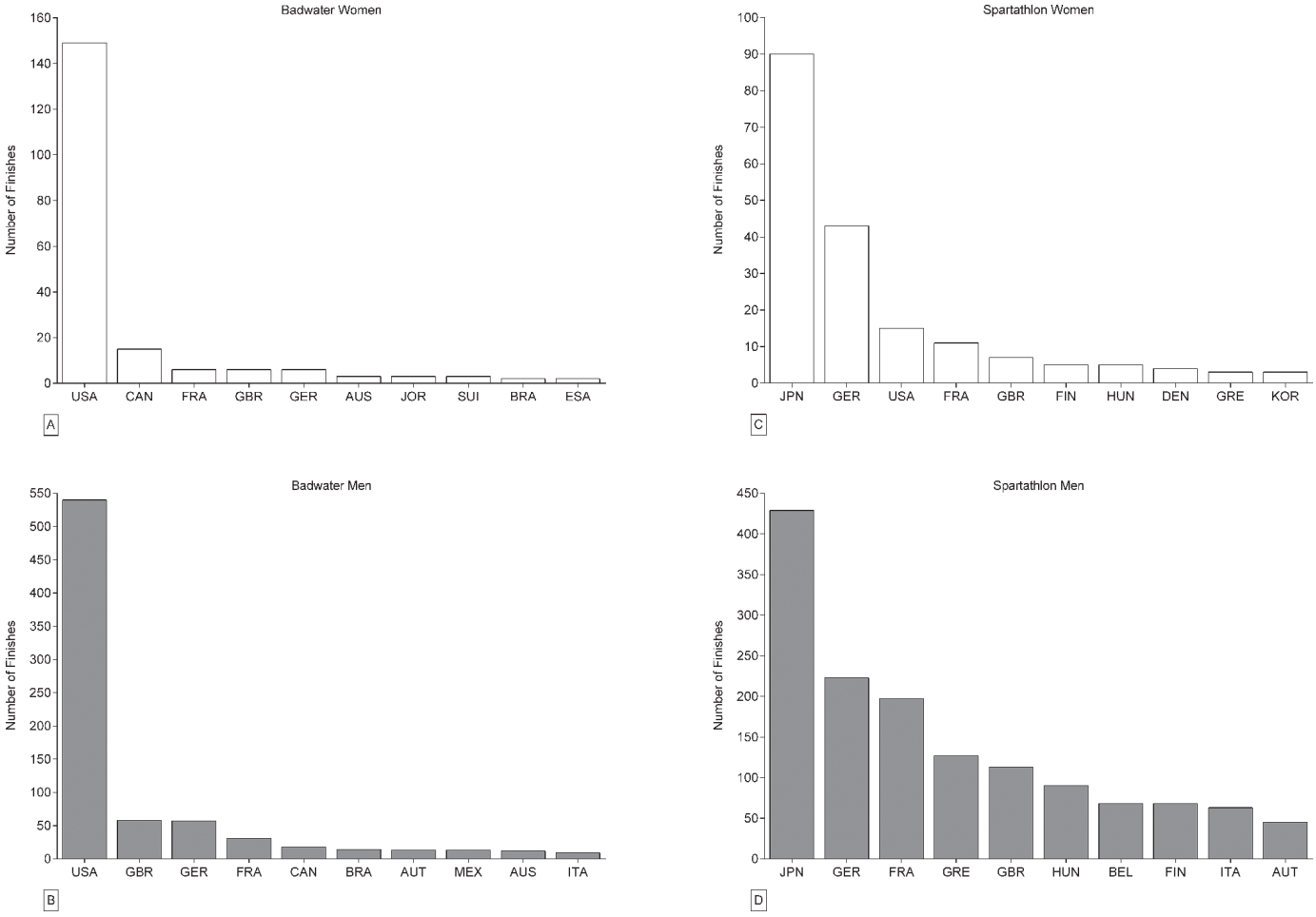

Figure 3: Number of finishes for women (panel A) and men (panel B) in 'Badwater' and women (panel C) and men (panel D) in 'Spartathlon'.

Data analysis

In order to increase comparability of data, all running times were converted to running speed prior to analysis using the equation running speed [km/h = running distance [km]/running time [h]. To obtain the most accurate results, conversion and further calculations were carried out to 10 decimal places. To analyse both the development of performance and the development of the age of peak performance over time in both women and men, the top five athletes (*i.e.* five fastest running speeds) per sex, year and race were determined and analysed for running speed and age. The sex difference between women and men was calculated using the equation sex difference [%] = (running speed in women [km/h] −running speed in men [km/h])/running speed in men [km/h] × 100. All sex differences were converted to absolute values. To analyse the development of performance regarding the nationality of the athletes, from all nations with at least one athlete per year the top performance (*i.e.* fastest running speed) per year, sex and race was determined and analysed. In 'Badwater', for both women and men, only athletes from the USA finished at least once per year. In 'Spartathlon', women from Japan and Germany and men from Japan, Greece, France, Hungary, Finland, Great Britain, Austria and Sweden finished at least once a year.

Statistical analysis

In order to increase the reliability of data analyses, each set of data was tested for normal distribution as well as for homogeneity of variances in advance of statistical analyses. Normal distribution was tested using the D'Agostino and Pearson omnibus normality test and homogeneity of variances was tested using the Levene's test in case of two groups and the Bartlett's test in case of more than two groups. To find significant changes in the development of a variable across years, linear regression analysis was used. To determine formulas describing the development of a variable across years, the first analysed year (*e.g.* 2000 or 2012) was defined as

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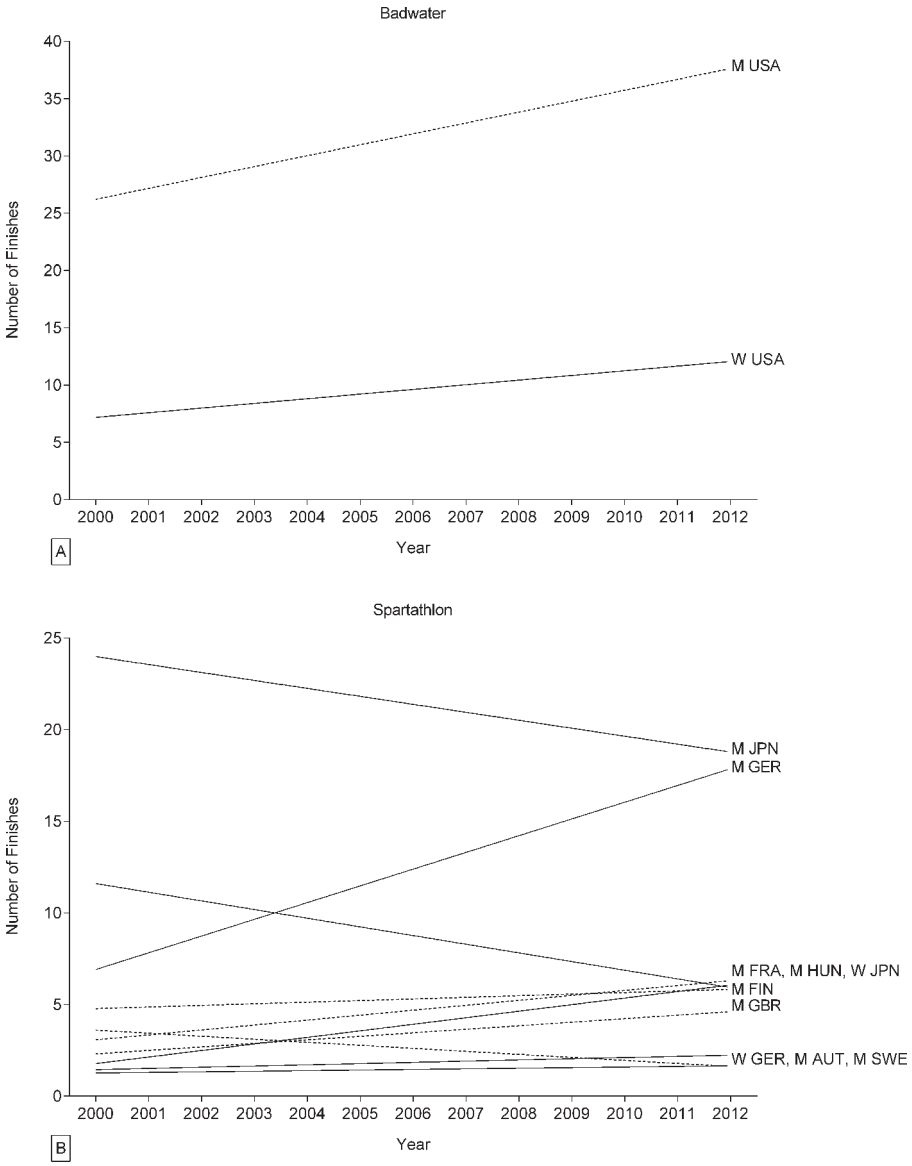

Figure 4: Annual number of finishes sorted by nationality in 'Badwater' (panel A) and 'Spartathlon' (panel B).

year = 0, thus formulas refer to year = relative year after the first year of analysis (e.g. 2012 = 12). To find significant differences between the two groups, a Student's t-test was used in case of normal distributed data (with additional Welch's correction in case of significantly different variances between the analysed groups) and Mann–Whitney test was used in case of non-normal distributed data. To compare the performance of women and men between the different competitions, a year-by-year analysis was performed using a two-way analysis of variance (ANOVA) with subsequent Bonferroni post-hoc analysis. The interaction between the type of competition and time (years) on performance in sex was analysed using a two-way ANOVA (competition × time). Statistical analyses were performed using IBM SPSS Statistics (Version 19, IBM SPSS, Chicago, IL, USA) and Graph Pad Prism (Version 5, Graph Pad Software, La Jolla, CA, USA). Significance was accepted at $p < 0.05$ (two-sided for t-tests). Data are presented as mean ± standard deviation (SD).

Results

Between 2000 and 2012, 183 women and 663 men finished successfully in 'Badwater' and 141 women and 1,166 men in 'Spartathlon'.

Participation trends

In 'Badwater', the number of male finishes increased linearly, whereas the number of female finishes increased exponentially (Figure 1A). The percentage of female finishes increased from no female finisher in 1982 to 19.1% female finishes in 2012. Over time, women accounted for 16.1 ± 14.2% of the field. In 'Spartathlon', the number of male finishes increased exponentially and the number of female finishes linearly (Figure 1B). The percentage of female finishes increased from no female finisher in 1982 to 12.5% female finishes in 2012. The percentage of female finishers was 9.5 ± 4.2% across years.

In 'Badwater', most of the finishes were achieved by athletes from the USA, followed by athletes from Germany and Great Britain (Figure 2A). In 'Spartathlon', the highest number of finishes was achieved by athletes from Japan, followed by athletes from Germany and France (Figure 2B). When women and men were separated, most of the female finishes in 'Badwater' were achieved by athletes from the USA, followed by athletes from Canada and France (Figure 3A). For men, again athletes from the USA achieved the highest number of finishes, followed by athletes from Great Britain and Germany (Figure 3B). In 'Spartathlon' the highest number of male finishes were attained by runners from Japan, followed by runners from Germany and USA (Figure 3C). For women, most of the finishes were achieved by athletes originating from Japan, followed by athletes from Germany and France (Figure 3D).

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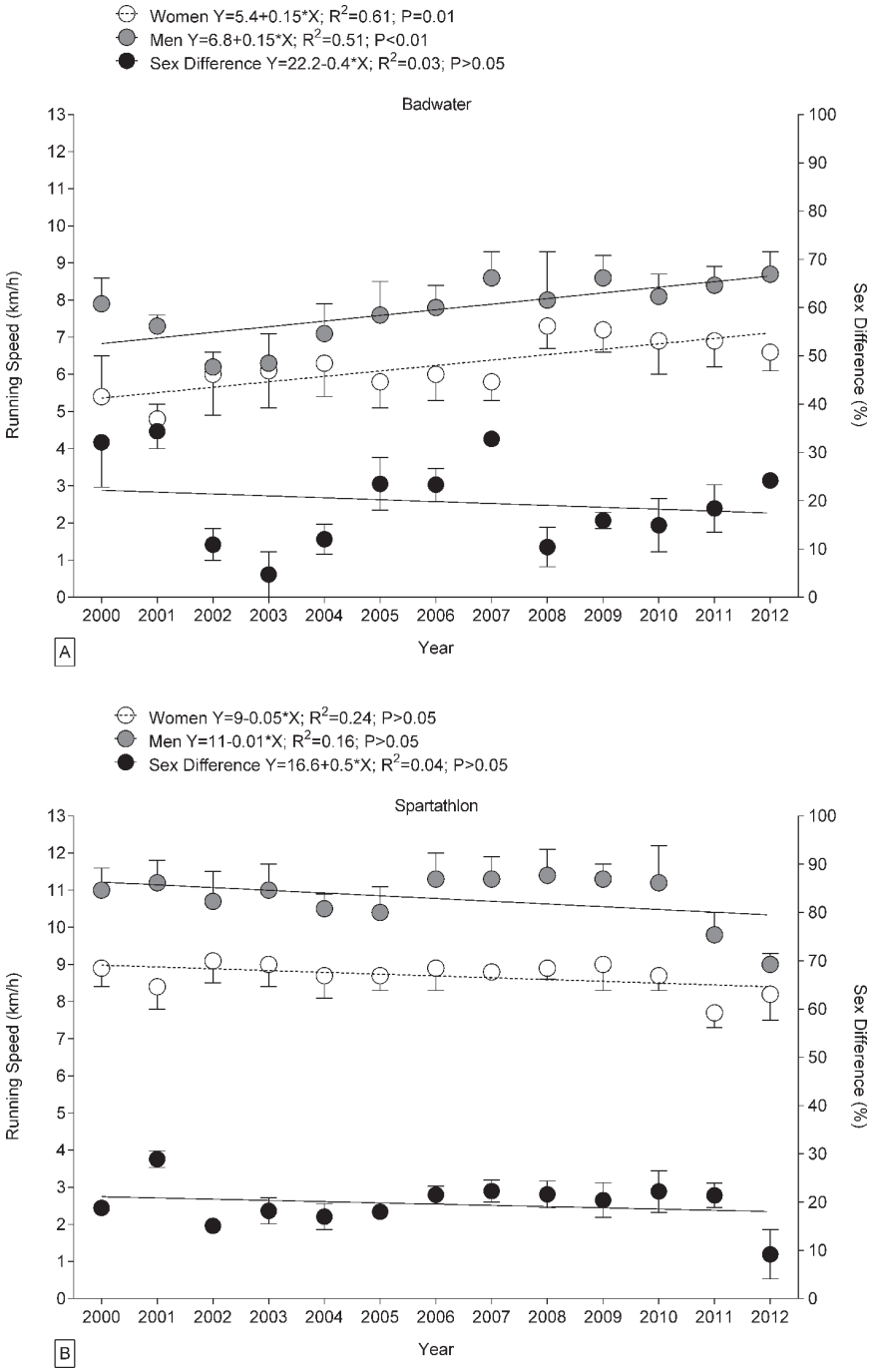

Figure 5: Running speed of the annual top five women and men in 'Badwater' (panel A) and 'Spartathlon' (panel B).

In 'Badwater', the annual number of male American finishes increased ($r^2 = 0.35$, $p = 0.03$) (Figure 4). In 'Spartathlon', the annual number of finishes increased for German men ($r^2 = 0.31$, $p = 0.04$) and decreased for Finish men ($r^2 = 0.31$, $p = 0.04$).

Performance trends

In 'Badwater', the running speed increased for both women and men (Figure 5A). In women, the running speed increased from 5.4 ± 1.1 km/h to 6.6 ± 0.5 km/h, and in men from 7.9 ± 0.7 km/h to 8.7 ± 0.6 km/h. The sex difference in performance, however, remained unchanged at 19.8 ± 4.0%. In 'Spartathlon', running speed remained unchanged at 8.7 ± 0.5 km/h for women and 10.8 ± 0.6 km/h for men. The sex difference in performance remained stable at 19.6 ± 2.5% (Figure 5B).

Figure 6 presents the running speed of the 10 fastest finishers sorted by the origin of the runners. In 'Badwater', women from USA were the fastest (7.7 ± 0.4 km/h), followed by women from Canada (6.2 ± 0.6 km/h) (Figure 6A). For men, the fastest finishes were achieved by competitors from the USA (8.6 ± 0.4 km/h), followed by athletes from Mexico (8.2 ± 1.0 km/h) and Canada (7.0 ± 0.8 km/h) (Figure 6B). In 'Spartathlon', the fastest finishes were obtained by women from Japan (9.6 ± 0.3 km/h), followed by women from Germany (9.1 ± 0.4 km/h) and the USA (8.8 ± 0.3 km/h) (Figure 6C). In men, the fastest finishes were achieved by runners from Greece (11.7 ± 0.8 km/h), followed by athletes from Japan (11.4 ± 0.4 km/h) and Germany (11.1 ± 0.3 km/h) (Figure 6D). Top male American runners increased running speed in 'Badwater' from 7.2 km/h to 9.5 km/h ($r^2 = 0.63$, $p = 0.001$) (Figure 7A). In 'Spartathlon', top male Finish runners decreased running speed from 9.7 km/h to 7.1 km/h ($r^2 = 0.32$, $p = 0.04$) (Figure 7B).

The age of peak running speed

In 'Badwater', the age of the annual five fastest women showed no changes over time and was on average at 42.3 ± 7.1 years (Figure 8A). For men, the age of the annual five fastest runners decreased from 42.4 ± 4.2 years to 39.8 ± 5.7 years. In 'Spartathlon', the annual five fastest women were on average 44.6 ± 6.8 years of age, the annual five fastest men 39.7 ± 5.6 years (Figure 8B) with no change over time.

Figure 9 presents the age of the 10 fastest finishers sorted by origin

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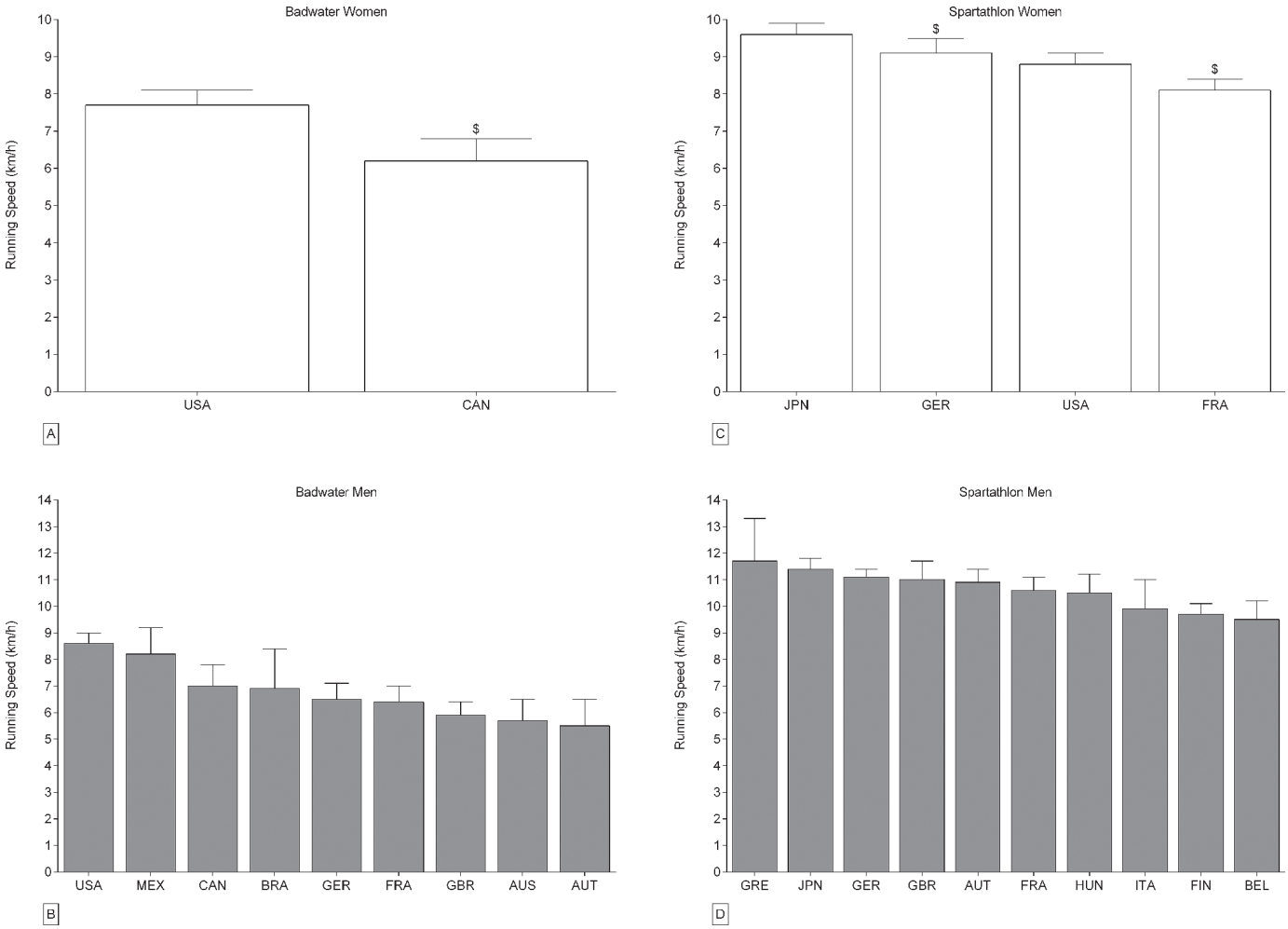

Figure 6: Running speed for the fastest women (panel A) and men (panel B) in 'Badwater' and the fastest women (panel C) and men (panel D) in 'Spartathlon'. $ = significantly slower compared with the next fastest country.

of the runners. In Badwater, the youngest women originated from Canada (39 ± 6 years) followed by athletes from USA (40 ± 6 years) (Figure 9A). In men, the youngest finishers were from USA (36 ± 6 years), followed by athletes from Austria (41 ± 9 years) and Mexico (42 ± 5 years) (Figure 9B). In Spartathlon, the youngest men originated from the USA (37 ± 7 years), followed by athletes from Germany (44 ± 4 years) and Japan (44 ± 6 years) (Figure 9C). For women, the youngest finishers originated from Hungary (32 ± 5 years), followed by runners from Belgium (34 ± 3 years) and Greece (40 ± 5 years) (Figure 9D).

Discussion

This study compared participation and performance trends in ultra-marathons covering >200 km in distance with regard to the nationality of the finishers in 'Badwater' and 'Spartathlon'. It was hypothesized that participation would increase, European athletes would compete in both the European and the American race and Japanese ultra-marathoners would dominate performance in both races. The main findings were that (i) the number of finishes increased in both 'Badwater' and 'Spartathlon' where the highest number of finishes were achieved by US-American athletes in 'Badwater' and Japanese runners in 'Spartathlon', (ii) the fastest race times were achieved by female and male US-American runners in 'Badwater' and by female Japanese runners and male Greek runners in 'Spartathlon', and (iii) the fastest race times were achieved by athletes aged about 40 years in both races.

US-Americans dominated participation in 'Badwater' and Japanese in 'Spartathlon'

The 'Badwater' is held in the Death Valley in California and most of the finishers originated from the USA. The 'Spartathlon' is held in Southern Europe and athletes from Japan, Germany and France were ahead of local athletes from Greece with regard to participation. Recent studies investigated participation and performance

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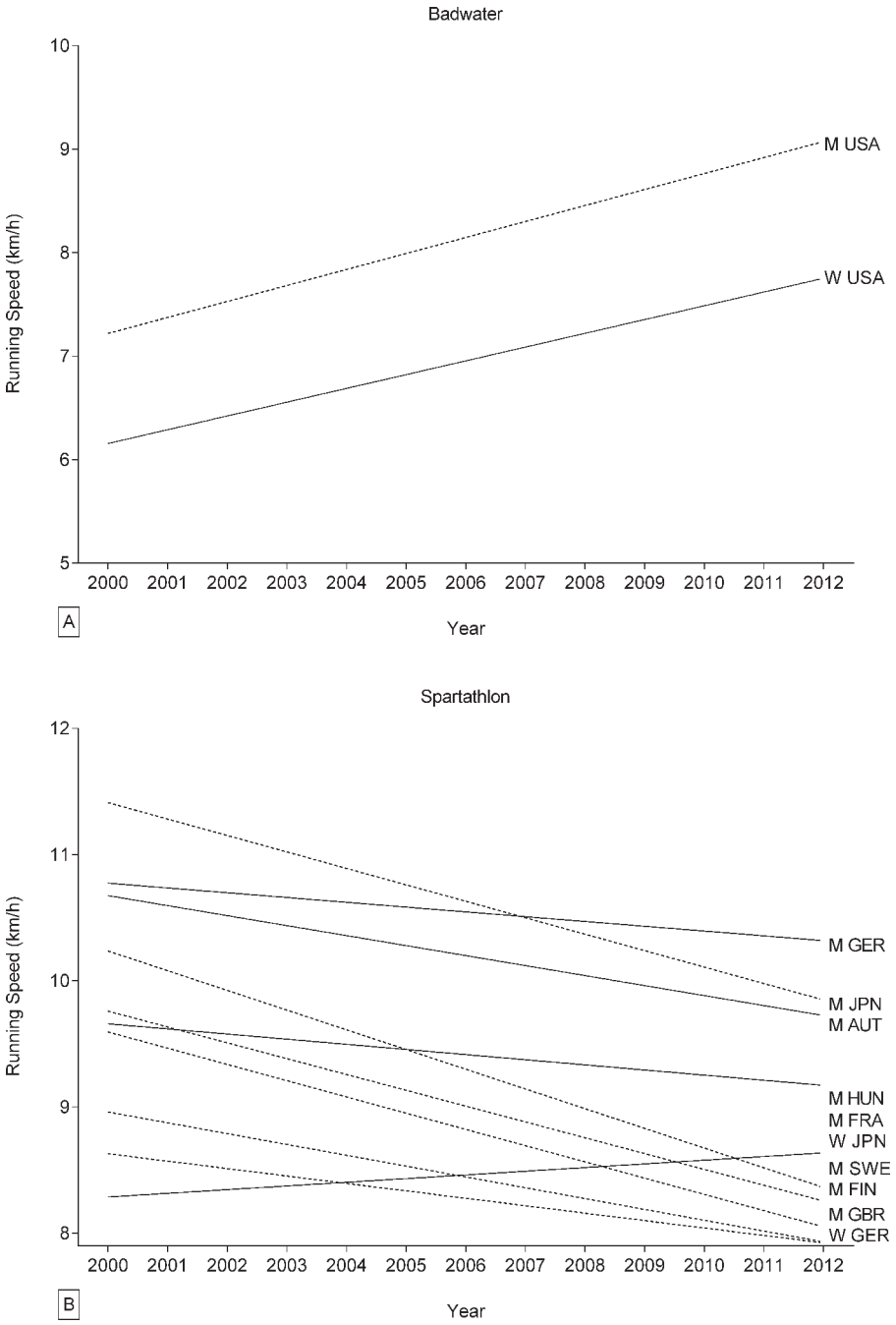

Figure 7: Change in running speed over time for women and men in 'Badwater' (panel A) and 'Spartathlon' (panel B).

trends in ultra-distance duathletes and triathletes[25–30] and multi-stage ultra-marathoners.[31,32] The general findings were that multi-sports athletes and ultra-marathoners from Europe primarily dominated participation and performance in races held in both Europe and overseas[25–32]. Ultra-endurance races held in Central Europe at both national[26] and international levels[29] were dominated in both participation and performance by European athletes. Therefore, the trend for ultra-distance athletes to travel around seems rather low. These recent findings may explain why American runners dominated both participation and performance in 'Badwater'.

In 'Spartathlon', however, male and female Japanese ultra-marathoners dominated participation and Japanese women were also the fastest. Preparation for an ultra-marathon needs a lot of training[14,17] compared with that for shorter distances such as a half-marathon[12] or a marathon[40] and Japanese citizens have little leisure time. The national statistics showed that more than six million people worked for 60 h or more per week during 2000 and 2004[41]. Despite of the reduced work hours in Japanese employees since the late 1980s the work hours remain longer than those in most European countries[41]. Most probably, Japanese ultra-marathoners are highly motivated to compete in an ultra-endurance challenge such as the 'Spartathlon'. Regarding female ultra-marathoners, Krouse et al. described women ultra-runners as task oriented, internally motivated, healthy and financially conscious individuals[42]. This specific motivation to compete in ultra-marathons may explain why Japanese women dominated both participation and performance in 'Spartathlon'.

It is also possible that Japanese may have an advantageous genetic endowment that would be associated with an endurance effect. Previous studies demonstrated a genetic influence on elite athletic performance for Japanese[43]. Further, Japanese runners may be influenced by favourable factors that contribute to their success in ultra-marathons such as environmental conditions[23,44], along with cultural[23] and motivational[21,23] aspects and unique dietary intake[45], as has been shown for East African runners. In the men's race in Spartathlon, however, Greek runners were faster than Japanese and German runners. Obviously, local male athletes were of advantage in this race. Similar findings have been reported for the 'Marathon des Sables' where Moroccan men but European women achieved most of the victories[32].

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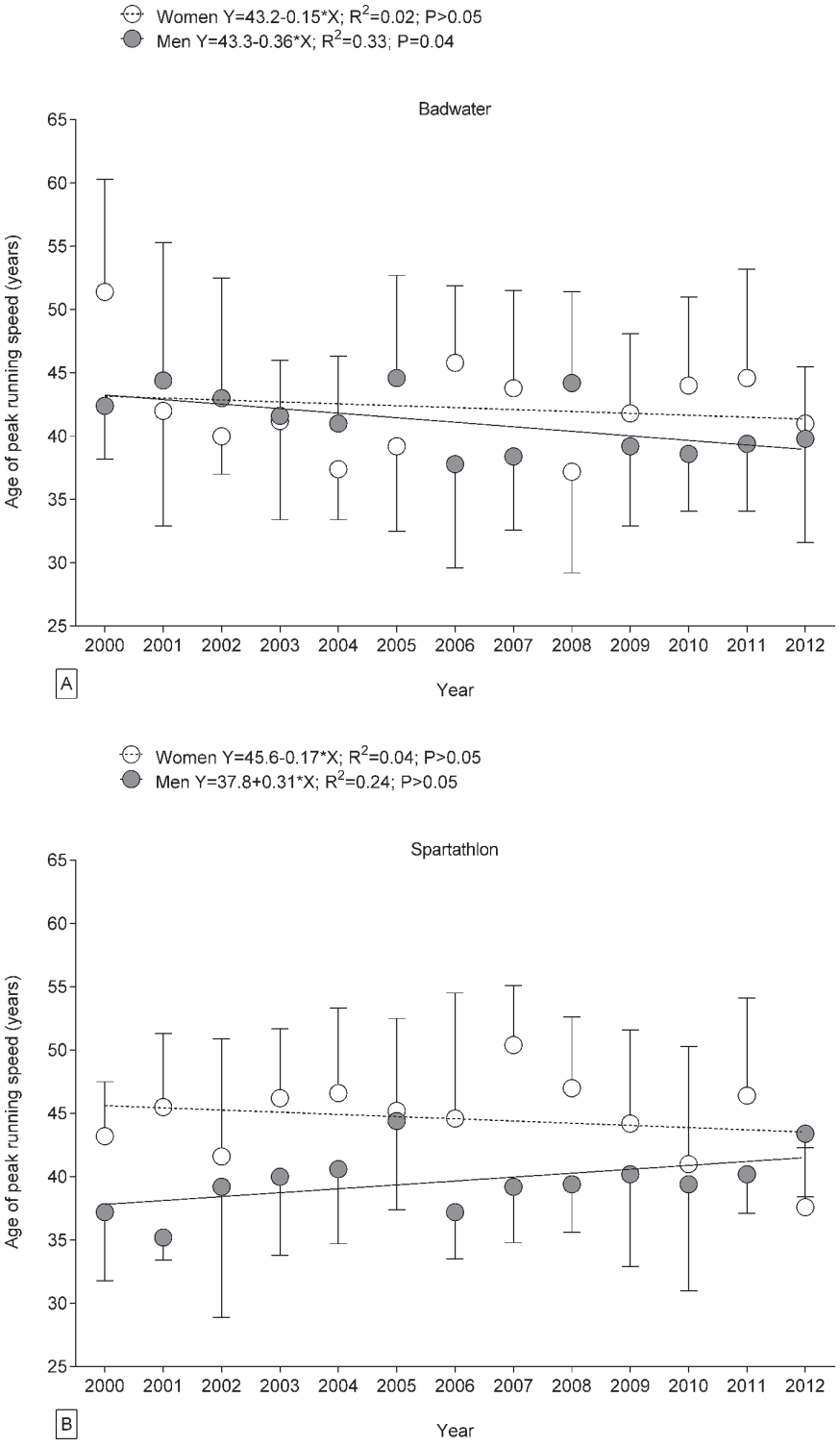

Figure 8: Age of peak running speed for the annual fastest five women and men in 'Badwater' (panel A) and 'Spartathlon' (panel B).

A further important finding was that Kenyans were not participating in these races. With regard to the participation of athletes from Africa, runners from South Africa were at the 16th position and athletes from Jordania at the 18th position in 'Badwater'. In Spartathlon, no African runners were within the 20 first nations. The fame and fortune afforded to marathon runners could encourage Kenyan runners to participate rather in marathons[21] than in ultra-marathons. Concerning the motivation of national (39%) and international (34%) Kenyan athletes to become a competitive athlete both declared economic empowerment was the primary reason. The estimated unemployment rate among the total Kenyan population is 40%. Kenyan athletes see athletics as a means to help their families, parents and friends by making money[21]. Thus, Kenyan runners may not have a tendency to participate in ultra-marathons, as they may not see career options in it. The winner's prize money for the IAAF World Championships 2011 for marathon was US$ 60,000[46]. In both 'Badwater'[47] and 'Spartathlon'[48], there is no prize money. Most probably Kenyan runners see no profit to run an ultra-marathon such as 'Badwater' and 'Spartathlon' without gaining prize money.

The fastest race times were achieved at the age of 'master runners'

A further important finding was that the fastest runners were at an age where they were classified as 'master runners'. Reaburn and Dascombe defined master athletes as athletes typically older than 35 years and who systematically train for and compete in organized forms of sport specifically designed for older adults[49]. The age of peak running performance was found to be at ~42 years in 'Badwater' for both sexes and at ~39 years for men and ~45 years for women in 'Spartathlon'. The age of the fastest runners showed no changes across years in both races, although the number of finishers in both races constantly increased over time, the age of peak running speed was levelled in both races. Regarding the fastest athletes by country, male American runners were the youngest and the fastest in 'Badwater'. In Spartathlon, however,

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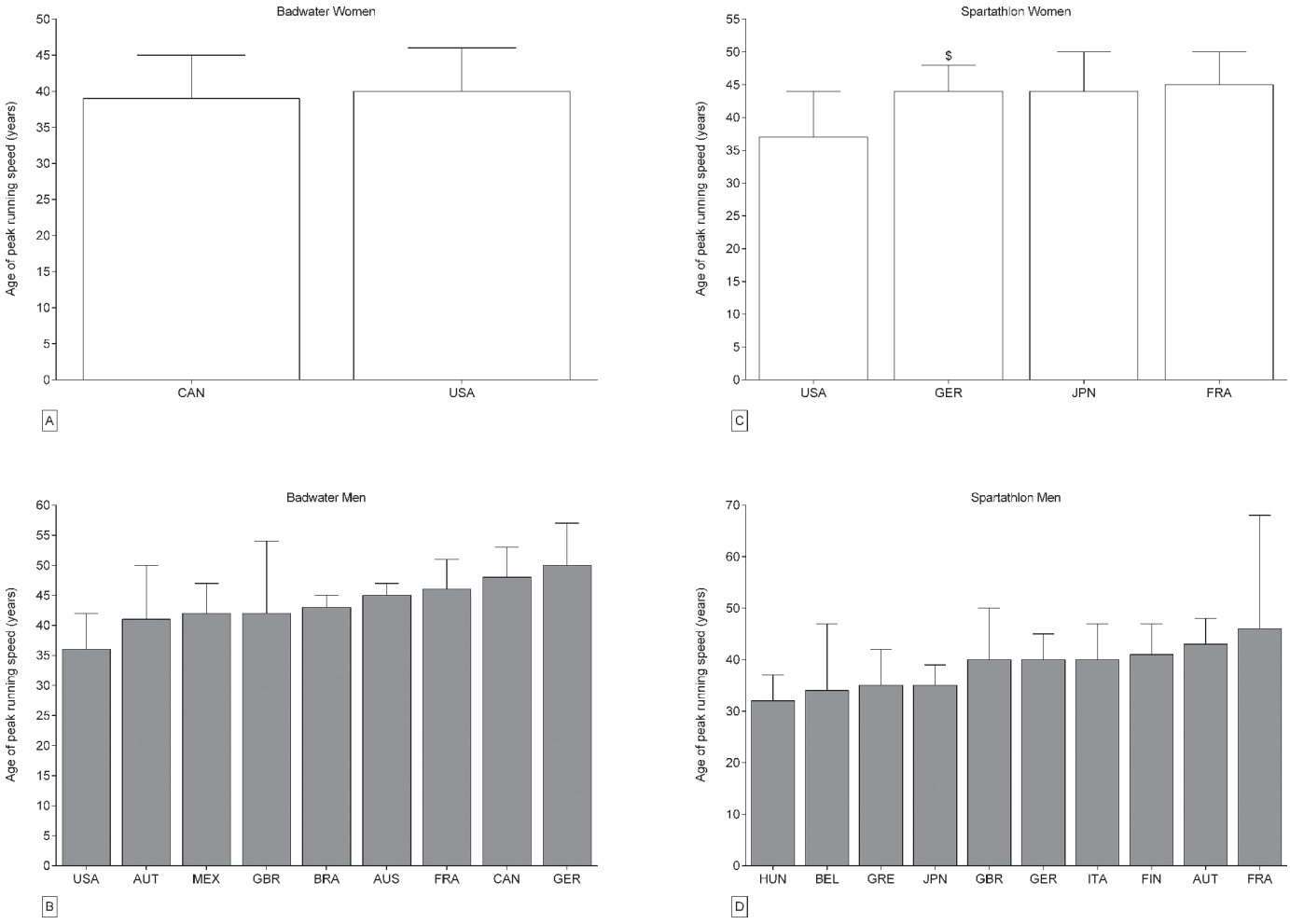

Figure 9: Age for the fastest women (panel A) and men (panel B) in 'Badwater' and the fastest women (panel C) and men (panel D) in 'Spartathlon'. $ = significantly slower compared to the next fastest country.

Japanese women as the fastest were the third oldest, and Greek men as the fastest were also the third oldest.

Generally, factors such as pleasure, health and fitness benefits, social affiliation and competition seemed the primary motivations of master athletes[50]. Hoffman and Fogard reported that participants in ultra-marathons are mostly middle-aged (>45 years), married men who are well-educated and rarely miss work due to illness or injury and maintain appropriate body mass compared with the general population[51]. For master athletes, the sport is an opportunity to achieve social recognition and to have social interaction. They enjoy their participation, are very committed and self-determined[52]. In these races, among the most gruelling ultra-endurance events in the world, athletes at the age of master runners (>35 years) dominated performance. Obviously, the limit of 35 years to define master runners needs to be moved towards 45–50 years to describe master runners competing in these races with no intention to win.

A limitation in our cross-sectional study is the fact that factors of endurance performance such as physiological variables[7–9], anthropometric characteristics[11,12,15], training variables[14,16,17,40], fluid and food intake[45,53–55], medical problems[56], environmental conditions of the race[57–60] and motivation[42,52,61] were not taken into consideration.

Conclusions

Ultra-marathoners of American origin dominated both participation and performance in 'Badwater' held in the USA. In 'Spartathlon' in Europe, both female and male runners from Japan were dominating participation whereas male ultra-marathoners from Greece and female ultra-marathoners from Japan dominated performance in 'Spartathlon'. Future studies need to investigate participation and performance trends for Japanese ultra-marathoners in other races such as 100-km and 100-miles ultra-marathons. Other studies should investigate the age and

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nationality of ultra-marathoners in order to establish a new definition for master runners in ultra-marathons.

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