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Performance Trends in Age Group Breaststroke Swimmers in the FINA World Championships 1986-2014

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Abstract

Performance trends in breaststroke swimmers competing at world class level in pool competitions are well investigated for elite swimmers, but not for age group swimmers. This study investigated trends in participation, performance and sex difference in performance in a total of 35,143 (16,160 women and 18,983 men) age group breaststroke swimmers aged 25-29 to 95-99 years competing in the Fédération Internationale de Natation (FINA) World Masters Championships between 1986 and 2014. Trends in participation were analysed using linear regression analyses and trends in performance were investigated using mixed-effects regression analyses with sex, distance and calendar year as fixed variables. Women and men improved performance in all age groups. For age groups 25-29 to 85-89 years, men were faster than women. For age groups 90-94 to 95-99 years, men were not faster than women. Sex and distance showed a significant interaction for all distances in age groups 25-29 to 80-84 years. In 50 m, women reduced the gap to men in age groups 40-44 to 70-74 years and in 100 m and 200 m, women reduced the gap in age groups 50-54 to 60-64 years. In summary, (*i*) women and men improved performance in all race distances and in all age groups, (*ii*) men were faster than women from 25 to 89 years, but not from 90 to 99 years, and (*iii*) women reduced the gap to men between ~40 and ~75 years, but not in younger (<40 years) or older (>75 years) age groups. Based on these findings for a time period of nearly 30 years, we may assume a further increase in partici-pation and a further improvement in performance in the near future in age group breaststroke swimmers competing at world class level.

Key Words: aging, master athletes, sex difference, swimming

Introduction

Swimming can be performed in different strokes (*i.e.* freestyle, backstroke, breaststroke, butterfly and as the combination of the four strokes in individual medley) (18, 29, 35-37). Swimming competitions are mainly held in indoor and outdoor pools in short course (25 m) and long course (50 m) pools (15, 17, 28, 35).

Improvements in elite swimmers competing at world class level (*e.g.* World Championships, Olympic Games) are well investigated for freestyle swimming (19, 25, 30). However, performance trends in age group freestyle swimmers for distances from 100 m to 800 m or longer are not well known (2, 29). Akkari *et al.* (2) recently investigated changes in swimming performance in age group athletes competing in 100 m freestyle swimming between 1975 and 2013, but not for other strokes. Senefeld *et al.* (29) showed for age groups swimmers competing in 50 m to 1,500 m freestyle in age groups from 25-29 to 85-89 years that swimmers in age groups 25-29 and 30-34 years had the fastest swimming velocities.

Considering age group swimmers, it is well known that swimming performance decreases with increasing

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age (10, 27, 29). However, less data exists for changes in performance of age groups of swimmers from one year to another year (29). Apart from the World Championships and Olympic Games for elite swimmers, the Fédération Internationale de Natation (FINA) holds since 1986 biannually the World Masters Championships for all disciplines and distances in pool and open-water swimming.[1] Breaststroke is one of the four swim strokes. Changes in breaststroke swimming performance have already been investigated for elite swimmers (37). Similarly, the age of the best breaststroke swimming performance has been reported for elite athletes competing at national and international level (19, 36).

However, no data exists for performance trends in age group breaststroke swimmers. Moreover, it has not examined previously whether these trends are similar in female and male swimmers. Such information might be of practical value for coaches and fitness trainers who work with master swimmers in order to develop sex- and age-tailored training programs. Furthermore, changes in sex difference in age group swimmers across time are not known. A recent study investigated sex differences in finishing times of the top ten female and male world record performances from 1986 to 2011 in age group swimmers from 25 to 89 years in all four strokes (29). Men were faster than women for freestyle (12.4 ± 4.2%), backstroke (12.8 ± 3.0%), and breaststroke (14.5 ± 3.2%), with the greatest sex differences for butterfly (16.7 ± 5.5%). However, this study investigated the sex difference in age group swimmers only across age groups, but not across years.

The aim of the present study was to investigate trends in changes in participation, performance and sex difference in performance in of female and male age group breaststroke swimmers competing in the FINA World Masters Championships held between 1986 and 2014 from 50 m to 200 m. We hypothesized that participation would increase and performance would improve in these athletes as it has already been shown for other sports disciplines such as running in age group marathoners (1, 21) and age group ultramarathoners (11).

Materials and Methods

Ethical Approval

This study was approved by the Institutional Review Board of St. Gallen, Switzerland, with waiver of the requirement for informed consent given that the study involved the analysis of publicly available data.

Data Sampling and Data Analysis

All data were obtained from the official and publicly accessible FINA website.[1] FINA defines master swimmers as swimmers equal or older than 25 years. FINA records all competitors in 5-years age groups from 25-29 years to 105-109 years.[1] All female and male breaststroke swimmers competing in all age groups (*i.e.* from 25-29 to 95-99 years) in the FINA World Masters Championships between 1986 and 2014 were considered. The FINA World Masters Championships were held in 1986 in Tokyo (Japan), 1988 in Brisbane (Australia), 1990 in Rio de Janeiro (Brazil), 1992 in Indianapolis (USA), 1994 in Montreal (Canada), 1996 in Sheffield (Great Britain), 1998 in Casablanca (Morocco), 2000 in Munich (Germany), 2002 in Christchurch (New Zealand), 2004 in Riccione (Italy), 2006 in San Francisco (USA), 2008 in Perth (Australia), 2010 Göteborg and Borås (Sweden), 2012 in Riccione (Italy) and 2014 in Montreal (Canada). Mean performance time for all age groups for each year was calculated. We analysed the data for trends in participation, performance and sex difference in performance. We used linear regression analysis for predicting the unknown value of a variable from the known value of another variable. We also used mixed-effects regression modelling to distinguish fixed-effects and random-effects.

Statistical Analysis

To eliminate a selection bias (*i.e.* a restriction to top swimmers such as the three fastest per age group) all successful swimmers for all age groups in all years were included for data analysis. Trends in participation across years were analysed using linear regression analysis. The men-to-women ratio was calculated with all men and all women for each age group and the trend across age groups was analysed using linear regression analysis. To investigate changes in swimming performance, a mixed-effects regression model with finisher as random variable (*i.e.* a variable that is drawn from a larger population of variables and thus will represent them) was used to consider finishers who had competed in several races. We included sex, distance and calendar year as fixed variables (*i.e.* a variable that is assumed to be measured without error) in the regression model. We also considered interaction effects between sex and distance. The final model was selected by means of Akaike information Criterion (AIC). Sex difference was calculated in absolute values using the equation ([mean race time in women] – [mean race time in men] / [mean race time

[1]FINA World Masters Championships, website http://www.fina.org/H2O/index.php?option=com_content&view=category&layout=blog&id=54&Itemid=378, accessed September 18, 2015.

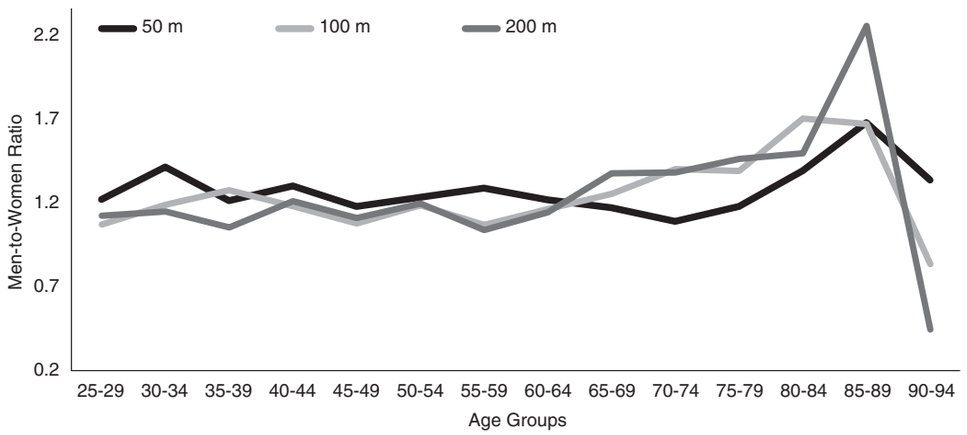

Fig. 1. The men-to-women ratio across age groups from 25-29 to 90-94 years

in men] × 100). Trends in sex difference across years were analysed using linear regression models. Statistical analyses were performed using IBM SPSS Statistics (Version 22, IBM SPSS, Chicago, IL, USA). Significance was accepted at $P < 0.05$ (two-sided for *t*-tests). Data in the tables are given as mean ± standard deviation (SD).

Results

Participation Trends

Between1986 and 2014, a total of 35,143 (16,160 women and 18,983 men) age group breaststroke swimmers of 25 years and older were recorded. Table 1 presents the trends in participation for women and Table 2 for men for all distances. In 50 m, participation increased in athletes recorded in age groups 70-74 to 95-99 years in women and from 45-49 to 90-94 years in men. In 100 m, participation increased in women competing in age groups 40-44 to 90-94 years and in men from 35-39 to 85-89 years. In 200 m, participation increased in athletes recorded in age groups 40-44 to 90-94 years in women and from 45-49 years to 90-94 years in men. The men-to-women ratio (Fig. 1) across age groups from 25-29 to 90-94 years remained unchanged for 50 m ($r^2 = 0.08$, $P = 0.32$), 100 m ($r^2 = 0.14$, $P = 0.19$) and 200 m ($r^2 = 0.07$, $P = 0.36$).

Performance Trends

Tables 3 and 4 summarize race times for women and men for all distances and age groups between 1986 and 2014 and Table 5 shows the results of the mixed-effects regression analyses for performance. For age groups 25-29 to 95-99 years, both women and men improved their race times between 1986 and 2014. For age groups 25-29 to 85-89 years, men were faster than women. For age groups 90-94 to 95-99 years, women were not slower than men. Sex and distance showed a significant interaction in age groups 25-29 to 80-84 years for all distances (Table 6). When the men-to-women ratio was considered from 25-29 to 85-89 years (*i.e.* where men were faster than women), it remained unchanged for 50 m ($r^2 = 0.07$, $P = 0.38$), but increased in 100 m ($r^2 = 0.60$, $P = 0.0018$) and 200 m ($r^2 = 0.55$, $P = 0.0039$).

Sex Difference

Table 7 presents the trend in sex difference across years. In 50 m, women reduced the gap to men in age groups 40-44 to 70-74 years, and in both 100 m and 200 m in age groups 50-54 to 60-64 years.

Discussion

This study investigated changes in participation and performance in age group breaststroke swimmers competing from 50 m to 200 m in the FINA World Masters Championships held between 1986 and 2014 and we hypothesized that participation would increase and performance would improve. The most important findings were, (*i*) participation increased in women and men preferably in the older age groups (>40 years), (*ii*) women and men improved performance in all distances and age groups, (*iii*) women were not slower compared to men in age groups 90-94 to 95-99 years, and, (*iv*) women reduced the gap to men preferably in middle ages (~40-75 years).

Participation Increased in Women and Men in the Older Age Groups

A first important finding was that participation increased for both women and men mainly in older age

Table 1. Participation in women in age groups from 50 m to 200 m

Distance	Age group	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	r^2	*P*
50 m	25-29	40	42	23	15	24	42	18	56	11	48	39	23	42	58	49	0.13	0.193
	30-34	40	46	26	27	40	45	26	73	23	74	31	25	35	67	30	0.01	0.696
	35-39	59	63	13	33	41	40	20	65	25	64	52	33	47	70	51	0.05	0.433
	40-44	70	66	25	30	38	33	16	75	31	71	66	42	63	98	79	0.20	0.098
	45-49	63	73	24	28	52	50	23	53	23	53	63	52	58	103	67	0.14	0.165
	50-54	45	91	36	30	48	48	18	50	37	31	57	36	58	88	80	0.08	0.319
	55-59	40	60	26	29	49	37	30	54	33	40	34	37	34	46	46	0.00	0.972
	60-64	41	57	20	32	45	34	29	44	34	32	36	38	29	42	48	0.00	0.990
	65-69	16	46	16	19	30	29	24	37	38	39	35	34	28	37	30	0.15	0.155
	70-74	12	23	12	18	20	29	18	28	15	20	24	29	24	25	29	0.37	0.015
	75-79	6	8	7	13	11	16	8	16	15	15	13	11	10	17	17	0.40	0.012
	80-84		3	2	5	10	11		13	4	7	7	17	7	11	13	0.39	0.012
	85-89		1				1		2	2	3	4	3	4	4	4	0.83	<0.0001
	90-94								1	1	1			3	3	1	0.43	0.007
	95-99													1		1	0.30	0.035
100 m	25-29	21	42	20	15	29	37	15	62	10	41	46	20	46	64	54	0.26	0.050
	30-34	25	40	19	25	44	42	30	66	27	64	42	19	45	72	35	0.15	0.158
	35-39	29	54	10	33	45	42	16	61	28	47	51	27	47	58	43	0.12	0.211
	40-44	40	56	19	27	40	33	11	71	34	72	73	45	65	89	83	0.44	0.006
	45-49	28	40	17	30	37	44	24	55	18	48	69	53	71	100	84	0.62	0.0005
	50-54	21	55	27	28	42	30	11	42	25	28	63	29	64	84	84	0.38	0.014
	55-59	26	38	20	25	40	40	29	48	31	34	36	40	46	56	58	0.53	0.002
	60-64	17	30	12	20	28	33	22	45	31	31	32	42	39	45	52	0.66	0.0002
	65-69	6	23	10	17	29	22	16	29	32	30	24	24	38	40	32	0.61	0.0006
	70-74	6	11	6	9	21	17	11	23	14	18	19	23	23	29	33	0.75	<0.0001
	75-79	2	6	5	9	7	10	8	11	11	14	17	8	13	17	15	0.72	<0.0001
	80-84		2		3	7	6		11	4	6	6	13	3	7	9	0.36	0.017
	85-89						1		2	4	4	4	2	3	4	2	0.60	0.0007
	90-94										1	1		2	2	2	0.62	0.0005
200 m	25-29	18	27	11	14	20	29	10	46	7	30	21	10	23	37	41	0.13	0.192
	30-34	20	29	14	20	24	36	18	37	18	47	24	13	19	38	27	0.04	0.483
	35-39	25	37	8	24	19	37	13	42	19	44	35	19	30	40	24	0.06	0.381
	40-44	25	35	14	18	23	27	7	50	26	60	39	29	41	51	53	0.39	0.013
	45-49	23	25	12	17	25	36	12	46	18	42	40	38	31	63	52	0.51	0.002
	50-54	23	31	18	21	22	29	9	34	24	22	39	28	36	61	47	0.42	0.008
	55-59	14	22	14	23	24	31	22	45	26	36	33	30	32	31	42	0.53	0.002
	60-64	15	18	12	15	14	25	17	32	21	30	22	21	23	30	40	0.55	0.001
	65-69	7	14	6	11	16	14	14	19	22	23	21	19	21	27	23	0.78	<0.0001
	70-74	5	8	4	5	14	21	7	12	10	17	17	18	16	24	19	0.60	0.0006
	75-79	1	5	2	5	3	10	6	10	10	9	10	9	9	11	12	0.73	<0.0001
	80-84		2	1	3	2	4		7	6	3	5	7	4	4	8	0.50	0.003
	85-89								1	3	1	3	1	2	1	2	0.49	0.003
	90-94											1		2	2	3	0.55	0.001

Table 2. Participation in men in age groups from 50 m to 200 m

Distance	Age group	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	r^2	*P*
	25-29	61	41	19	17	41	56	24	85	12	73	35	15	52	95	43	0.05	0.426
	30-34	45	49	36	36	54	55	25	98	26	106	45	40	70	107	65	0.19	0.100
	35-39	70	57	19	25	49	58	24	101	29	106	46	41	48	97	56	0.06	0.362
	40-44	66	69	28	40	60	73	29	81	37	95	77	51	81	134	62	0.20	0.094
	45-49	62	57	32	40	48	55	22	83	27	80	74	49	59	154	84	0.27	0.049
	50-54	54	45	31	24	55	46	20	80	43	77	76	55	81	124	78	0.47	0.004
	55-59	29	53	21	36	45	48	30	71	35	60	65	49	61	88	73	0.53	0.002
50 m	60-64	35	53	34	33	42	34	28	66	37	47	47	33	45	76	59	0.27	0.045
	65-69	12	40	14	33	32	32	19	51	40	29	38	45	41	60	50	0.50	0.003
	70-74	10	25	12	21	21	23	11	30	23	27	21	24	37	41	27	0.47	0.004
	75-79	5	10	5	18	11	11	10	20	9	19	21	15	16	24	24	0.59	0.0008
	80-84	1	7	4	6	10	11	2	8	5	11	9	12	15	18	17	0.64	0.0003
	85-89		1		2	5	1	2	6	3	5	13	4	5	7	4	0.39	0.013
	90-94				1	1			2		1		2	2	3	2	0.48	0.004
	95-99														2		0.14	0.173
	25-29	26	29	16	20	34	48	24	73	12	54	33	10	39	86	43	0.15	0.148
	30-34	24	41	21	40	54	47	25	90	18	64	47	26	61	92	62	0.24	0.062
	35-39	33	42	15	30	53	51	23	93	22	88	48	40	55	97	64	0.27	0.045
	40-44	29	51	18	37	64	58	22	76	32	75	78	43	76	124	59	0.36	0.017
	45-49	35	32	24	33	44	49	14	68	23	62	79	43	48	130	79	0.42	0.009
	50-54	35	35	18	18	49	34	20	61	37	53	69	42	58	75	71	0.57	0.001
	55-59	16	43	17	25	32	39	31	56	28	43	45	40	50	89	75	0.59	0.0009
100 m	60-64	12	34	26	29	32	31	19	48	30	36	45	38	41	60	58	0.62	0.0005
	65-69	11	26	13	30	22	34	17	33	33	26	34	40	36	46	37	0.62	0.0005
	70-74	6	18	16	18	21	20	18	28	20	25	22	24	30	40	31	0.72	<0.0001
	75-79	3	11	7	16	11	9	10	22	8	15	22	16	13	23	17	0.43	0.007
	80-84		3	3	5	8	11	2	5	5	12	8	13	13	17	13	0.69	0.0001
	85-89		2		2	3		2	4	2	4	10	4	4	8	4	0.48	0.004
	90-94						1		2		1		2	2	1		0.21	0.082
	95-99														2		0.14	0.173
	25-29	22	20	11	19	27	30	16	45	9	35	22	9	24	52	28	0.10	0.245
	30-34	17	23	17	29	31	31	18	61	11	41	23	14	33	68	28	0.12	0.203
	35-39	22	33	11	23	30	32	13	54	13	54	24	17	23	47	36	0.08	0.317
	40-44	26	33	15	27	32	51	16	53	26	58	32	27	43	71	41	0.25	0.057
	45-49	35	23	17	33	29	36	7	41	18	53	36	26	32	83	51	0.27	0.049
	50-54	34	30	15	18	36	28	16	44	34	35	35	26	47	61	45	0.38	0.013
	55-59	18	33	12	16	21	34	21	42	24	31	31	29	29	57	38	0.39	0.012
200 m	60-64	11	22	16	28	17	26	14	36	27	27	26	25	30	36	28	0.43	0.008
	65-69	6	17	13	21	14	34	15	28	27	24	26	32	24	33	24	0.47	0.004
	70-74	8	13	9	12	11	17	9	21	17	16	18	17	17	30	23	0.63	0.0004
	75-79	2	6	5	10	5	8	5	16	9	17	16	14	7	19	10	0.43	0.008
	80-84		2	1	2	4	7	1	4	2	9	6	7	11	11	11	0.73	<0.0001
	85-89		1					1	4	1	2	5	1	3	5	5	0.60	0.0007
	90-94					1					1		2	1	1	1	0.39	0.012
	95-99														2		0.17	0.173

Table 3. Race times for women in min:sec (±SD) in age groups from 50 m to 200 m

Distance	Age group	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014
50 m	25-29	0:46 ± 0:06	0:44 ± 0:06	0:42 ± 0:07	0:42 ± 0:11	0:45 ± 0:08	0:41 ± 0:06	0:41 ± 0:04	0:40 ± 0:03	0:40 ± 0:03	0:39 ± 0:02	0:39 ± 0:02	0:39 ± 0:03	0:39 ± 0:02	0:38 ± 0:01	0:37 ± 0:02
	30-34	0:47 ± 0:07	0:47 ± 0:07	0:44 ± 0:07	0:40 ± 0:03	0:46 ± 0:06	0:42 ± 0:04	0:41 ± 0:04	0:41 ± 0:03	0:41 ± 0:05	0:40 ± 0:02	0:39 ± 0:02	0:39 ± 0:03	0:38 ± 0:02	0:39 ± 0:02	0:38 ± 0:03
	35-39	0:51 ± 0:06	0:49 ± 0:08	0:43 ± 0:05	0:46 ± 0:09	0:45 ± 0:06	0:43 ± 0:04	0:44 ± 0:07	0:42 ± 0:03	0:43 ± 0:05	0:41 ± 0:02	0:41 ± 0:02	0:41 ± 0:03	0:40 ± 0:02	0:40 ± 0:02	0:40 ± 0:02
	40-44	0:51 ± 0:09	0:53 ± 0:09	0:49 ± 0:11	0:47 ± 0:07	0:48 ± 0:08	0:45 ± 0:07	0:47 ± 0:08	0:44 ± 0:03	0:44 ± 0:05	0:42 ± 0:02	0:42 ± 0:03	0:43 ± 0:04	0:42 ± 0:03	0:42 ± 0:03	0:41 ± 0:03
	45-49	0:55 ± 0:08	0:55 ± 0:10	0:52 ± 0:16	0:46 ± 0:06	0:51 ± 0:09	0:47 ± 0:04	0:51 ± 0:10	0:45 ± 0:03	0:45 ± 0:05	0:44 ± 0:03	0:43 ± 0:03	0:44 ± 0:03	0:43 ± 0:03	0:43 ± 0:03	0:42 ± 0:03
	50-54	0:59 ± 0:10	1:00 ± 0:13	0:56 ± 0:09	0:52 ± 0:09	0:55 ± 0:10	0:51 ± 0:09	0:54 ± 0:10	0:48 ± 0:06	0:51 ± 0:07	0:46 ± 0:03	0:45 ± 0:03	0:47 ± 0:05	0:45 ± 0:03	0:44 ± 0:04	0:44 ± 0:04
	55-59	0:59 ± 0:10	1:04 ± 0:11	1:04 ± 0:25	0:57 ± 0:11	0:58 ± 0:10	0:54 ± 0:10	0:55 ± 0:11	0:52 ± 0:08	0:52 ± 0:13	0:47 ± 0:03	0:47 ± 0:03	0:51 ± 0:05	0:47 ± 0:04	0:45 ± 0:04	0:45 ± 0:04
	60-64	1:02 ± 0:11	1:06 ± 0:13	1:03 ± 0:12	1:01 ± 0:12	1:03 ± 0:15	0:59 ± 0:14	0:59 ± 0:11	0:53 ± 0:08	0:56 ± 0:12	0:48 ± 0:04	0:50 ± 0:05	0:51 ± 0:05	0:48 ± 0:04	0:49 ± 0:04	0:50 ± 0:05
	65-69	1:10 ± 0:13	1:12 ± 0:19	1:05 ± 0:17	0:59 ± 0:10	1:04 ± 0:15	1:02 ± 0:10	1:04 ± 0:14	0:58 ± 0:07	0:59 ± 0:09	0:53 ± 0:05	0:55 ± 0:04	0:56 ± 0:06	0:52 ± 0:04	0:52 ± 0:05	0:51 ± 0:04
	70-74	1:12 ± 0:17	1:15 ± 0:20	1:14 ± 0:33	1:14 ± 0:29	1:10 ± 0:20	1:05 ± 0:11	1:09 ± 0:30	1:04 ± 0:15	1:06 ± 0:14	0:58 ± 0:06	1:01 ± 0:05	1:01 ± 0:08	0:55 ± 0:10	0:54 ± 0:05	0:55 ± 0:05
	75-79	1:18 ± 0:23	1:17 ± 0:13	1:22 ± 0:25	1:22 ± 0:20	1:11 ± 0:08	1:13 ± 0:15	1:12 ± 0:16	1:06 ± 0:07	1:09 ± 0:16	1:05 ± 0:07	1:05 ± 0:10	1:05 ± 0:10	1:02 ± 0:06	0:58 ± 0:06	1:01 ± 0:07
	80-84		1:49 ± 0:23	1:44 ± 0:05	1:27 ± 0:15	1:33 ± 0:21	1:40 ± 0:31		1:21 ± 0:12	1:15 ± 0:23	1:10 ± 0:08	1:13 ± 0:13	1:17 ± 0:13	1:09 ± 0:14	1:12 ± 0:12	1:11 ± 0:10
	85-89		3:29				1:21		2:08 ± 0:58	1:14 ± 0:01	1:31 ± 0:14	1:12 ± 0:07	1:27 ± 0:19	1:20 ± 0:13	1:08 ± 0:08	1:32 ± 0:17
	90-94								1:37	2:23	1:54			1:45 ± 0:17	1:45 ± 0:29	1:16 ± 0:21
	95-99													2:50		3:02
100 m	25-29	1:37 ± 0:10	1:38 ± 0:13	1:31 ± 0:08	1:32 ± 0:25	1:35 ± 0:10	1:30 ± 0:12	1:30 ± 0:11	1:30 ± 0:07	1:27 ± 0:08	1:26 ± 0:04	1:26 ± 0:05	1:26 ± 0:06	1:27 ± 0:06	1:25 ± 0:05	1:25 ± 0:05
	30-34	1:41 ± 0:14	1:39 ± 0:15	1:33 ± 0:11	1:29 ± 0:06	1:37 ± 0:11	1:30 ± 0:07	1:31 ± 0:08	1:31 ± 0:07	1:31 ± 0:10	1:28 ± 0:05	1:27 ± 0:05	1:27 ± 0:07	1:28 ± 0:07	1:26 ± 0:05	1:26 ± 0:06
	35-39	1:48 ± 0:12	1:11 ± 0:15	1:38 ± 0:15	1:35 ± 0:09	1:40 ± 0:13	1:35 ± 0:11	1:33 ± 0:09	1:34 ± 0:07	1:37 ± 0:17	1:29 ± 0:05	1:31 ± 0:06	1:32 ± 0:06	1:30 ± 0:08	1:28 ± 0:05	1:28 ± 0:06
	40-44	1:48 ± 0:12	1:51 ± 0:16	1:43 ± 0:11	1:44 ± 0:13	1:47 ± 0:15	1:38 ± 0:12	1:39 ± 0:11	1:39 ± 0:08	1:36 ± 0:09	1:34 ± 0:07	1:33 ± 0:08	1:35 ± 0:09	1:34 ± 0:08	1:32 ± 0:07	1:32 ± 0:08
	45-49	1:54 ± 0:15	1:49 ± 0:13	1:50 ± 0:20	1:42 ± 0:13	1:52 ± 0:15	1:45 ± 0:11	1:49 ± 0:18	1:40 ± 0:08	1:40 ± 0:16	1:38 ± 0:07	1:38 ± 0:08	1:38 ± 0:07	1:40 ± 0:12	1:36 ± 0:07	1:35 ± 0:08
	50-54	1:59 ± 0:13	2:06 ± 0:20	1:59 ± 0:16	1:51 ± 0:15	1:58 ± 0:18	1:44 ± 0:11	1:47 ± 0:14	1:46 ± 0:10	1:49 ± 0:10	1:41 ± 0:09	1:39 ± 0:08	1:42 ± 0:12	1:44 ± 0:12	1:38 ± 0:08	1:39 ± 0:08
	55-59	2:02 ± 0:15	2:13 ± 0:17	2:06 ± 0:16	1:54 ± 0:09	2:05 ± 0:20	1:55 ± 0:13	1:52 ± 0:12	1:52 ± 0:11	1:52 ± 0:17	1:46 ± 0:09	1:43 ± 0:07	1:50 ± 0:10	1:47 ± 0:11	1:43 ± 0:10	1:45 ± 0:10
	60-64	2:13 ± 0:22	2:12 ± 0:18	2:06 ± 0:17	2:10 ± 0:22	2:08 ± 0:16	2:04 ± 0:21	1:58 ± 0:11	1:54 ± 0:11	2:01 ± 0:17	1:50 ± 0:11	1:51 ± 0:11	1:57 ± 0:13	1:53 ± 0:12	1:51 ± 0:10	1:51 ± 0:11
	65-69	2:16 ± 0:32	2:24 ± 0:31	2:14 ± 0:24	2:11 ± 0:17	2:17 ± 0:24	2:23 ± 0:27	2:04 ± 0:14	2:11 ± 0:20	2:09 ± 0:15	1:56 ± 0:10	2:01 ± 0:12	2:05 ± 0:13	2:00 ± 0:14	1:57 ± 0:13	1:56 ± 0:12
	70-74	2:22 ± 0:16	2:26 ± 0:26	2:07 ± 0:12	2:09 ± 0:14	2:28 ± 0:29	2:23 ± 0:32	2:22 ± 0:32	2:19 ± 0:16	2:17 ± 0:19	2:08 ± 0:14	2:14 ± 0:14	2:16 ± 0:19	2:09 ± 0:14	2:05 ± 0:14	2:06 ± 0:12
	75-79	2:22 ± 0:20	2:57 ± 0:30	2:36 ± 0:15	3:06 ± 1:02	2:51 ± 0:42	2:46 ± 0:37	2:44 ± 0:40	2:34 ± 0:23	2:29 ± 0:18	2:27 ± 0:22	2:26 ± 0:22	2:28 ± 0:30	2:24 ± 0:23	2:11 ± 0:13	2:18 ± 0:16
	80-84		3:54 ± 0:56		3:13 ± 0:43	3:10 ± 0:37	3:14 ± 0:51		3:05 ± 0:36	2:25 ± 0:09	2:39 ± 0:25	2:29 ± 0:36	3:01 ± 0:36	2:24 ± 0:03	2:27 ± 0:34	2:38 ± 0:21
	85-89						3:04		4:08 ± 2:06	3:06 ± 0:30	3:29 ± 0:34	2:50 ± 0:19	2:55 ± 0:14	2:50 ± 0:33	2:33 ± 0:16	3:26 ± 1:24
	90-94										4:38	3:23		2:57 ± 0:54	2:37 ± 0:18	3:13 ± 0:23
200 m	25-29	3:27 ± 0:22	3:22 ± 0:22	3:09 ± 0:18	3:15 ± 0:19	3:24 ± 0:20	3:18 ± 0:24	3:02 ± 0:08	3:14 ± 0:15	3:08 ± 0:11	3:07 ± 0:11	3:07 ± 0:13	2:59 ± 0:12	3:03 ± 0:12	3:06 ± 0:11	3:07 ± 0:14
	30-34	3:38 ± 0:26	3:33 ± 0:33	3:20 ± 0:19	3:15 ± 0:16	3:22 ± 0:19	3:13 ± 0:12	3:10 ± 0:11	3:15 ± 0:12	3:08 ± 0:13	3:11 ± 0:12	3:06 ± 0:12	3:07 ± 0:15	3:01 ± 0:10	3:03 ± 0:10	3:08 ± 0:14
	35-39	4:00 ± 0:32	3:34 ± 0:23	3:18 ± 0:11	3:20 ± 0:18	3:27 ± 0:23	3:26 ± 0:23	3:13 ± 0:05	3:22 ± 0:15	3:21 ± 0:15	3:16 ± 0:14	3:18 ± 0:13	3:19 ± 0:12	3:11 ± 0:13	3:12 ± 0:13	3:11 ± 0:15
	40-44	3:55 ± 0:35	3:53 ± 0:31	3:24 ± 0:26	3:45 ± 0:33	3:36 ± 0:23	3:26 ± 0:19	3:21 ± 0:20	3:35 ± 0:20	3:28 ± 0:20	3:25 ± 0:13	3:17 ± 0:15	3:21 ± 0:16	3:20 ± 0:15	3:19 ± 0:14	3:19 ± 0:18
	45-49	4:13 ± 0:33	3:48 ± 0:25	3:23 ± 0:24	3:24 ± 0:11	3:51 ± 0:31	3:43 ± 0:21	3:34 ± 0:20	3:36 ± 0:19	3:34 ± 0:13	3:33 ± 0:16	3:29 ± 0:15	3:30 ± 0:16	3:24 ± 0:16	3:27 ± 0:14	3:24 ± 0:17
	50-54	4:24 ± 0:24	4:21 ± 0:39	4:12 ± 0:37	3:59 ± 0:34	4:04 ± 0:31	3:55 ± 0:28	3:44 ± 0:24	3:53 ± 0:30	3:50 ± 0:17	3:36 ± 0:18	3:34 ± 0:18	3:39 ± 0:24	3:34 ± 0:15	3:36 ± 0:14	3:34 ± 0:17
	55-59	4:26 ± 0:27	4:35 ± 0:39	4:19 ± 0:35	4:14 ± 0:34	4:19 ± 0:41	4:02 ± 0:23	3:56 ± 0:20	4:07 ± 0:29	3:51 ± 0:21	3:47 ± 0:18	3:47 ± 0:18	3:55 ± 0:22	3:42 ± 0:19	3:41 ± 0:20	3:40 ± 0:20
	60-64	4:33 ± 0:23	4:37 ± 0:42	4:36 ± 0:36	4:20 ± 0:36	4:17 ± 0:38	4:24 ± 0:37	4:13 ± 0:22	4:06 ± 0:21	4:08 ± 0:27	3:58 ± 0:22	3:54 ± 0:21	4:06 ± 0:23	3:57 ± 0:19	4:00 ± 0:21	3:58 ± 0:22
	65-69	4:42 ± 0:35	4:44 ± 0:36	5:14 ± 0:58	4:39 ± 0:39	4:45 ± 0:45	5:01 ± 0:43	4:23 ± 0:27	4:28 ± 0:25	4:34 ± 0:29	4:19 ± 0:25	4:15 ± 0:24	4:17 ± 0:28	4:08 ± 0:23	4:13 ± 0:24	4:06 ± 0:20
	70-74	5:08 ± 0:30	5:10 ± 0:47	4:41 ± 0:46	4:22 ± 0:11	5:00 ± 0:40	5:04 ± 1:01	4:37 ± 0:38	4:48 ± 0:34	4:41 ± 0:36	4:31 ± 0:26	4:43 ± 0:26	4:51 ± 0:33	4:28 ± 0:25	4:33 ± 0:30	4:31 ± 0:31
	75-79	4:36	6:25 ± 1:15	5:46 ± 0:42	7:36 ± 2:45	5:21 ± 0:56	6:32 ± 1:44	5:24 ± 1:01	5:33 ± 0:53	5:12 ± 0:34	4:57 ± 0:31	4:55 ± 0:34	5:10 ± 0:52	4:53 ± 0:39	4:46 ± 0:17	5:05 ± 0:28
	80-84		8:15 ± 2:00	8:00	7:23 ± 1:14	6:50 ± 0:39	6:39 ± 0:55		6:27 ± 1:17	5:37 ± 0:50	5:31 ± 0:1:02	5:32 ± 1:06	5:46 ± 1:01	5:52 ± 0:25	5:56 ± 1:17	5:31 ± 0:35
	85-89								9:31	6:52 ± 1:20	5:50	6:07 ± 0:39	5:58	5:44 ± 1:03	5:43	6:31 ± 1:25
	90-94											7:30		8:10 ± 1:48	7:27 ± 0:46	7:52 ± 1:42

Table 4. Race times for men in min:sec (±SD) in age groups from 50 m to 200 m

Distance	Age group	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014
	25-29	0:38 ± 0:05	0:38 ± 0:04	0:34 ± 0:02	0:34 ± 0:03	0:35 ± 0:03	0:35 ± 0:03	0:34 ± 0:02	0:34 ± 0:02	0:35 ± 0:04	0:33 ± 0:01	0:33 ± 0:01	0:33 ± 0:02	0:32 ± 0:01	0:33 ± 0:01	0:32 ± 0:01
	30-34	0:39 ± 0:05	0:39 ± 0:04	0:36 ± 0:03	0:35 ± 0:03	0:37 ± 0:03	0:35 ± 0:02	0:34 ± 0:03	0:34 ± 0:02	0:35 ± 0:03	0:34 ± 0:01	0:33 ± 0:02	0:34 ± 0:02	0:33 ± 0:01	0:33 ± 0:01	0:32 ± 0:01
	35-39	0:40 ± 0:04	0:40 ± 0:05	0:38 ± 0:05	0:34 ± 0:03	0:39 ± 0:05	0:37 ± 0:05	0:36 ± 0:04	0:36 ± 0:03	0:38 ± 0:04	0:34 ± 0:02	0:34 ± 0:02	0:35 ± 0:03	0:34 ± 0:02	0:34 ± 0:01	0:33 ± 0:02
	40-44	0:41 ± 0:04	0:41 ± 0:04	0:39 ± 0:05	0:38 ± 0:05	0:38 ± 0:03	0:39 ± 0:05	0:39 ± 0:09	0:36 ± 0:02	0:38 ± 0:04	0:35 ± 0:02	0:35 ± 0:02	0:36 ± 0:03	0:35 ± 0:02	0:35 ± 0:02	0:35 ± 0:02
	45-49	0:41 ± 0:04	0:44 ± 0:09	0:40 ± 0:06	0:40 ± 0:07	0:40 ± 0:06	0:39 ± 0:05	0:39 ± 0:05	0:37 ± 0:02	0:39 ± 0:04	0:36 ± 0:02	0:36 ± 0:02	0:37 ± 0:03	0:36 ± 0:02	0:36 ± 0:02	0:36 ± 0:02
	50-54	0:43 ± 0:04	0:44 ± 0:06	0:42 ± 0:05	0:41 ± 0:06	0:43 ± 0:07	0:40 ± 0:03	0:39 ± 0:09	0:39 ± 0:02	0:39 ± 0:05	0:38 ± 0:02	0:37 ± 0:02	0:39 ± 0:03	0:37 ± 0:02	0:38 ± 0:02	0:37 ± 0:02
	55-59	0:43 ± 0:06	0:45 ± 0:08	0:43 ± 0:06	0:42 ± 0:11	0:43 ± 0:06	0:42 ± 0:05	0:41 ± 0:05	0:40 ± 0:03	0:42 ± 0:07	0:39 ± 0:02	0:39 ± 0:03	0:41 ± 0:04	0:39 ± 0:03	0:39 ± 0:03	0:39 ± 0:03
50 m	60-64	0:48 ± 0:03	0:49 ± 0:16	0:45 ± 0:16	0:44 ± 0:06	0:46 ± 0:06	0:46 ± 0:07	0:44 ± 0:08	0:42 ± 0:04	0:45 ± 0:07	0:41 ± 0:03	0:41 ± 0:03	0:41 ± 0:03	0:40 ± 0:03	0:43 ± 0:05	0:40 ± 0:03
	65-69	0:47 ± 0:08	0:55 ± 0:08	0:55 ± 0:07	0:46 ± 0:06	0:49 ± 0:10	0:46 ± 0:06	0:46 ± 0:06	0:45 ± 0:04	0:45 ± 0:07	0:42 ± 0:03	0:44 ± 0:04	0:44 ± 0:04	0:43 ± 0:03	0:42 ± 0:03	0:42 ± 0:03
	70-74	0:51 ± 0:04	0:55 ± 0:08	0:53 ± 0:09	0:53 ± 0:10	0:52 ± 0:09	0:50 ± 0:06	0:48 ± 0:07	0:48 ± 0:05	0:50 ± 0:07	0:46 ± 0:02	0:45 ± 0:05	0:47 ± 0:05	0:45 ± 0:03	0:45 ± 0:04	0:45 ± 0:04
	75-79	0:58 ± 0:07	1:00 ± 0:19	0:53 ± 0:28	0:58 ± 0:22	1:04 ± 0:16	0:55 ± 0:11	0:53 ± 0:04	0:52 ± 0:08	0:54 ± 0:08	0:49 ± 0:05	0:50 ± 0:06	0:50 ± 0:04	0:48 ± 0:03	0:49 ± 0:05	0:49 ± 0:04
	80-84	1:00 ± 0:08	1:13 ± 0:07	1:30 ± 0:17	1:08 ± 0:16	1:02 ± 0:08	1:03 ± 0:10	0:56 ± 0:09	0:55 ± 0:05	0:54 ± 0:05	0:54 ± 0:05	0:59 ± 0:09	1:01 ± 0:09	0:56 ± 0:06	0:55 ± 0:05	0:55 ± 0:05
	85-89		2:19		1:05 ± 0:09	1:24 ± 0:20	1:07	1:22 ± 0:18	1:15 ± 0:15	0:55 ± 0:11	1:06 ± 0:07	1:04 ± 0:11	1:04 ± 0:09	1:07 ± 0:08	1:05 ± 0:04	1:08 ± 0:08
	90-94				2:39	1:57			1:34 ± 0:28		1:08		1:21 ± 0:18	1:11 ± 0:08	1:09 ± 0:11	1:04 ± 0:03
	95-99														1:57 ± 0:29	
	25-29	1:25 ± 0:10	1:24 ± 0:09	1:19 ± 0:05	1:17 ± 0:08	1:21 ± 0:09	1:18 ± 0:07	1:17 ± 0:07	1:17 ± 0:04	1:17 ± 0:06	1:14 ± 0:04	1:16 ± 0:03	1:14 ± 0:04	1:12 ± 0:03	1:14 ± 0:03	1:13 ± 0:04
	30-34	1:30 ± 0:12	1:26 ± 0:11	1:20 ± 0:06	1:18 ± 0:07	1:24 ± 0:09	1:18 ± 0:06	1:17 ± 0:06	1:18 ± 0:05	1:20 ± 0:08	1:16 ± 0:04	1:16 ± 0:05	1:17 ± 0:06	1:14 ± 0:04	1:15 ± 0:04	1:14 ± 0:04
	35-39	1:28 ± 0:08	1:29 ± 0:09	1:24 ± 0:09	1:19 ± 0:07	1:32 ± 0:11	1:22 ± 0:09	1:23 ± 0:09	1:22 ± 0:06	1:26 ± 0:15	1:17 ± 0:05	1:18 ± 0:05	1:21 ± 0:06	1:17 ± 0:06	1:18 ± 0:05	1:16 ± 0:05
	40-44	1:29 ± 0:09	1:32 ± 0:10	1:28 ± 0:10	1:26 ± 0:11	1:28 ± 0:10	1:26 ± 0:11	1:23 ± 0:10	1:23 ± 0:06	1:27 ± 0:13	1:21 ± 0:04	1:20 ± 0:05	1:20 ± 0:06	1:19 ± 0:05	1:20 ± 0:05	1:18 ± 0:05
	45-49	1:34 ± 0:10	1:35 ± 0:14	1:29 ± 0:12	1:27 ± 0:09	1:31 ± 0:13	1:27 ± 0:06	1:25 ± 0:10	1:25 ± 0:06	1:25 ± 0:06	1:22 ± 0:06	1:22 ± 0:06	1:23 ± 0:07	1:21 ± 0:06	1:22 ± 0:05	1:21 ± 0:06
	50-54	1:37 ± 0:11	1:37 ± 0:13	1:34 ± 0:11	1:29 ± 0:09	1:33 ± 0:12	1:28 ± 0:08	1:26 ± 0:09	1:27 ± 0:06	1:30 ± 0:13	1:24 ± 0:05	1:25 ± 0:06	1:28 ± 0:08	1:23 ± 0:06	1:24 ± 0:05	1:23 ± 0:06
	55-59	1:38 ± 0:07	1:44 ± 0:14	1:37 ± 0:10	1:31 ± 0:10	1:38 ± 0:16	1:36 ± 0:11	1:33 ± 0:10	1:32 ± 0:08	1:34 ± 0:14	1:29 ± 0:06	1:28 ± 0:06	1:31 ± 0:09	1:29 ± 0:07	1:31 ± 0:07	1:29 ± 0:07
100 m	60-64	1:40 ± 0:07	1:49 ± 0:18	1:42 ± 0:12	1:40 ± 0:11	1:43 ± 0:11	1:45 ± 0:19	1:37 ± 0:10	1:35 ± 0:07	1:40 ± 0:14	1:32 ± 0:06	1:32 ± 0:09	1:34 ± 0:08	1:33 ± 0:07	1:35 ± 0:09	1:32 ± 0:07
	65-69	1:48 ± 0:17	2:00 ± 0:33	1:56 ± 0:17	1:43 ± 0:09	1:47 ± 0:14	1:48 ± 0:14	1:47 ± 0:15	1:45 ± 0:14	1:42 ± 0:14	1:38 ± 0:07	1:41 ± 0:08	1:40 ± 0:11	1:37 ± 0:08	1:36 ± 0:08	1:37 ± 0:08
	70-74	2:00 ± 0:18	1:59 ± 0:16	2:10 ± 0:27	1:57 ± 0:16	2:00 ± 0:16	1:54 ± 0:13	1:51 ± 0:16	1:52 ± 0:11	1:56 ± 0:15	1:47 ± 0:09	1:43 ± 0:12	1:48 ± 0:16	1:44 ± 0:09	1:44 ± 0:09	1:47 ± 0:12
	75-79	2:24 ± 0:20	2:26 ± 0:26	2:05 ± 0:15	2:06 ± 0:27	2:13 ± 0:31	2:00 ± 0:13	2:04 ± 0:13	2:01 ± 0:18	2:08 ± 0:17	1:53 ± 0:11	1:53 ± 0:10	2:00 ± 0:16	1:49 ± 0:09	1:49 ± 0:11	1:45 ± 0:13
	80-84		2:20 ± 0:26	3:39 ± 0:14	2:50 ± 0:35	2:22 ± 0:18	2:27 ± 0:27	2:24 ± 0:28	2:13 ± 0:17	2:16 ± 0:22	2:06 ± 0:15	2:15 ± 0:20	2:17 ± 0:20	2:11 ± 0:15	2:09 ± 0:14	2:06 ± 0:17
	85-89		4:09 ± 0:27		3:13 ± 0:23	3:07 ± 0:51		3:20 ± 0:53	2:52 ± 0:40	2:22 ± 0:27	2:43 ± 0:25	2:34 ± 0:25	2:34 ± 0:25	2:25 ± 0:23	2:43 ± 0:16	2:52 ± 0:5
	90-94						3:08		3:24 ± 0:45		3:48		3:03 ± 0:35	2:55 ± 0:27	2:48	
	95-99														4:27 ± 0:43	
	25-29	3:07 ± 0:22	2:55 ± 0:16	2:53 ± 0:14	2:52 ± 0:18	2:53 ± 0:17	2:47 ± 0:11	2:46 ± 0:11	2:52 ± 0:10	2:46 ± 0:11	2:44 ± 0:10	2:47 ± 0:09	2:47 ± 0:10	2:42 ± 0:07	2:41 ± 0:08	2:46 ± 0:18
	30-34	3:18 ± 0:42	3:05 ± 0:21	2:57 ± 0:13	2:51 ± 0:13	3:05 ± 0:18	2:53 ± 0:14	2:51 ± 0:11	2:53 ± 0:11	2:46 ± 0:08	2:48 ± 0:09	2:41 ± 0:10	2:45 ± 0:14	2:45 ± 0:09	2:44 ± 0:09	2:45 ± 0:10
	35-39	3:19 ± 0:27	3:11 ± 0:16	3:00 ± 0:14	2:57 ± 0:17	3:14 ± 0:26	3:02 ± 0:22	2:59 ± 0:15	2:58 ± 0:13	2:57 ± 0:12	2:50 ± 0:11	2:50 ± 0:11	2:50 ± 0:14	2:50 ± 0:11	2:50 ± 0:09	2:46 ± 0:12
	40-44	3:22 ± 0:25	3:19 ± 0:19	3:11 ± 0:19	3:05 ± 0:22	3:10 ± 0:20	3:12 ± 0:24	2:56 ± 0:12	3:04 ± 0:14	3:05 ± 0:15	2:59 ± 0:10	2:55 ± 0:12	2:55 ± 0:14	2:54 ± 0:12	2:56 ± 0:12	2:54 ± 0:12
	45-49	3:32 ± 0:23	3:33 ± 0:44	3:07 ± 0:12	3:15 ± 0:22	3:20 ± 0:24	3:15 ± 0:16	2:53 ± 0:10	3:09 ± 0:16	3:10 ± 0:14	3:02 ± 0:13	2:57 ± 0:12	3:00 ± 0:14	2:59 ± 0:14	2:59 ± 0:11	3:00 ± 0:12
	50-54	3:34 ± 0:21	3:42 ± 0:37	3:34 ± 0:28	3:20 ± 0:18	3:24 ± 0:25	3:14 ± 0:16	3:07 ± 0:11	3:16 ± 0:13	3:16 ± 0:21	3:07 ± 0:12	3:01 ± 0:12	3:08 ± 0:15	3:06 ± 0:14	3:07 ± 0:13	3:06 ± 0:13
	55-59	3:44 ± 0:26	3:47 ± 0:29	3:24 ± 0:16	3:23 ± 0:22	3:33 ± 0:24	3:36 ± 0:25	3:21 ± 0:18	3:23 ± 0:17	3:25 ± 0:20	3:18 ± 0:11	3:15 ± 0:14	3:17 ± 0:20	3:16 ± 0:14	3:16 ± 0:13	3:16 ± 0:15
200 m	60-64	3:49 ± 0:18	3:54 ± 0:26	3:41 ± 0:24	3:50 ± 0:27	3:46 ± 0:25	3:41 ± 0:23	3:38 ± 0:15	3:38 ± 0:21	3:36 ± 0:20	3:25 ± 0:16	3:19 ± 0:16	3:23 ± 0:18	3:28 ± 0:14	3:24 ± 0:19	3:23 ± 0:18
	65-69	3:41 ± 0:15	4:13 ± 0:42	4:19 ± 0:42	3:50 ± 0:21	3:54 ± 0:28	3:56 ± 0:23	3:52 ± 0:19	3:51 ± 0:26	3:47 ± 0:27	3:43 ± 0:16	3:42 ± 0:19	3:42 ± 0:25	3:41 ± 0:21	3:37 ± 0:19	3:35 ± 0:19
	70-74	4:18 ± 0:34	4:20 ± 0:39	4:17 ± 0:34	4:20 ± 0:33	4:25 ± 0:36	4:05 ± 0:33	4:03 ± 0:33	4:07 ± 0:23	4:08 ± 0:19	3:52 ± 0:15	3:42 ± 0:21	3:47 ± 0:32	3:46 ± 0:21	3:48 ± 0:15	3:53 ± 0:26
	75-79	4:39 ± 0:08	5:29 ± 1:08	4:48 ± 0:27	4:24 ± 0:29	4:25 ± 0:53	5:11 ± 1:30	4:53 ± 0:38	4:32 ± 0:37	4:24 ± 0:37	4:17 ± 0:24	4:09 ± 0:20	4:18 ± 0:27	3:56 ± 0:15	4:05 ± 0:28	4:11 ± 0:29
	80-84		5:49 ± 0:55	5:11	5:45 ± 0:17	5:26 ± 0:37	5:20 ± 1.14	4:33	5:11 ± 0:44	4:58 ± 1:15	4:44 ± 0:31	4:54 ± 0:54	4:39 ± 0:49	4:55 ± 0:30	4:41 ± 0:27	4:34 ± 0:30
	85-89		5:36					8:25	6:29 ± 1:47	4:38	5:41 ± 0:21	5:31 ± 0:45	6:39	4:36 ± 0:36	6:02 ± 0:29	5:39 ± 0:37
	90-94					7:03					8:06		6:44 ± 1:16	6:02	6:23	7:10
	95-99														10:00 ± 2:33	

Table 5. Results of the mixed-effects regression analyses for performance in age groups

	Estimate	Standard error	df	t	*P*
25-29 years					
Constant term	35.23	0.38	2305.61	92.59	<0.0001
[sex = women]	6.94	0.56	2386.33	12.28	<0.0001
[distance = 200]	134.64	0.45	1875.96	293.36	<0.0001
[distance = 100]	42.59	0.38	1691.76	111.34	<0.0001
30-34 years					
Constant term	35.60	0.35	2946.46	100.59	<0.0001
[sex = women]	7.38	0.54	3023.95	13.55	<0.0001
[distance = 200]	137.21	0.46	2448.01	293.84	<0.0001
[distance = 100]	43.54	0.38	2261.43	112.70	<0.0001
35-39 years					
Constant term	37.12	0.40	3064.85	92.33	<0.0001
[sex = women]	7.60	0.60	3058.82	12.66	<0.0001
[distance = 200]	141.82	0.51	2409.72	273.15	<0.0001
[distance = 100]	45.41	0.41	2239.64	108.67	<0.0001
40-44 years					
Constant term	37.83	0.39	3338.95	94.78	<0.0001
[sex = women]	8.70	0.59	3391.80	14.74	<0.0001
[distance = 200]	146.59	0.46	2818.84	312.67	<0.0001
[distance = 100]	46.49	0.39	2667.17	117.70	<0.0001
45-49 years					
Constant term	38.94	0.43	3121.16	90.15	<0.0001
[sex = women]	10.05	0.63	3184.38	15.85	<0.0001
[distance = 200]	150.52	0.51	2677.21	294.59	<0.0001
[distance = 100]	47.52	0.43	2481.08	109.89	<0.0001
50-54 years					
Constant term	39.96	0.51	2846.58	77.38	<0.0001
[sex = women]	11.62	0.75	2934.11	15.39	<0.0001
[distance = 200]	156.58	0.59	2534.61	261.78	<0.0001
[distance = 100]	49.34	0.52	2397.50	93.84	<0.0001
55-59 years					
Constant term	42.19	0.59	2305.14	71.13	<0.0001
[sex = women]	13.18	0.88	2421.77	14.96	<0.0001
[distance = 200]	163.79	0.64	2146.67	254.62	<0.0001
[distance = 100]	51.91	0.55	2049.42	93.81	<0.0001
60-64 years					
Constant term	44.28	0.65	1934.843	67.803	<0.0001
[sex = women]	14.09	0.95	2013.537	14.751	<0.0001
[distance = 200]	172.73	0.72	1935.198	238.147	<0.0001
[distance = 100]	54.85	0.61	1832.766	89.065	<0.0001
65-69 years					
Constant term	47.30	0.86	1527.52	54.90	<0.0001
[sex = women]	13.75	1.27	1534.86	10.82	<0.0001
[distance = 200]	182.80	0.91	1615.30	199.38	<0.0001
[distance = 100]	57.70	0.80	1511.49	71.42	<0.0001
70-74 years					
Constant term	49.10	1.14	1209.95	42.70	<0.0001
[sex = women]	16.09	1.68	1168.23	9.54	<0.0001
[distance = 200]	194.08	1.26	1182.04	153.25	<0.0001
[distance = 100]	63.33	1.08	1094.59	58.40	<0.0001
75-79 years					
Constant term	54.57	2.19	743.94	24.88	<0.0001
[sex = women]	17.78	3.28	732.36	5.41	<0.0001
[distance = 200]	213.21	2.44	698.88	87.28	<0.0001
[distance = 100]	68.32	2.11	643.47	32.35	<0.0001
80-84 years					
Constant term	58.84	2.83	411.27	20.76	<0.0001
[sex = women]	23.62	4.29	403.51	5.50	<0.0001
[distance = 200]	240.23	3.27	382.74	73.43	<0.0001
[distance = 100]	78.97	2.79	365.65	28.28	<0.0001
85-89 years					
Constant term	70.03	5.52	130.62	12.67	<0.0001
[sex = women]	30.72	9.77	128.06	3.14	0.002
[distance = 200]	285.88	6.43	134.18	44.39	<0.0001
[distance = 100]	97.13	4.97	123.27	19.53	<0.0001
90-94 years					
Constant term	92.71	10.22	40.30	9.06	<0.0001
[sex = women]	7.98	15.63	41.15	0.51	0.612
[distance = 200]	326.50	11.92	35.84	27.38	<0.0001
[distance = 100]	102.43	10.54	34.07	9.70	<0.0001
95-99 years					
Constant term	117.43	39.19	7.14	2.99	0.020
[sex = women]	59.05	55.42	7.14	1.06	0.321
[distance = 200]	502.57	43.74	5.24	11.48	<0.0001
[distance = 100]	149.95	43.74	5.24	3.42	0.017

Table 6. Results of the mixed-effects regression analyses for interaction in age groups

	Estimate	Standard error	df	t	*P*
25-29 years					
[sex = women] × [distance = 200]	16.37	0.67	1873.65	24.43	<0.0001
[sex = women] × [distance = 100]	5.94	0.56	1699.78	10.59	<0.0001
30-34 years					
[sex = women] × [distance = 200]	15.59	0.69	2407.06	22.45	<0.0001
[sex = women] × [distance = 100]	5.66	0.58	2255.97	9.70	<0.0001
35-39 years					
[sex = women] × [distance = 200]	17.65	0.74	2392.76	23.58	<0.0001
[sex = women] × [distance = 100]	5.91	0.62	2246.79	9.41	<0.0001
40-44 years					
[sex = women] × [distance = 200]	18.30	0.68	2808.78	26.70	<0.0001
[sex = women] × [distance = 100]	6.70	0.57	2650.31	11.59	<0.0001
45-49 years					
[sex = women] × [distance = 200]	18.53	0.74	2660.46	24.98	<0.0001
[sex = women] × [distance = 100]	6.97	0.63	2504.45	11.04	<0.0001
50-54 years					
[sex = women] × [distance = 200]	23.04	0.88	2582.29	26.01	<0.0001
[sex = women] × [distance = 100]	8.35	0.77	2456.40	10.79	<0.0001
55-59 years					
[sex = women] × [distance = 200]	23.20	0.94	2197.53	24.48	<0.0001
[sex = women] × [distance = 100]	8.26	0.82	2099.68	9.97	<0.0001
60-64 years					
[sex = women] × [distance = 200]	23.22	1.07	1999.57	21.52	<0.0001
[sex = women] × [distance = 100]	8.34	0.92	1906.44	9.03	<0.0001
65-69 years					
[sex = women] × [distance = 200]	27.30	1.38	1629.73	19.66	<0.0001
[sex = women] × [distance = 100]	11.05	1.20	1537.91	9.18	<0.0001
70-74 years					
[sex = women] × [distance = 200]	29.21	1.86	1186.43	15.65	<0.0001
[sex = women] × [distance = 100]	9.35	1.61	1111.55	5.77	<0.0001
75-79 years					
[sex = women] × [distance = 200]	42.65	3.70	704.32	11.50	<0.0001
[sex = women] × [distance = 100]	14.33	3.22	660.59	4.44	<0.0001
80-84 years					
[sex = women] × [distance = 200]	50.29	5.14	401.22	9.76	<0.0001
[sex = women] × [distance = 100]	19.21	4.37	370.91	4.39	<0.0001
85-89 years					
[sex = women] × [distance = 200]	12.18	10.76	128.08	1.13	0.260
[sex = women] × [distance = 100]	1.84	8.54	122.26	0.21	0.830
90-94 years					
[sex = women] × [distance = 200]	45.35	16.59	34.17	2.73	0.010
[sex = women] × [distance = 100]	25.77	14.96	31.23	1.72	0.095

groups (>40 years) although the youngest age group in the FINA World Masters Championships was 25-29 years. A potential explanation that participation showed no increase in age group swimmers younger than ~40 years could be the fact that the fastest elite breaststroke swimmers in younger age groups (<40 years) preferably compete at world class level races such as the World Championships and the Olympic Games (3, 4, 19). Elite breaststroke swimmers competing in finals at the World Championships and the Olympic Games are generally ~25 years in age or younger (19). For swimmers competing in the older age groups (>40 years),

Table 7. Sex difference (%) in age groups from 50 m to 200 m

Distance	Age group	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	r^2	*P*
50 m	25-29	19.0	16.7	22.4	22.9	29.1	17.4	20.2	18.8	12.2	17.4	16.2	18.6	18.5	15.7	17.0	0.18	0.112
	30-34	21.5	19.3	22.3	15.9	25.3	20.1	19.6	20.0	15.4	19.3	16.6	14.1	15.4	16.8	18.3	0.24	0.155
	35-39	27.3	21.1	12.7	32.5	15.2	16.3	20.2	18.0	14.2	18.8	19.5	16.6	18.4	17.9	18.4	0.11	0.224
	40-44	23.8	29.2	23.8	21.9	26.8	16.6	20.9	21.9	16.1	17.5	21.8	21.1	20.0	18.3	18.3	0.39	0.013
	45-49	31.7	25.0	30.3	13.7	27.7	22.6	29.7	19.3	17.1	20.5	18.4	18.7	19.1	17.6	16.3	0.43	0.007
	50-54	35.6	37.4	30.5	28.2	27.8	29.1	37.0	23.8	28.5	20.4	19.3	20.6	20.8	17.1	18.6	0.75	<0.0001
	55-59	36.2	41.2	47.5	33.4	36.1	26.6	32.7	29.0	21.5	20.3	19.3	24.1	18.9	15.1	17.0	0.82	<0.0001
	60-64	27.9	34.4	38.7	37.1	37.1	28.2	32.5	25.2	25.3	18.9	23.7	24.8	19.7	14.7	23.4	0.63	0.0004
	65-69	48.5	29.1	18.5	28.9	30.5	33.9	37.8	28.1	31.8	25.3	26.6	27.5	20.6	24.3	21.4	0.28	0.041
	70-74	41.0	36.5	39.0	44.1	34.7	29.7	44.8	31.5	33.0	26.1	35.5	28.5	22.4	19.4	22.1	0.64	0.0003
	75-79	32.9	28.6	53.5	39.6	11.6	31.6	35.7	27.2	27.0	33.3	30.9	30.3	27.3	19.1	23.7	0.16	0.135
	80-84		49.2	14.5	27.9	50.1	59.0		46.9	39.5	29.1	23.1	26.1	23.2	30.8	28.2	0.14	0.213
	85-89		50.6				20.6		70.3	33.2	38.4	12.9	34.4	19.0	4.6	35.0	0.24	0.155
	90-94								3.1		67.4			48.4	52.1	17.8	0.04	0.759
100 m	25-29	14.8	16.5	14.5	19.3	17.3	15.5	16.4	16.9	12.6	16.3	13.5	15.9	21.0	15.4	16.0	0.00	0.847
	30-34	12.1	15.2	15.9	14.2	15.8	14.7	18.5	15.3	14.0	15.8	15.4	11.7	18.3	15.2	16.5	0.06	0.360
	35-39	22.7	17.7	17.3	20.4	8.6	16.0	11.6	14.2	11.7	14.6	16.1	13.3	16.0	12.1	15.3	0.20	0.094
	40-44	21.5	21.4	16.7	20.1	20.7	13.7	19.7	18.4	10.5	16.5	17.3	18.2	19.2	15.2	17.6	0.15	0.150
	45-49	21.2	15.3	22.4	17.3	21.8	19.6	28.9	18.0	18.2	19.1	19.1	16.7	23.0	17.1	17.8	0.02	0.592
	50-54	22.1	29.2	26.0	24.6	26.9	18.1	24.6	21.0	20.6	19.9	16.7	15.5	24.2	16.9	19.2	0.44	0.007
	55-59	26.5	28.0	29.4	25.8	27.6	19.9	20.3	21.1	18.3	18.9	17.1	19.9	20.4	13.6	18.2	0.73	<0.0001
	60-64	33.0	20.9	23.1	29.3	23.2	18.0	21.8	19.6	21.4	19.5	20.1	24.1	20.9	16.9	20.7	0.32	0.026
	65-69	25.6	20.0	15.7	27.3	27.6	32.0	16.3	24.6	25.5	18.3	20.2	23.8	23.0	21.4	19.2	0.03	0.504
	70-74	18.1	22.4	2.5	10.4	23.1	26.1	28.2	23.7	18.2	19.2	29.4	25.8	24.4	19.3	18.0	0.11	0.219
	75-79	1.2	21.1	25.1	47.3	28.4	37.9	31.5	27.0	15.9	29.4	29.1	23.4	32.8	20.0	20.0	0.00	0.839
	80-84		66.7		13.8	33.3	31.6		39.0	6.3	26.1	24.8	32.1	9.6	29.0	25.1	0.20	0.140
	85-89								44.5	30.3	27.9	10.9	13.4	17.6	5.8	19.9	0.36	0.115
	90-94										21.9			35.4	23.3		0.14	0.757
200 m	25-29	10.5	15.0	9.3	13.3	17.6	18.0	9.1	12.4	13.3	13.7	11.7	7.2	12.8	15.2	12.9	0.00	0.843
	30-34	10.3	14.7	12.8	13.9	9.1	11.7	11.3	12.3	13.2	13.3	15.0	13.3	9.8	11.3	13.7	0.01	0.774
	35-39	22.3	12.1	9.8	12.7	6.3	13.4	7.8	13.3	13.5	15.4	16.3	17.1	12.7	13.4	15.2	0.02	0.660
	40-44	16.0	17.2	17.1	21.3	13.3	7.5	14.5	16.6	12.1	14.2	12.7	14.9	15.3	12.7	14.6	0.11	0.236
	45-49	19.3	7.0	19.1	4.5	15.4	13.8	23.1	14.1	12.3	16.8	18.1	16.5	14.3	15.5	13.6	0.02	0.642
	50-54	23.0	17.8	17.5	19.8	19.3	20.8	19.6	18.5	17.5	15.1	18.0	15.9	15.1	15.3	15.0	0.61	0.006
	55-59	18.7	21.3	26.9	24.9	21.5	12.3	17.4	21.5	12.5	14.8	16.8	19.0	13.1	12.7	12.2	0.46	0.005
	60-64	19.4	18.3	24.7	12.9	13.6	19.4	16.1	13.0	14.8	16.1	17.3	20.8	13.8	17.4	17.0	0.29	0.036
	65-69	27.5	12.2	21.2	21.0	21.7	27.2	13.3	15.8	20.5	15.7	14.6	15.7	11.9	16.5	14.6	0.04	0.460
	70-74	19.2	19.0	9.0	0.6	13.1	24.3	14.1	16.6	13.1	16.6	27.5	28.0	18.7	20.0	15.9	0.15	0.159
	75-79	1.1	17.1	19.9	72.7	21.1	25.8	10.4	22.6	18.0	15.7	18.0	20.1	24.0	16.6	21.4	0.01	0.788
	80-84		41.8	54.0	28.3	25.4	24.5		24.4	13.2	16.3	12.9	23.9	19.2	26.9	21.0	0.24	0.155
	85-89								46.8	48.3	2.5	10.8	10.2	24.6	5.2	15.2	0.36	0.115
	90-94													35.4	16.4	9.8	0.93	0.173

the most likely explanation for the increase in participation could be the increase in life expectancy in the last decades (22, 24, 32, 33). Today, more and more people reach older ages with a better overall functioning (7). The worldwide number of elderly people older than 80 years is growing steadily.[2]

Actually, the life expectancy at birth exceeds ~83 years in Japan, the current leader, and is at ~81 years in several other countries.[3] For nonagenarians, for example, the number of people living past the age of 90 years has trebled to 440,000 in the last 30 years in England.[4] For centenarians, the number of new centenarians in Western Europe and Japan grew at an annual rate of ~7% between the 1950s and the 1980s, doubling every decade.[5] Today, centenarians are on average functioning physically and cognitively as well as 92-93-year-olds due to selective mortality (6). An increase in the number of successful master athletes has, however, also been reported for shorter (2) and longer swimming distances (8) and for different running distances (1, 5, 13, 21, 31). However, this is the first study to demonstrate that the number of age group breaststroke swimmers competing at international level has also increased.

Women and Men Improved Performance in All Distances

A further important finding was that both women and men reduced their race times across years for all distances and in all age groups. A potential explanation that elderly swimmers improved performance could be their training and their pre-race preparation (34). Chronic endurance training preserves muscle mass in the aging athlete (38) and delays the age-related decrease in maximum oxygen uptake (14). A study investigating French master swimmers showed a positive health outcome in terms of body weight management, respiratory function, and vitality due to race preparation (26). Interestingly, the positive health outcomes were higher for female than for male age groups swimmers (26).

The finding that women and men improved performance in all age groups confirms previous findings for age group athletes such as age group marathoners (13, 21) and age group swimmers (2, 23). However, this is the first study to show that octogenarians and nonagenarians improved their athletic performance in pool swimming. In the studies of Akkari *et al.* (2) for swimmers and Lepers and Cattagni (21) for marathoners, the oldest age group was 75-79 years. However, this trend for very old athletes seems not a general trend. A very recent study investigating female and male marathoners older than 75 years competing between 2004 and 2011 showed that participation for both sexes remained unchanged and the fastest women and men became slower across years (1). The disparate findings between the present age group swimmers and the mentioned age group marathoners older than 75 years might be explained by the different time spans. While Ahmadyar *et al.* (1) considered only seven years we investigated in the present study a period of 28 years.

Women Were Not Slower Compared to Men in Age Groups 90-94 to 95-99 Years

A third important finding was that men were faster than women from 25 to 89 years, but not from 90 to 99 years. The small number of female and male athletes older than 90 years might be a potential explanation for these findings. The men-to-women ratio remained unchanged across age groups from 25-29 to 90-94 years. The ratio increased, however, in 100 m and 200 m when age groups 25-29 to 80-89 years were considered. In other terms, the number of women increased in age groups 25-29 to 80-89 years relative to men, but not after the age of 90 years.

This difference for swimmers older than 90 years might be explained by differences in anthropometric characteristics such as skeletal muscle mass in elderly people (9, 12, 39). There seemed to be differences between the sexes regarding an age-related loss in skeletal muscle mass. In people older than 80 years, the prevalence of sarcopenia was ~31% in women and ~53% in men (12). Men older than 70 years lose significantly more fat free mass than women (9). In people aged 68-78 years, the rate of loss in leg muscle mass was significantly higher in men than in women (39).

Our findings differ from recent findings of Senefeld *et al.* (29) investigating finishing times of the top ten female and male world record performances for 50 m to 200 m breaststroke from 1986 to 2011 between 25 and 89 years of age. Men were faster than women in breaststroke swimming across all age groups, world record places and distances (29). The most likely explanation for these disparate findings are that Senefeld *et al.* (29) considered the top ten women and men world record performances until the age of 89 years while we considered all finishers at the FINA

[2]The 2015 Revision of World Population Prospects, website http://esa.un.org/unpd/wpp/, accessed September 18, 2015.
[3]Global Health and Aging, website www.nia.nih.gov/research/publication/global-health-and-aging/living-longer, accessed September 18, 2015.
[4]Number of people living past 90 has trebled to 440,000 in the last 30 years, website www.dailymail.co.uk/news/article-2297069/Number-people-living-past-90-trebled-440-000-30-years.html, accessed September 18, 2015.
[5]The emergence and proliferation of centenarians, website www.popline.org/node/291152, accessed September 18, 2015.

World Masters Championships until the age of 99 years and without a selection of the top athletes. However, we must admit that the age groups 90-94 and 95-99 years are very exclusive age groups with very low numbers of recorded athletes. Furthermore, women and men in these age groups started to compete only in recent years (Table 1) which might also influence the results.

Women Reduced the Gap to Men in Middle Ages (~40-75 Years)

A further important finding was that women were not able to reduce the sex difference to men in age groups younger than ~40-50 years and older than ~60-75 years. Between these age ranges, women were able to reduce the gap to men. Our findings differ again from the findings of Senefeld *et al.* (29). These authors found for breaststroke swimming a decrease in performance with longer distances across all world record places (29). The most likely explanation is that we considered all successful finishers in the FINA World Masters Championships without selection of the ten fastest whereas Senefeld *et al.* (29) investigated world record performances of the ten fastest women and men. The findings for age group swimmers in Senefeld *et al.* (29) were also different to findings for age group marathon runners. When freestyle swimming and marathon running were compared, the sex difference was larger for marathon running than for freestyle swimming across all age groups (29).

Other studies showed a U-shaped association between sex difference and age for running (16, 20). When world single age records in marathon running in 1-year intervals were analysed for women and men, the sex difference was lowest (7.5%) at the age of ~49 years (16). The sex difference remained unchanged from ~20 to ~50 years and increased after the age of ~50 years (16). Similarly, for top ten women and men analysed at 1-year intervals (*e.g.* from 18 to 75 years) competing in the 'New York City Marathon', the sex difference in race times remained stable at ~18.7% between 18 and 57 years of age. After this age, the sex difference progressively increased with advancing age (20).

Limitations

Caution is needed to generalize the findings of the present study to swimmers of other strokes, because strokes differ with regards to physiological and biomechanical characteristics. In addition, the findings concerned trends in performance over a particular period (1986-2014); thus, in the future, it would be necessary to examine these trends under new conditions (*e.g.* increased age in the general population and probably relatively higher participation in the older age groups).

Practical Applications

Based on the findings of this study, athletes and coaches should be aware that at the moment no limit for age groups swimmers regarding participation and performance exists. Elderly swimmers should be encouraged to continue training and competing also in the very old and 'geriatric' age groups of 90 years and older. We might soon expect the first female and male age groups breaststroke swimmers of 100 years and older. Moreover, the results might enhance the understanding of both sports scientists and coaches working with master swimmers concerning age- and sex-related aspects of performance. Knowledge about the age of peak performance or sex differences, and whether this information has changed from the past, might help coaches to set evidence-based training aims.

In summary, in age group breaststroke swimmers competing in the FINA World Masters Championships between 1986 and 2014, (*i*) women and men improved performance in all distances, (*ii*) women were not slower compared to men in age groups 90-94 to 95-99 years, and (*iii*) women reduced the gap to men from ~40-75 years, but not in older age groups. Based on these findings for a time period of nearly 30 years, we expected a further increase in participation and a further improvement in performance in age group breaststroke swimmers competing at world class level.

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