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Analysis of the fastest backstroke age group swimmers competing in the World Masters Championships 1986–2024

Mielad Fariod[1], Aldo Seffrin[2], Marilia Santos Andrade[3], Mathias Wilhelm[1], Katja Weiss[4], Wais Ahmad[5], Sascha Moreitz[6], Arkadiusz Stanula[7], Pantelis T. Nikolaidis[8], Thomas Rosemann[4] & Beat Knechtle[4,9]✉

Backstroke has been thoroughly investigated in the context of sports science. However, we have no knowledge about the nationalities of the fastest age group backstroke swimmers. Therefore, the present study intended to investigate the nationalities of the fastest backstroke swimmers. For all World Masters Championships held between 1986 and 2024, the year of competition, the first and last name, the age, and the age group, and both the stroke and the distance were recorded for each swimmer. Descriptive data were presented using mean, standard deviation, maximum and minimum values, and confidence intervals. The top ten race times for each swimming distance and sex were identified for descriptive purposes. Nationalities were then grouped into six categories: the top five nationalities with the most appearances in the backstroke swimming top ten times by distance each year and one group consisting of all other nationalities. The Kruskal–Wallis test compared nationality differences, followed by Bonferroni-adjusted pairwise comparisons to identify specific distinctions. Between 1986 and 2024, most age group backstroke swimmers (39.6%) competed in the 50 m event (11,964, 6206 women, and 5,758 men), followed by the 100 m event (32.3%, n = 9764, 5157 women, and 4607 men), and the 200 m event (28.1%, n = 8483, 4511 women, and 3,972 men). Germany had the highest number of top ten female swimmers in the 50 m backstroke distance. Brazil had the highest number of top ten male swimmers in the same distance. The USA had the highest number of female and male swimmers among the top ten in the 100 m and 200 m backstroke distances. Germany and Great Britain were the only countries with swimmers in the top ten for all female backstroke distances. Brazil, the USA, Italy, and Germany were the countries that had swimmers in the top ten for all male backstroke distances. In summary, the fastest backstroke age group swimmers originated from Germany, Brazil, USA, Great Britain, and Italy, where differences between the sexes and race distances exist.

Keywords Age group athlete, Master swimmer, Nationality, Origin

Swimming is a basic mode of human locomotion, and – considering its beneficial role for human functions—its practice is often included in the guidelines of public health policies, especially for special populations such as pregnant women and the elderly[1,2]. In addition, swimming has been considered a competitive sport for centuries (www.britannica.com/sports/swimming-sport). The first known swimming races were held in Japan in the first century BCE (before the Common Era). Swimming was also a popular sport in ancient Greece and Rome

[1]Centre for Rehabilitation and Sports Medicine, Inselspital Bern, University Hospital Bern, Bern, Switzerland. [2]Postgraduate Program in Translation Medicine, Federal University of São Paulo, São Paulo, Brazil. [3]Department of Physiology, Federal University of São Paulo, São Paulo, Brazil. [4]Institute of Primary Care, University of Zurich, Zurich, Switzerland. [5]Sanatorium Kilchberg, Kilchberg, Switzerland. [6]Radiology and Neuroradiology, Institute of Radiology, Spital Zollikerberg, Zurich, Switzerland. [7]Institute of Sport Sciences, Department of Swimming and Water Rescue, Academy of Physical Education in Katowice, Katowice, Poland. [8]School of Health and Caring Sciences, University of West Attica, Athens, Greece. [9]Medbase St. Gallen Am Vadianplatz, Vadianstrasse 26, 9001 St. Gallen, Switzerland. ✉email: beat.knechtle@hispeed.ch

(www.olympics.com), where the early Olympic Games included swimming events in open water rather than pools (www.olympics.com).

Modern competitive swimming as we know it today developed in the nineteenth century (www.olympics.com). The National Swimming Society was founded in England in 1837 and was one of the first swimming organizations in the world (www.eastswimming.org). Its main purpose was to promote swimming as a sport and to organize swimming competitions. The society was responsible for organizing the first swimming championship in Australia in 1846, and it played a crucial role in developing swimming as a competitive sport worldwide (www.britannica.com).

While the National Swimming Society is a historical organization with a focus on promoting swimming as a sport and organizing competitions at the national level, the International Swimming Federation (Fédération Internationale de Natation/FINA – now it is World Aquatics(www.worldaquatics.com/about) is a global organization responsible for overseeing and regulating aquatic sports, including swimming, diving, water polo, synchronized swimming, and open water swimming at an international level (www.worldaquatics.com). In January 2023, the federation underwent an official name change and became known as World Aquatics (www.worldaquatics.com).

The swimming world boasts some of its biggest events through FINA, including the prestigious FINA World Championships and the FINA World Cup (worldaquatics.com /competitions). These competitions attract the world's best swimmers to showcase their skills and compete in various events and disciplines.

Swimming is a cyclic sport that displays a repeating structure due to the continuous action of the limbs. However, swimming also presents biomechanical variability in each one of the conventional propulsive techniques, demonstrating similar but not identical consecutive cycles[3]. Backstroke is an alternated swimming technique characterized by continuous propulsion or shorter non-propulsive lags[4]. It is one of four swimming styles, including freestyle, breaststroke, and butterfly[5]. Backstroke swimming races are mainly held at 50 m, 100 m, and 200 m. Backstroke is, however, also part of the individual medley[6]. Like the front crawl, it is an alternate swimming technique. Among the alternating techniques, swimmers usually achieve a faster swimming velocity in front crawl compared to backstroke, despite their similarities, such as the six-beat kick during each upper limb cycle. This difference in velocity is likely due to variations in energy expenditure at a given velocity[7]. Scientific research on backstroke swimming focused mainly on elite swimmers[8–15] and technical details[16,19]. Only little research was performed regarding youth swimmers[20–22] and master (age group) swimmers[5,23–26]. In recent years, there has been a high scientific interest in this specific swimming technique, resulting in a large body of studies. Specific topics were anthropometry[21,27], the age of the elite athletes[9], the sex difference in performance[12], biomechanical analyses[16] such as arm coordination[10], the body roll (rollover)[28] and pacing[5,15,28,29], and modeling progress in swimmers' performance[30].

A large topic is kinematics[20,31–33], where aspects such as the influence of distance on swimming kinematics[31], stroke technique[17], and performance level have been undertaken[20]. A further important topic was the start of backstroke swimming[16,34–40].

Apart from elite swimmers, youth swimmers[21–24] and age group (master, recreational) swimmers[5,23–25,41] also compete at international level. Master swimmers compete specifically at the FINA World Masters Championships[25]. Also, for these master swimmers, specific research exists, such as the swimming performance with increasing age[42,43], technical aspects[24,26], the development of master world records[41], pacing[5], and the participation and performance trends across age groups[25].

Little is known regarding the aspect of nationality of these swimmers[8]. Especially since we have no knowledge of where the best backstroke age group swimmers might be coming from. Data exist for cold-water swimmers[44] and long-distance open-water swimmers[45,46] regarding the origin of swimmers.

Regarding master swimmers, only one study investigated the origin of open-water master swimmers[47]. However, several studies have investigated the participation and performance of American master swimmers[48–51]. Therefore, the present study intended to investigate the origin of the fastest backstroke age group swimmers. We hypothesized that the United States of America (USA) would produce the fastest swimmers, males would have better times than females in the same age group, and younger categories would have better times overall.

Method

Ethical approval

This study was approved by the Institutional Review Board of Kanton St. Gallen, Switzerland, with a waiver of the requirement for informed consent of the participants as the study involved the analysis of publicly available data (EKSG 01/06/2010). The study was conducted in accordance with recognized ethical standards according to the Declaration of Helsinki adopted in 1964 and revised in 2013.

Data set and data preparation

The race data were obtained from the official website of World Aquatics, former FINA (Fédération Internationale de Natation) (www.worldaquatics.com). We obtained full data for all World Masters Championships held between 1986 and 2024 (www.worldaquatics.com/masters/archives/masters-archives). From each swimmer, year of competition, first name, last name, age, age group, stroke, and distance were recorded. World Aquatics follows rigorous verification and publication procedures to ensure the accuracy and integrity of the information. These data are publicly accessible and can be validated and checked by any interested party. Additionally, we conducted internal cross-referencing and manual reviews to further ensure data integrity. Our dataset, as submitted to the analysis procedures, is available upon request to the leading author.

	50 m			100 m			200 m		
Age group	Female	Male	Ratio	Female	Male	Ratio	Female	Male	Ratio
25–29	562	623	0.90	547	497	1.10	423	349	1.21
30–34	630	636	0.99	570	536	1.06	468	414	1.13
35–39	653	657	0.99	539	521	1.03	451	429	1.05
40–44	666	680	0.98	592	546	1.08	491	488	1.01
45–49	761	676	1.13	587	539	1.09	536	474	1.13
50–54	787	637	1.24	579	500	1.16	577	450	1.28
55–59	661	533	1.24	504	413	1.22	481	389	1.24
60–64	619	526	1.18	481	397	1.21	437	363	1.20
65–69	526	421	1.25	417	338	1.23	349	335	1.04
70–74	419	373	1.12	339	291	1.16	286	270	1.06
75–79	261	271	0.96	218	208	1.05	180	188	0.96
80–84	154	181	0.85	137	139	0.99	120	115	1.04
85–89	57	73	0.78	50	63	0.79	47	55	0.85
90 +	23	45	0.51	25	38	0.66	20	24	0.83

Table 1. Female to male ratio in each age group and distance.

Statistical analysis

Descriptive data were presented using mean, standard deviation, maximum and minimum values, confidence intervals. Overall, the top ten race times for each swimming distance and sex were identified for descriptive purposes. Nationalities were then grouped into six categories to provide a structured analysis based on the top five nationalities with the most appearances in the backstroke swimming top ten times by distance each year while consolidating the remaining nationalities into a single group for comparative purposes. This approach allows for a clearer understanding of trends among the most prominent nationalities while ensuring comprehensive coverage of all participating countries. This segmentation is done for convenience, aiming to identify which nationalities have the highest likelihood of podium placement. The data did not follow a normal distribution or exhibit homogeneous variances, as determined by Shapiro–Wilk and Levene's tests, respectively. Therefore, the Kruskal–Wallis test was used to compare differences between nationalities, and multiple pairwise comparisons adjusted by Bonferroni correction were performed to identify differences. The significance level was set at 0.05, and SPSS version 26.0 (SPSS, Inc., Chicago, IL, USA) was used for all statistical analyses.

Results

Between 1986 and 2024, a total of 204,005 swimmers (94,312 women and 109,693 men) competed in 50m, 100m, 200m, 400m, and 800m races. The majority of swimmers were in freestyle (40.2%; n = 82,019; 36,977 women and 45,042 men), followed by breaststroke (21.2%; n = 43,159; 20,003 women and 23,156 men), backstroke (16.3%; n = 33,169; 17,331 women, and 15,838 men), butterfly (14.2%; n = 29,026; 12,266 women, and 16,760 men), and individual medley (8.2%; n = 16,627; 7735 women, and 8,892 men).

Due to the need to work with a smaller sample, only the backstroke swimming style was selected. In backstroke swimming, most swimmers (39.8%) competed in the 50m event (n = 13,111; 6779 women and 6332 men), followed by the 100m event (32.2%; n = 10,611; 5585 women and 5026 men), and the 200m event (28,0%; n = 9209; 4866 women and 4343 men). A ratio between the number of female and male competitors in each swim distance and age group was calculated for descriptive purposes, which are presented in Table 1.

The 50m backstroke event had an overall mean time of 43.55 ± 13.08 seconds (minimum 25.92/maximum 154.38). Females had a mean time of 48.01 ± 13.95 seconds (minimum 28.85/maximum 154.38) and males had a mean time of 38.77 ± 10.09 seconds (minimum 25.92/maximum 142.15). The 100m backstroke event had an overall mean time of 91.97 ± 25.71 seconds (minimum 49.13/maximum 370.47). Females had a mean time of 99.74 ± 26.56 seconds (minimum 61.75/maximum 370.47) and males had a mean time of 83.35 ± 21.70 seconds (minimum 49.13/maximum 304.12). The 200m backstroke event had an overall mean time of 200.42 ± 51.86 seconds (minimum 121.91/maximum 627.00). Females had a mean time of 214.61 ± 52.77 seconds (minimum 121.91/maximum 627.00) and males had a mean time of 184.52 ± 45.87 seconds (minimum 123.62/maximum 626.45). Figure 1 displays the histograms of race times for women and men in all swimming distances.

Figure 2 presents the mean time for each swimming distance for both men and women overall group and the mean times achieved by the top ten athletes annually. It is important to note that the top ten times for the year 1988 were excluded in Fig. 2 as they were not part of the nationality analysis due to the unavailability of information in the database. Additionally, there was no men's data available for 2008.

The mean time of all top ten swimmers for each gender, year, and country were compared and are displayed in Table 2 (females) and Table 2 (males). However, these averages should be interpreted with caution, even though no outliers were identified and only a brief deviation from normality was observed.

Germany had the highest number of top ten female swimmers in the 50 m backstroke distance (Table 2), while Brazil had the highest number of top ten male swimmers in the same distance (Table 2). The United States had the highest number of female and male swimmers among the top ten in the 100 m and 200 m backstroke distances (Tables 2 and 3). Additionally, the United States, Germany, Great Britain, and Brazil were the countries that had

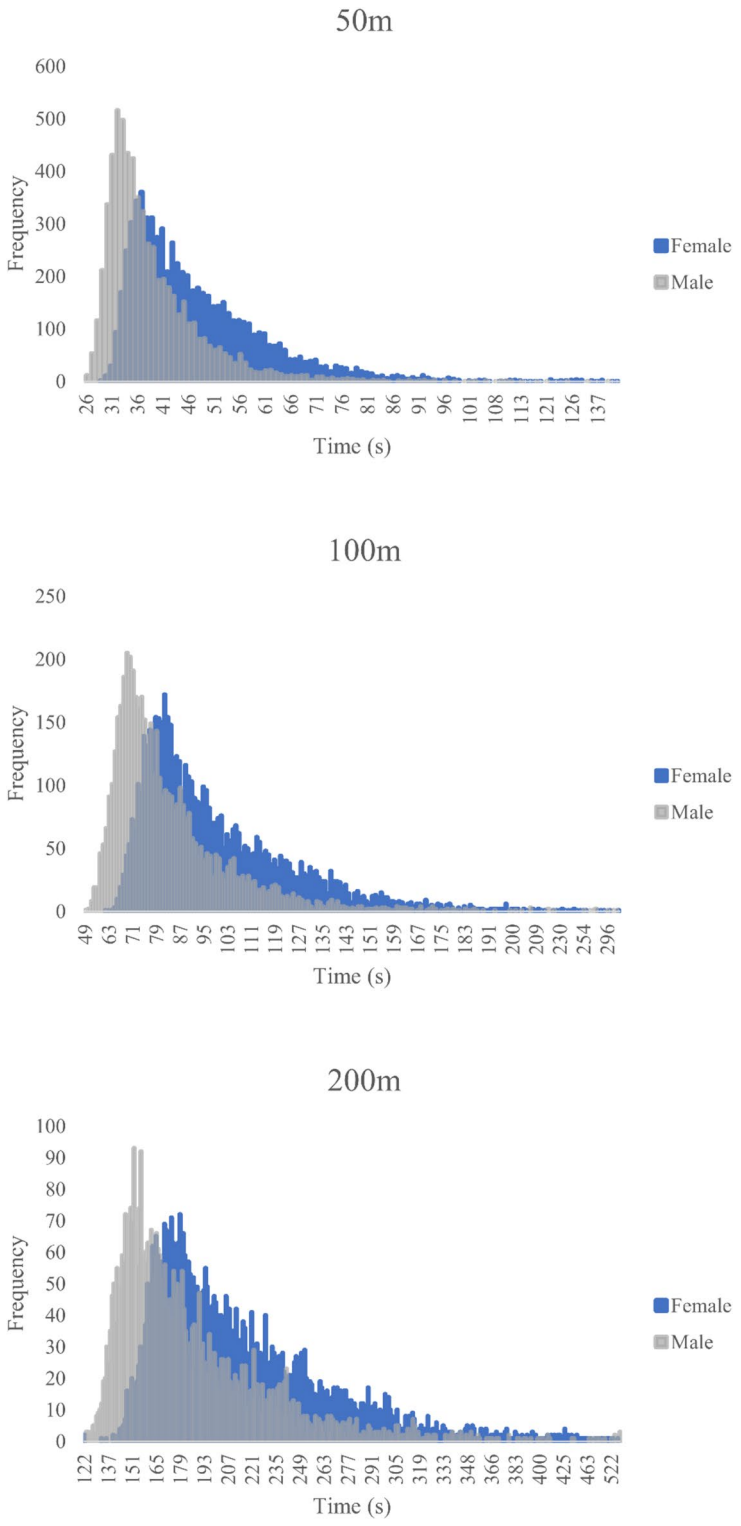

Figure. 1. Race times histograms for women and men in all swimming distances.

swimmers in the top ten for all female backstroke distances (Table 2), while Brazil, the United States, Italy, and Germany were the countries that had swimmers in the top 10 for all male backstroke distances (Table 2). In the female sample, there were no significant differences in performance between countries in the 50 m, 100 m, and 200 m backstroke distances (Table 2). However, in the male sample, there were no significant differences in performance between countries in the 200 m backstroke distances, but for the 50 m, Japan (mean rank 49.23) performed better than Brazil (mean rank 93.34) ($p = 0.006$) (Table 2), and 100 m, "Others" (mean rank 82.77) performed better than the United States (mean rank 119.33) ($p = 0.019$) (Table 2).

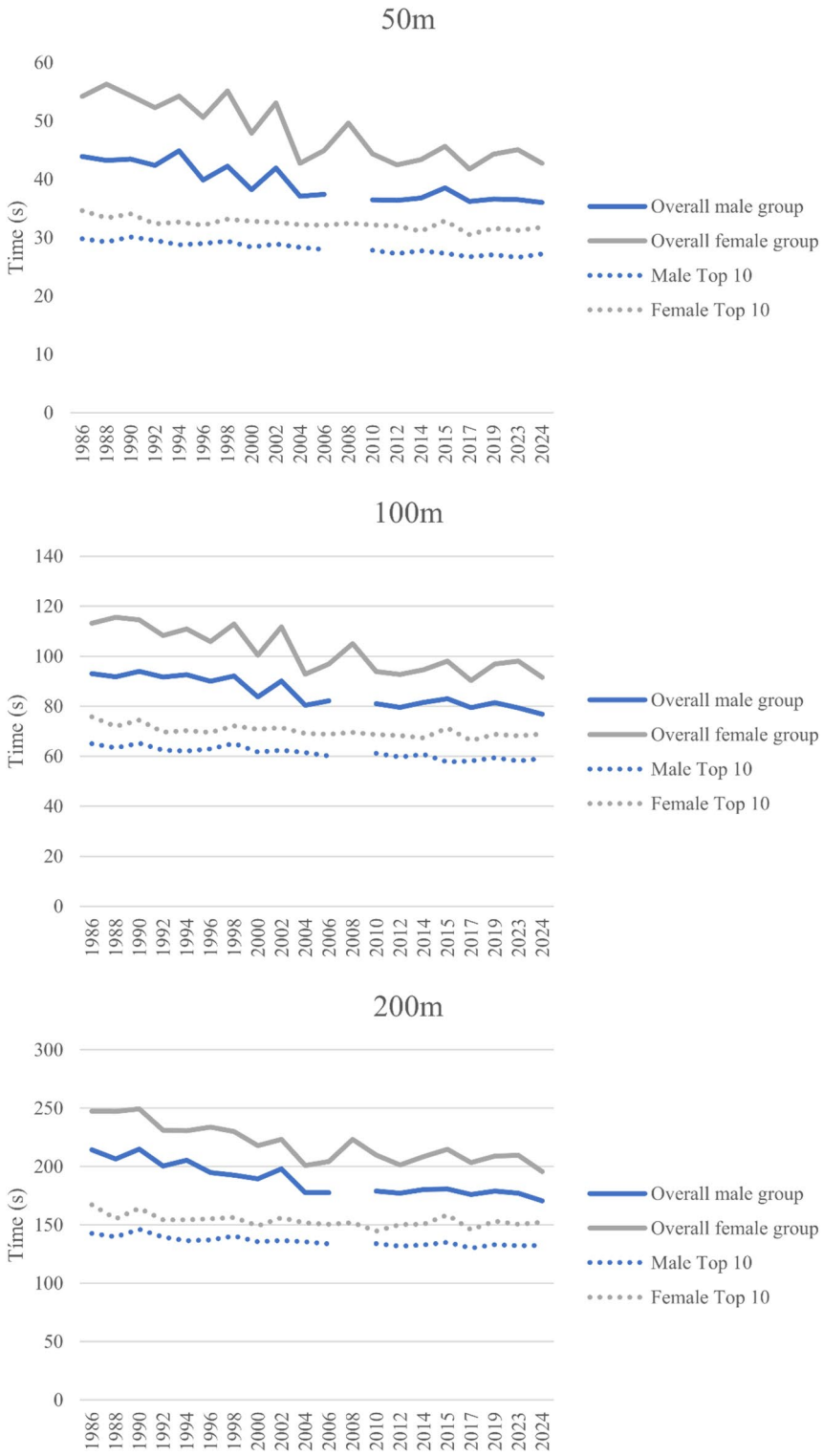

Figure. 2. Overall and Top ten mean time for each swimming distance between sexes.

Discussion

The purpose of this study was to explore the trends in participation and performance among age group backstroke swimmers competing in 50 m, 100 m, and 200 m races held in FINA competitions between 1986 and 2019, broken down by nationality, sex, and age groups. The main findings were that (i) Germany had the highest number of top ten female swimmers in the 50 m backstroke distance, (ii) Brazil had the highest number of top ten male swimmers in the same distance, (iii) the USA had the highest number of female and male swimmers among the top ten in the 100 m and 200 m backstroke distances, (iv) Germany and Great Britain were the only countries

Race	Ranking	Country	N	Mean ± SD			CI 95%		Median	Minimum	Maximum	X^2	Df	p	Post-hoc differences
							Lower Limit	Upper Limit							
50 m backstroke	1	GER	27	32.63	±	0.71	32.35	32.91	32.65	31.12	33.75	5.183	5	0.394	
	2	USA	26	31.97	±	1.25	31.46	32.48	32.39	25.85	34.42				
	3	GBR	21	32.53	±	0.84	32.15	32.91	32.48	31.14	34.79				
	4	JPN	16	32.51	±	1.79	31.55	33.46	31.89	29.74	35.97				
	5	BRA	15	32.86	±	1.56	32.00	33.72	32.71	30.20	35.74				
	6	Others	95	32.33	±	1.17	32.10	32.57	32.22	29.89	35.54				
100 m backstroke	1	USA	36	69.64	±	3.57	68.43	70.84	69.21	61.75	78.47	9.697	5	0.084	
	2	GER	22	71.04	±	1.72	70.28	71.81	70.79	67.88	74.83				
	3	GBR	20	70.66	±	2.89	69.31	72.01	69.75	67.36	77.30				
	4	JPN	14	69.51	±	2.89	67.84	71.17	69.07	65.43	75.24				
	5	BRA	12	70.77	±	2.67	69.07	72.47	70.77	67.41	77.06				
	6	Others	96	69.85	±	2.93	69.26	70.44	69.49	64.00	78.78				
200 m backstroke	1	USA	41	152.33	±	6.22	150.37	154.30	151.88	139.98	169.99	8.858	5	0.115	
	2	GBR	31	153.88	±	7.94	150.97	156.79	154.75	136.28	171.19				
	3	GER	14	155.43	±	4.10	153.06	157.80	155.90	147.23	160.44				
	4	BRA	11	155.50	±	4.39	152.55	158.45	154.79	150.37	163.17				
	5	ITA	11	151.06	±	4.34	148.14	153.98	149.86	143.93	160.12				
	6	Others	92	153.85	±	8.54	152.08	155.62	152.95	121.91	175.17				
Race	Ranking	Country	N	Mean ± SD			CI 95%		Median	Minimum	Maximum	X^2	Df	p	Post-hoc differences
							Lower Limit	Upper Limit							
50 m backstroke	1	BRA	37	28.29	±	1.35	27.84	28.74	27.84	26.44	30.92	12.876	5	0.025	BRA vs JPN
	2	USA	28	28.73	±	1.01	28.34	29.13	28.87	26.72	30.49				
	3	ITA	13	28.29	±	0.99	27.68	28.89	27.95	27.15	30.70				
	4	GER	13	28.35	±	0.80	27.86	28.83	28.17	26.81	29.71				
	5	JPN	11	27.32	±	1.37	26.40	28.24	26.71	26.27	30.97				
	6	Others	88	28.23	±	1.25	27.96	28.49	28.19	25.92	30.67				
100 m backstroke	1	USA	32	62.62	±	2.67	61.65	63.58	62.45	58.66	68.29	15.575	5	0.008	Others vs USA
	2	BRA	28	61.94	±	2.54	60.11	62.08	60.67	57.53	67.60				
	3	GBR	15	62.73	±	3.06	61.03	64.42	62.83	57.49	67.76				
	4	GER	14	61.98	±	2.19	60.72	63.25	62.08	58.09	66.83				
	5	ITA	13	61.07	±	1.10	60.41	61.73	60.52	59.53	63.21				
	6	Others	88	60.69	±	3.03	60.05	61.34	60.42	49.13	67.59				
200 m backstroke	1	USA	31	137.82	±	4.64	136.12	139.52	137.40	125.62	147.66	7.257	5	0.202	
	2	GER	22	135.07	±	4.64	133.01	137.13	135.89	123.80	145.07				
	3	FRA	17	134.93	±	4.40	132.67	137.19	134.19	128.23	145.79				
	4	BRA	16	136.37	±	5.26	133.57	139.17	135.07	130.24	151.71				
	5	ITA	14	135.79	±	5.18	132.80	138.78	134.78	129.67	149.64				
	6	Others	90	135.81	±	6.13	134.52	137.09	135.43	123.62	152.01				

Table 2. Significant differences between nationalities with female athletes in the top 10 times in all backstroke distances.

that had swimmers in the top ten for all female backstroke distances and (v) while Brazil, the USA, Italy, and Germany were the countries that had swimmers in the top ten for all male backstroke distances.

Regarding our hypothesis that the fastest swimmers would originate from the USA, we could only confirm that swimmers from the USA were among the fastest in men but not in women. Especially swimmers from Germany, Brazil, Great Britain, and Italy also provided the top age group backstroke swimmers.

For example, in the USA, U.S. MASTERS SWIMMING has a large calendar of different events, helps its members find a swimming club, provides articles and videos to help improve swimming performance, and has a large library for workouts for a variety of training styles (www.usms.org). In Germany, the DSV (Deutscher Schwimm-Verband) offers a list of potential clubs and all potential swimming races for age group swimmers (www.dsv.de/masterssport). In Great Britain, Swim England Masters offers a large list of different races, and links to the masters community, technique tips, and nutrition advice). In Italy, Federazione Italiana Nuoto has a special section for master swimmers with a large list of races (www.federnuoto.it/home/master.html). Most probably, all these countries have a high interest in promoting master swimming.

Our hypothesis was that the USA would produce the fastest swimmers. The study found that Germany had the highest number of top ten female swimmers in the 50 m backstroke distance in younger ages, the age groups

fastest for both women and men, whereas Brazil also shows the fastest in both men and women. Similar findings have been reported for other disciplines such as running, for example, in ultra-marathon/triathlon races[52,53]. It was shown that Germany and Great Britain were the only countries that had swimmers in the top ten for all female backstroke distances, while Brazil, the USA, Italy, and Germany were the countries that had swimmers in the top ten for all male backstroke distances. The excellence of these countries in master backstroke swimming reflected the corresponding performance of these countries in overall swimming competitions. For instance, the USA was 1st, Italy 3rd, Great Britain 9th, Germany 12th and Brazil 14th in the swimming table of medals in the 19th FINA World Championships Budapest 2022 (https://www.worldaquatics.com/competitions). It was reasonable to assume that master backstroke swimmers from these countries were former elite swimmers during their youth, which might explain their high performance when getting older. In addition, success in the race does not only result from age but also highlights the importance of physiological variables such as oxygen uptake, maximal heart rate, stroke volume, arteriovenous oxygen difference, active muscle mass, type II muscle fiber size, and blood volume[54,55]. VO_2max is an indicator of endurance performance and a strong predictor of cardiovascular disease and mortality.

Some limitations must be acknowledged for this study. In the FINA Masters World Championships, swimmers can be considered as the best age group swimmers in the world. In low-performance swimmers, there is a chance for a different pacing; therefore, the pacing patterns should be generalized for swimmers of a similar level. It is also important to note that the competition took place in a 50-m-long outdoor pool with different physiological aspects (e.g., turns or push parts off the wall) compared to a smaller pool, for example, a length of 25 m. Another limitation of this study might be the environmental conditions, such as the temperature of air and water, since the competition did not take place indoors. Finally, a statistically significant outcome was clearly attributable to the high number of participants. No information about the training conditions was considered. It is possible that the same athlete who performed among the top ten over multiple years had his/her performance included multiple times in the analysis, which could affect the independence of the observation but cannot be excluded due to the format of the database. On the other hand, the strength of the study was its novelty as it was the first one to examine this topic covering such a long period. The findings have practical applications for coaches and trainers to set optimal training goals, and develop sex- and age-tailored exercise programs.

Conclusion

Germany had the highest number of top ten female swimmers in the 50 m backstroke distance. Whether Brazil had the highest number of top ten male swimmers in the same distance. Also, the USA had the highest number of female and male swimmers among the top ten in the 100 m and 200 m backstroke distances. In contrast, Germany and Great Britain were the only countries that had swimmers in the top ten for all female backstroke distances. However, Brazil, the USA, Italy, and Germany were the countries that had swimmers in the top ten for all male backstroke distances. This study's findings can help identify the specific countries of origin of the top-performing master backstroke swimmers and lend themselves as a basis for future studies to identify the contributing factors to this success, which can support the development of policies, more effective training programs, and coaching strategies. As technology and science continue to advance, we will likely see further improvements in athletic performance and new records being set. Backstroke results will soon also improve due to FINA's change to the Backstroke finish rule, allowing the swimmer to fully submerge prior to reaching for the surface (www.csoaofficials.org/ncaa-position-on-revised-fina-backstroke-finish-rule/). This solution will probably favor younger age-group competitors, who will be able to swim underwater without breathing in the final meters of the distance.

Data availability

Availability of data and materials For this study, we have included official results from the official race website (www.worldaquatics.com). The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Author contributions

MF drafted the manuscript, AS and MSA performed the statistical analysis and prepared the methods and results, SM and WA obtained the data, MW, AS, MSA, AS, PTN, KW, TR and BK helped in drafting the final version. All authors read and approved the final manuscript.

Competing interests

The authors declare no competing interests.

Additional information

Correspondence and requests for materials should be addressed to B.K.

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