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Original Investigation

Deaflympic Games 2017 vs. Olympic Games 2016 - male swimming competition, analysis of the age, reaction time, speed and final time

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Purpose: The aim was to analyze the swimming performance of the world's best deaf male swimmers at the Deaflympic Games (2017) and male hearing swimmers at the Olympic Games (2016).
Methods: To analysis at Deaflympic competition the results of 8 the best finalists in all strokes and distances were used (n=128 records). Olympic participants (n=312) were divided into two groups (a) 8 the best finalists in all swimming strokes and distances (b) outsiders – last 16 places (records) from the participation's lists were used to compare. The age, start reaction time, average speed swimming and finish time of race in all strokes and distances were compared. The comparison of starting variables was made using one-way analysis of variance with Tukey's post-hoc test or, alternatively, the Kruskal-Wallis test.
Results: No statistically significant differences were found for age and start reaction time. Differences between deaf and best hearing swimmers were found for average speed swimming and final race time (all $P < .001$, except freestyle at the distance 50 m ($P = .264$)). Comparing deaf and last 16 places hearing swimmers' significant values was found for: freestyle at distance 50 m and 1500 m ($P = .009$, $P = .017$), breaststroke at distance 100 m and 200 m ($P = .038$; $P = .009$), butterfly at 200 m ($P = .006$), individual medley at distance 200 m and 400 m ($P = .011$, $P = .004$).
Conclusions: The results achieved by the best deaf swimmers placed them rather at the same level with the group of hearing swimmers with the worst times than with the group of hearing leaders. The results obtained by deaf swimmers confirm the necessity of separating competitions for deaf and hearing people due to health and organizational limitations. Include Deaf swimmers in hearing sports, they could reach the level of hearing swimmers. The analyses performed may be helpful in the training process and in setting sports goals.

Keywords: social exclusion, disability, hearing impaired, sport competition, winners

Introduction

There are many scientific publications in the world literature that comprehensively analyze swimming as a sport at various levels of sports advancement. Many of the publications concern world championship events and the Olympic Games. Knechtle et al.[1] and König et al.[2] analyzed the importance of the age of competitors in the competition during the swimming world championships in 1994-2013 and during the world championships in 1992-2012. Schulz[3] and Curnow dealt with the issue of what age the peak sports abilities of super athletes occur. Wolfrum[4] et al. analyzed gender differences and the age at which swimming abilities peak for breaststroke and freestyle. Stanula[5] et al. noticed that the differences in the final results for individual swimming stroke and distances between swimmers starting in the final races and the losers closing the group of swimmers are constantly decreasing. Buhl[6] et al. compared changes in women's and men's swimming times in individual medley and freestyle during the Swiss Championships and during the World Championships in 1994-2011. Vaso et al.[7] analyzed the swimming medley and freestyle in relation to age and gender. Rüst et al.[8,9] undertook to assess changes in the age at which the peak speed occurs in swimmers (women and men) swimming freestyle in the years 1994-2012. Koch-Ziegenbein et al.[10] dealt with the issue of changes in swimming speed over short and long distances for women and men in breaststroke at the national and international level. Nevill[11] et al. wondered what aspects determine the limitations in breaking subsequent world records in swimming and that the differences between the times achieved by men and women remain at a constant level. Rüst et al.[12] analyzed national data based on which they attempted to examine the age range of the maximum speed of freestyle swimming and to find differences in the age range and peak speed of freestyle swimming between women and men swimming freestyle at distances from 50 to 1500 m. Nadobnik and Wiążewicz[13] analyzed strength abilities in sports swimming. Santos et al.[14] analyzed the progression and variability of swimming results (from start times to best results) at distances of 50, 100 and 200 m during the FINA World Championships in Budapest 2022 and compared the results of the 16 best competitors, semi-finalists and finalists between all rounds. Mallet et al.[15] analyzed a problem of the age, height and body mass of the elite Olympic swimmers.

There are no scientific literature analyzing the swimming of deaf swimmers; therefore this article compares selected starting variables achieved by deaf swimmers during the XXIII Summer Deaflympic Games (Samsun, Turkey, 2017) with the starting variables achieved by swimmers of the XXXI Summer Olympic Games (Rio de Janeiro, Brazil, 2016). In both cases, the competition took place in a 50-meter indoor swimming pool. In addition to the age of the competitors, reaction time, swimming speed and final time, the records for the Olympic Games and the Deaflympic Games are given. From the technical side of swimming competitions for the deaf, the element that differentiates the competitions for the deaf from the competitions for the hearing is the starting mechanism. During competitions for hearing people, the starting stimulus is only an acoustic signal. During the Deaflympics Games, in addition to the sound signal, a three-color light signal is used, located in the lower part of each starting post on the side of the pool basin. This means that a deaf competitor must focus his attention on the traffic light and not on swimming lane. Competitors with a hearing loss of at least 55 dB are allowed to participate in competitions for the deaf. During competitions, deaf athletes cannot compete with hearing aids, including implants. It should be emphasized that people with moderate hearing loss (40-60 dB) cannot hear quiet and medium-loud sounds and have significant difficulties understanding speech, especially in noise. However, people with profound hearing loss (70-90 dB) can only hear some very loud sounds, and conversations in large groups require considerable effort. Swimming at the highest level requires proper breathing work. Physiologically, deaf people have a less developed respiratory system, which they do not use for verbal communication. Deaf people do not experience changes in airway pressure caused by speech, singing or shouting[16]. Deaf people contact their surroundings using conventional visual-spatial sign language. Sign language has a grammatical structure separate from the native language. Specialized concepts regarding professional life in sign language are available to a limited extent, therefore, in each phase of training, contact between a deaf player and the coach is very difficult. Most specialized information is at an abstract level. Therefore, deaf swimmers have additional training difficulties that negatively affect the technique of correct swimming stroke. It should be noted that most deaf athletes combine professional work with training and are not included in the same Olympic preparation program as top hearing athletes. In addition, deaf athletes belonging to national deaf sports associations/federations do not have the support of national Olympic committees, and corporate sponsorship is rare. All of the above factors may significantly influence the differences between hearing and deaf swimmers. Therefore, in this manuscript, the results achieved by the best swimmers of the Deaf Games were compared to the group of leaders (top eight – OG_1) of the Olympic Games and to the group of sixteen competitors who took the last places in the OG_2 eliminations. The authors assumed that the competitors of the OG_2 group, representing countries in Africa, Oceania, or from countries with no swimming tradition, may have similar training conditions and financial support to deaf athletes, and they may be distinguished by physiological factors.

This study will allow us to determine how big the differences are between the results of swimmers at the Olympic Games and the Deaflympic Games, both in terms of starting reaction time and the time and speed of swimming individual distances in various swimming strokes with varying degrees of technical difficulties. It is generally believed that deaf swimmers/athletes do not differ in terms of body build from hearing swimmers. Many people see no basis for separating sports competitions for deaf and hearing people. Until 2017, only two deaf swimmers participated in the Olympic Games: Jeffrey Float[17] (USA) - winner of the gold medal at the Games in Los Angeles (1984) - 4 x 200 m relay, and Terence Parkin[18] (RSA) - silver medal at the Games in Sydney (2000) – 200 m breaststroke and the Olympic Games in Athens (2004) – no medal – 7th place in the 200 m breaststroke semi-final. In our opinion, statistically significant differences in the considered starting variables between both groups may indicate the influence of the abovementioned factors on the achieved sports results, and may also support the separation of competitions into competitions for the deaf and for the hearing.

Methods

Participants

In the case of the Deaflympic Games (DL), all data used were obtained from the Swimming Competition Report (Results Book[19]) prepared by the organizers of the DL. In the case of the Olympic Games in Rio de Janeiro (OG), all data used were obtained from the Result Book of swimming competitions[20].

Design

Based on the Results Books DL and OG, a database was created which included: athlete's name, nationality, age, swimming stroke, distance, start reaction time, total race time, and calculate average speed. The OG swimmers were divided into two groups. Group one (OG_1) - competitors from the final eight of individual swimming strokes and distances (n=104 records), group two (OG_2) - competitors who placed at the end of the group of competitors, i.e. 16 competitors with the weakest qualifying times (n=208 records). In the case of DL - only the best players from the final groups (DL_1) were included in the analyses (n=128 records). It should be noted that during the OG, 904 swimmers (427 male) from 174 countries took part in 32 (16 male events) swimming events in the 50 m pool[21], while during the DG in 13 male events, 193 swimmers (110 male) representing 38 countries took part[22]. Number of swimmers authors calculated by analyzing all swimming distances and strokes and removing duplicate records/names of participants.

Methodology

The study took into account: age (AG), starting reaction time (RT), average speed over the distance (AS) and final time (FT) of swimmers taking part in the DL in Samsun, Turkey' 2017 and swimmers taking part in OG in Rio de Janeiro, Brazil '2016. Based on the results regarding the final distance time achieved by the gold Deaf medalists in the DL_1 group of individual swimming distances and strokes, it was estimated which place a deaf competitor could take during the Olympic Games in Rio (Rio_H/N), where N is the number of competitors taking part in the qualifying rounds. During the Deaflympic Games in Samsun, the 50-meter competition was held for the following swimming strokes: freestyle, backstroke, breaststroke, butterfly, while during the Olympic Games in Rio de Janeiro, the 50-meter competition was held exclusively for freestyle. Due to the impossibility of comparing the results over the 50-meter distances, it was decided not to present the results over these distances during the DL, except for Free_S_50.

The distance was analyzed comparatively:

- *short*: (S) – 50 m and 100 m swimming strokes: freestyle – Free_S_50, Free_S_100, backstroke – Back_S_100, breaststroke – Brea_S_100, butterfly stroke – Butterfly_S_100;
- *medium* (M) - 200, 400 m swimming strokes: freestyle – Free_M_200, Free_M_400, backstroke style – Back_M_200, breaststroke– Brea_M_200, medley – Medley_M_200, Medley_M_400, butterfly stroke – Butterfly_M_200;
- *long* (L) – 1500 m freestyle – Free_L_1500.

Statistical analysis

Descriptive statistics are presented as mean ± standard deviation, minimum and maximum values and if exist, statistically significant differences.

It was considered whether there are statistically significant differences relating to the age of competitors, starting reaction time, average speed and final time between swimmers from the DL_1 and OG_1 and DL_1 and OG_2 groups. For the variables: age (AG), starting reaction time (RT), average speed (AS), total time (FT), the analyzes were performed for each stroke and distance separately (50 m, 100 m, 200 m, 400 m, 1500 m). The statistical analyzes performed for this purpose included a one-way analysis of variance when the assumptions of normality of distribution (checked with the Shapiro-Wilk test) and homogeneity of variances (checked with the Levene test) were met. When the null hypothesis of the ANOVA test indicated significant differences in the means of the studied variables, the Tukey multiple comparisons test was used. If the assumptions of the parametric test were not met, the Kruskal-Wallis test was used, and multiple group comparisons were performed using the Dunn test. Statistical analyzes were performed using STATISTICA 13 (TIBCO Software Inc., Santa Clara, US (2017)).

Results

Age of participants – the information about the age of men competing at all individual distances and swimming strokes considered are presented in the Table 1. The statistical analyzes performed showed that there are no statistically significant differences between groups DL_1, OG_1 and OG_2 for the age variable, except for the male groups: Free_S_50 (Kruskal-Wallis test: P= .019; Dunn's test: DL_1 vs. OG_1: P= .035, but DL_1 vs. OG_2, P= 1) and Brea_S_100 (ANOVA: P= .015, Tukey's test: DL_1 vs. OG_1: P= .022, but DL_1 vs. OG_2: P= .064).
Start reaction time - considering the results regarding the start reaction time of men (Table 1), it turned out that for each stroke and distance the means in the DL_1 group were greater than or equal to OG_1, and in the case of the Brea_S_100 and Back_M_200 strokes, these differences were statistically significant (Dunn's test: P= .043, P= .048, respectively). Comparisons of DL_1 and OG_2 also showed that a faster reaction time should be expected in the OG_2 group. The results for the Backstroke group are interesting, because here the swimmers had the same starting time. The only group in which a reaction time is lower for DL_1 than for OG_2 was noticed is the Free_S_50 group. None of the comparisons between the DL_1 and OG_2 groups were statistically significant (Table 1).
Average speed - the average speed was calculated separately for each distance and swimming stroke. In the group of men, at all considered distances, it was observed that the average speed for the OG_1 > DL_1 group and for almost all comparison tests in these groups, the results were statistically significant (all P< .001 except FREE_S_50). The exception is one short distance: FREE_S_50, for which, despite the observed difference in means, Dunn's test did not find grounds to reject the null hypothesis of significant differences between the OG_1 and DL_1 groups (P= .264). A very interesting case is the Butterfly_S_100 group, for which the average speed in both abovementioned groups is very close to each other and equal to 1.95, but differences in the medians are clearly visible (for OG_1: 1.95, for DL_1: 1.77), hence the non-parametric statistical test showed a statistically significant difference (P = .0006). Comparing the OG_2 and DL_1 groups, more diversity can be seen. For short distances: FREE_S_50, FREE_S_100, BREA_S_100, BUTTERFLY_S_100, the average speed was equal or greater for DL_1 than for OG_2, but significant only for FREE_S_50 and BREA_S_100 (P= .009; P= .690, P= .038, P= .886, respectively). For medium and long distances, except for medium freestyle distances and BACK_M_200, this relationship was inverse and statistically significant (Table 1).
Final time (Table 1) - final time is strongly correlated with the variable swimming speed (R< –.95 for all distances), hence all results of statistical tests examining differences between deaf and hearing groups will show the same dependencies. Descriptive statistics for the final time are shown in Table 1.

Discussion

In this study, the analyzes carried out included verification and comparison of the following variables: swimmers' age, starting reaction time, average speed and final time in the group of men - participants of swimming competitions during the XXIII Summer Deaflympic Games in Samsun, Turkey (2017) and the XXXI Summer Olympic Games in Rio de Janeiro, Brazil (2016). An important aspect of the presented research is that the analyzes included all individual swimming distances and swimming strokes: freestyle, breaststroke, backstroke, butterfly and individual medley. For all considered distances and swimming strokes, the time of the Olympic record and the deaf games was also presented, as well as the hypothetical position of the best deaf swimmer on the list of results of the Rio_H/N qualifying races, where N is the number of competitors taking part in the qualifying races.
Age of swimmers - statistically significant differences were observed for Free_S_50 between DL_1 and OG_1 (P=.036) and between OG_1 and OG_2 (P=.042), as well as for Brea_S_100 (DL_1 vs OG_1: P=.022). Analyzing the age of the swimmers, it can be noticed that swimmers advanced to the final races for almost all swimming strokes and distances, where the age of the youngest swimmer of the OG_1(Min) groups was higher than that of the swimmers of the DL_1(Min) groups (except: Free_S_100, Butterfly_S_100, Free_M_400, Brea_M_200). Also, for the OG_2 group there was a similar relationship - the age of the youngest swimmer in the OG_1(Min) group was higher than in the OG_2(Min) group - with the exception of men's races: Free_S_100. Table 2 compares the age (with standard deviation) of the finalists of the Olympic Games in Rio (2016) and the Deaflympic Games in Samsun (2017) with the age of the finalists of the Olympic Games in London (2012), Beijing (2008) and Athens (2004). For short, medium and long distances (Table 2), the average age of the DL_1 finalists was in almost all cases lower than the competitors of the OG final races 2008-2016. Comparing the age of deaf swimmers with the age of hearing swimmers OG 2004-2016, deaf swimmers in the Free_S_50, Back_S_100 and Brea_S_100 races are on average 4.8 years, 3.5 years and 4.2 years younger than hearing swimmers. In the remaining cases, deaf swimmers are younger than hearing swimmers by a range of 1.2 years to 2.5 years. In the Free_M_200, Free_M_400 and Brea_M_200, deaf swimmers are on average 1.1 years, 1.0 years and 0.6 years older[2, 4, 15].
Starting reaction time - the average starting reaction time of deaf men had a higher value than that of the finalists of the Olympic Games OG_1 and OG_2 (except Free_L_1500). The difference between the longest and shortest start reaction time {Δ= (Max-Min)} was similar in male groups OG_1 and DL_1. For short distances it was: Free_S_50 (.11 s. vs. .14 s.), Free_S_100 (.12 s. vs. .33 s.), Brea_S_100 (.12 s. vs. .42 s.), Butterfly_S_100 (.13 s. vs. .19 s.), and for distances Back_M_200 (.12 s. vs. .15 s.), Medley_M_400 (.14 s. vs. .22 s.) and Free_L_1500 (.18 s. vs. .24 s.). The differences in reaction times were slightly different for the remaining middle distances. In the Free_M_200, Free_M_400, Butterfly_M_200 races, the differences were as

Table 1. Descriptive statistics of swimmers' results during the Deaflympic Games and the Olympic Games for different swimming strokes at short, middle and long distance.

				Age				Start reaction time [s]				Average speed swimming [m/s]				Finish distance time [s]				
	Strokes	Group	n	X ± SD	Min	Max	*P*	X ± SD	Min	Max	*P*	X ± SD	Min	Max	*P*	X ± SD	Min	Max	DR/OR	Rio_H/N
(a)		DL_1	8	21.50±3.01	19.00	28.00	**.019**	.71± .05	.64	.78	**.002**	2.07± .04	2.02	2.13	**< .0001**	24.12± .48	23.44	24.72	23.44	≅47/85
(b)	Free_ S_50	OG_1	8	26.25±4.06	22.00	35.00	**.036**	.66± .05	.60	.71	.210	2.31± .02	2.26	2.34	.264	21.67± .23	21.40	22.08	21.30	
(c)		OG_2	16	22.56±4.80	17.00	37.00	1.000	.74± .05	.64	.85	.655	1.81± .07	1.62	1.88	**.009**	27.72±1.17	26.56	30.86		
(a)		DL_1	8	22.75±3.20	19.00	28.00	.870	.72± .19	.54	.87	.216	1.88± .04	1.83	1.94	**.0001**	53.13±1.26	51.51	54.64	51.51	≅53/59
(b)	Free_ S_100	OG_1	8	22.63±3.93	18.00	28.00		.67± .04	.62	.74		2.09± .01	2.07	2.10	**.0001**	47.96± .25	47.58	48.41	47.05	
(c)		OG_2	16	22.06±3.17	18.00	30.00		.68± .05	.58	.77		1.88± .15	1.54	1.99	.690	53.57±4.75	50.26	64.95		
(a)		DL_1	8	20.50±2.67	15.00	24.00	.125	.65± .03	.62	.69	.595	1.64± .12	1.40	1.78	**< .0001**	61.40±4.86	56.09	71.49	56.09	≅33/39
(b)	Back_ S_100	OG_1	8	24.00±4.81	19.00	31.00		.62± .07	.54	.73		1.90± .02	1.87	1.92	**< .0001**	52.68± .54	51.97	53.50	51.97	
(c)		OG_2	16	21.25±3.24	17.00	30.00		.65± .08	.52	.82		1.76± .09	1.48	1.84	.113	56.92±3.37	54.40	67.47		
(a)		DL_1	8	21.00±2.73	16.00	25.00	**.015**	.74± .12	.52	.94	**.042**	1.50± .06	1.41	1.56	**< .0001**	66.77±2.74	64.11	70.86	63.51	≅45/46
(b)	Brea_ S_100	OG_1	8	25.13±3.40	21.00	30.00	**.022**	.66± .04	.57	.69	**.043**	1.70± .02	1.67	1.75	**< .0001**	58.99± .84	57.13	59.95	57.13	
(c)		OG_2	16	24.44±2.75	19.00	28.00	.064	.69± .03	.64	.75	.208	1.59± .05	1.46	1.64	**.038**	62.96±1.98	61.75	63.11		
(a)		DL_1	8	22.80±4.55	19.00	29.00	.719	.70± .06	.56	.75	.317	1.95± .56	1.71	3.34	**.0004**	57.43±1.35	55.80	59.96	53.90	≅40/43
(b)	Butterfly_ S_100	OG_1	8	23.38±4.17	17.00	31.00		.68± .05	.61	.74		1.95± .02	1.93	1.98	**.0006**	51.28± .46	50.39	51.84	50.39	
(c)		OG_2	16	24.00±5.19	14.00	35.00		.68± .05	.60	.77		1.82± .08	1.60	1.89	.886	55.14±2.55	53.00	62.54		
(a)		DL_1	8	24.13±3.60	19.00	29.00	.248	.74± .05	.65	.81	.235	1.73± .06	1.64	1.78	**< .0001**	115.58±3.94	112.55	122.01	112.55	≅44/48
(b)	Free_ M_200	OG_1	8	23.75±3.45	20.00	30.00		.70± .08	.63	.84		1.90± .01	1.89	1.91	**< .0001**	105.48± .44	104.65	105.91	102.96	
(c)		OG_2	16	21.75±3.75	17.00	28.00		.71± .04	.64	.78		1.80± .05	1.67	1.84	.126	111.38±3.35	108.42	119.71		
(a)		DL_1	8	24.00±1.69	22.00	26.00	.707	.76± .04	.69	.81	**.038**	1.74± .47	1.44	2.90	**.0003**	252.95±42.68	237.90	277.09	237.90	≅43/50
(b)	Free_ M_400	OG_1	8	23.25±2.38	20.00	27.00		.72± .04	.66	.79	.066	1.78± .02	1.75	1.81	**.0003**	224.24±2.36	221.55	229.07	220.14	
(c)		OG_2	16	23.13±3.86	17.00	29.00		.72± .03	.62	.76	.080	1.66± .07	1.46	1.72	.605	241.13±11.27	232.00	273.13		
(a)		DL_1	8	20.38±2.50	15.00	23.00	.367	.67± .04	.59	.74	**.018**	1.53± .06	1.41	1.64	**< .0001**	130.60±5.54	121.96	141.55	121.96	≅25/26
(b)	Back_ M_200	OG_1	8	22.00±2.20	19.00	26.00		.61± .04	.57	.69	**.048**	1.74± .02	1.72	1.76	**< .0001**	115.09±1.10	113.62	116.36	113.41	
(c)		OG_2	16	22.13±3.34	17.00	29.00		.67± .05	.60	.74	1.000	1.68± .03	1.60	1.71	.109	118.93±2.01	117.00	125.01		
(a)		DL_1	8	23.50±5.37	19.00	36.00	.966	.74± .10	.64	.95	.184	1.36± .06	1.27	1.41	**< .0001**	147.24±6.49	141.61	157.85	136.32	≅39/40
(b)	Brea_ M_200	OG_1	8	22.63±2.77	19.00	26.00		.70± .03	.65	.76		1.56± .01	1.56	1.57	**< .0001**	127.81± .28	127.46	128.34	127.22	
(c)		OG_2	16	22.69±3.74	16.00	29.00		.69± .03	.65	.79		1.49± .02	1.43	1.51	**.009**	134.15±2.01	132.47	140.18		

(a)	Butterfly_ M_200	DL_1	8	22.38±4.57	16.00	29.00	.626	.72± .03	.65	.77	.323	1.55± .04	1.50	1.60	**< .0001**	128.89±2.98	124.94	132.91	122.13	≅29/30
(b)		OG_1	8	24.25±4.33	20.00	31.00		.68± .05	.60	.74		1.74± .02	1.71	1.76	**< .0001**	114.65±1.29	113.36	117.04	112.03	
(c)		OG_2	16	22.75±3.42	17.00	29.00		.70± .06	.61	.82		1.70± .02	1.65	1.72	**.006**	117.67±1.33	116.48	121.22		
(a)	Medley_ M_200	DL_1	8	22.38±3.42	17.00	28.00	.062	.71± .04	.64	.76	.356	1.51± .07	1.43	1.61	**< .0001**	132.29±5.85	124.53	139.65	124.53	≅26/27
(b)		OG_1	8	26.25±4.13	22.00	32.00		.70± .04	.64	.79		1.71± .02	1.69	1.74	**< .0001**	117.13±1.16	114.66	118.54	114.23	
(c)		OG_2	16	24.13±2.36	21.00	29.00		.69± .04	.61	.74		1.66± .02	1.60	1.67	**.011**	120.81±1.51	119.67	124.95		
(a)	Medley_ M_400	DL_1	8	21.00±2.73	17.00	25.00	.106	.71± .08	.59	.81	.588	1.38± .09	1.29	1.49	**< .0001**	291.20±18.81	268.49	311.04	268.49	≅26/27
(b)		OG_1	8	22.38±2.07	20.00	26.00		.68± .05	.61	.75		1.59± .02	1.56	1.63	**< .0001**	251.22±3.72	246.05	256.58	243.84	
(c)		OG_2	18	23.94±3.78	17.00	30.00		.69± .05	.62	.80		1.55± .02	1.50	1.58	**.004**	258.40±3.67	253.87	267.27		
(a)	Free_ L_1500	DL_1	8	21.13±4.22	16.00	26.00	.530	.73± .08	.58	.82	.763	1.52± .05	1.45	1.60	**< .0001**	991.00±32.10	937.64	1032.3	937.64	≅42/46
(b)		OG_1	8	22.88±2.70	20.00	28.00		.74± .05	.66	.84		1.69± .02	1.66	1.72	**< .0001**	886.81±8.81	874.57	902.66	871.02	
(c)		OG_2	16	21.38±3.34	17.00	29.00		.74± .05	.66	.85		1.61± .02	1.56	1.63	**.017**	932.92±10.26	918.49	962.44		

Legend: Free - freestyle swimming; Back – backstroke swimming; Brea - breaststroke swimming; Butterfly - butterfly stroke; S – short distance; M – midium distance; L – long distance; DL – Deaflympic Games (Turkey, 2017); OG – Olympic Games (Brazil, 2016); 1 – the best 8 finalists results; 2 – last 16 swimmers results; n – number of swimmers, X ± SD – average and standard deviation, Min - minimal and Max - maximal value. *P* – p-values according to: in line marked with (a) ANOVA or Kruskall-Wallis test for comparison all three groups (DL_1, OG_1, OG_2), in line marked with (b) Tukey's or Dunn's non-parametric test for DL_1 vs OG_1 comparison, in line marked with (c) Tukey's or Dunn's non-parametric test for DL_1 vs OG_2 comparison. Statistically significant values at the significance level of .05 are in bold. Rio_H/N – hipotetic place of winners DL_1 (2017) at summary results list at Olimpic Games in Rio (2016), N – total number of participants for a given strokes and distance, DR – deaflympic record, OR – olympic record.

Table 2. Average and standard deviation of the age of the best 8 finalists at Summer Olympic Games from 2004 – 2012[2] and finalists at Summer Olympic Games 2016 and finalists Deaflympics Games 2017 for different strokes and distances.

Stroke	X±SD [year]				
	DL_2017	OG_2016	OG_2012	OG_2008	OG_2004
Free_S_50	21.50±3.01	26.25±4.06	27.1±3.58	25.0±2.81	26.9±3.63
Free_S_100	22.75±3.20	22.63±3.93	23.8±2.71	25.9±4.04	24.4±2.77
Back_S_100	20.50±2.67	24.00±4.81	25.7±2.67	23.5±1.19	22.6±3.89
Brea_S_100	21.00±2.73	25.13±3.40	26.3±3.33	26.2±1.68	23.1±1.40
Butterfly_S_100	22.80±4.55	23.38±4.17	25.1±2.88	24.1±2.21	24.7±3.92
Free_M_200	24.13±3.60	23.75±3.45	23.0±2.80	22.2±2.13	23.1±2.48
Free_M_400	24.00±1.69	23.25±2.38	23.6±4.32	22.9±2.80	22.1±2.35
Back_M_200	20.38±2.50	22.00±2.20	22.1±3.10	24.7±3.32	22.7±2.01
Brea_M_200	23.50±5.37	22.63±2.77	25.0±2.92	23.6±2.77	20.5±2.63
Butterfly_M_200	22.38±4.57	24.25±4.33	24.1±3.44	23.6±1.69	22.7±4.41
Medley_M_200	22.38±3.42	26.25±4.13	25.5±3.72	23.5±1.10	20.6±2.01
Medley_M_400	21.00±2.73	22.38±2.07	22.2±4.40	23.4±2.32	20.8±1.92
Free_L_1500	21.13±4.22	22.88±2.70	23.2±3.02	22.5±3.19	22.8±3.03

Legend: Free – freestyle swimming; Back – backstroke swimming; Brea – breaststroke swimming; Butterfly – butterfly stroke; S – short distance; M – medium distance; L – long distance; X±SD – average and standard deviation; DL_2017 – Deaflympic Games in Samsun (2017); OG – Olympic Games in: OG_2016 – Rio (2016), OG_2012 – London (2012), OG_2008 – Beijing (2008), OG_2004 – Athens (2004).

follows: (.21 sec. vs. .16 sec.), (.13 sec. vs. .12 sec.), (.14 sec. vs. .12 sec.), (.15 sec. vs. .12 sec.). In several cases, DL_1 players had a smaller or comparable reaction time range than the OG_2 group. In almost all cases, the competitor from the DL_1 group had a shorter or the same reaction time than the Olympic finalists - OG_1 (men: Free_S_100, Brea_S_100, Butterfly_S_100, Brea_M_200, Medley_M_200, Medlay_M_400, Free_L_1500). A greater range of the difference between the shortest reaction time and the longest reaction time Δ = (Max-Min) in the DL_1 groups may indicate poorer training of the start reaction or a different level of hearing loss. In deaf players with moderate hearing loss (≈ 55 dB), a sound signal may have a significant or decisive impact on the speed of the starting reaction. In the future, the influence of the level of hearing loss on the starting reaction time should be investigated.

Average speed - the average swimming speed was in all cases higher in the OG_1 group than in the DL_1 group. In the cases: Free_S_50, Butterfly_S_100, Free_M_400, the average flow rate was higher in DL_1 than in OG_2. Wolfrum et. al.[4] reported the results of the best Swiss swimmers from 2006-2010. Men in the classic style achieved an average speed of 1.79 m/s (50 m), 1.60 m/s (100 m), and 1.47 m/s (200 m) during national competitions, which were identical values as results of the best deaf competitors swimming breaststroke. The difference was .08 m/s; .01 m/s and .01 m/s. In turn, for the freestyle, the results of the Swiss masters were 2.25 m/s, 2.04 m/s, 1.87 m/s. The differences for freestyle were: .12 m/s, .01 m/s, .09 m/s, respectively.

Analyzing the differences between the fastest swimmer and the slowest swimmer {Δ = (Max-Min)}, in the groups of male finalists hearing OG_1, there is a slight difference Δ€ (.1, .8) between the winner and the eighth finalist. In the DL_1 and OG_2 groups, the Δ discrepancies are much larger Δ€ (.11, 1.46) and Δ€ (.07, .45).

Final time - because the final time of races is strongly correlated with the results regarding average swimming speed, the amounts of statistically significant differences in final time are reflected in the ANOVA statistics of average swimming speed. Information on the hypothetical place of deaf swimmers in the competition during the Rio Games (Rio_H/N) is presented in Table 1. Table 1 shows the records set during the Olympic Games and the Deaflympic Games. In the men's deaf Olympic short-distance events, new Olympic records were broken in almost every swimming stroke. For short distances (100 m) in men's competition, the average Olympic Games record is 51.64 s, while the average Deaflympic Games record is 56.25 s. For the 200 m medium distance, the average Olympic record time is 113.97 s, and the deaf record time is 123.50 s. For the medium distance of 400 m, the average time of the Olympic record is 231.99 s. and the Olympic record for the deaf - 253.20 s.

In the case of long distances for Free_L_1500 it was 871.02 seconds vs. 937.64 seconds. During the Deaflympic Games in Samsun, the medal classification was as follows: (1) Russia – 44 (26 - gold; 10 - silver; 8 - bronze), (2) Japan – 15 (3; 7; 5), (3) Belarus – 6 (3; 3; 0), (4) USA – 8 (3; 2; 3), (5) Great Britain – 7 (3; 0; 4), (6) Poland – 8 (1; 1; 6), (7) Brazil – 2 (1; 0; 1), (8) Ukraine – 17 (0; 8; 9), (9) China – 5 (0; 4; 1), (10) Italy – 4 (0; 2; 2), (11) South Africa – 2 (0; 2; 0), (12) Indonesia – 2 (0; 1; 1). During the Rio Olympic Games in swimming, the medal classification was as follows: (1) USA - 33 medals (16 - gold; 8 - silver; 9 - bronze), (2) Australia - 10 (3; 4; 3), (4) Japan – 7 (2; 2; 3), (6) China – 6 (1; 2; 3), (15) Russia – 4 (0; 2; 2), (18) Belarus – 1 (0; 0; 1).

Practical Applications

Deaf sports have little support in the form of scientific research and statistical studies of sports competitions. Statistical analyses conducted on top-class hearing and deaf swimmers contribute to increasing knowledge about the sports level of deaf athletes compared to hearing athletes. Extending statistical analyses to the group of hearing swimmers representing the lowest sports level at the Olympic Games allows us to indicate the sports level (athletes) of deaf people in relation to participants in the Olympic Games. Knowledge about the sports level of an athlete may constitute the basis for including a deaf athlete in the national team for the Olympic Games. The presented statistical analyses provide valuable advice for coaches and athletes as a reference to the current initial condition and results achieved by the best deaf swimmers and hearing swimmers. The results achieved by deaf swimmers may be an argument for including deaf athletes in training sessions of sports clubs for hearing people (despite communication barriers).

Conclusions

This study focuses on the assessment and comparison of measurable situational variables of top-class deaf and hearing swimmers - participants of the Deaf Summer Games (Samsun, Turkey 2017) and the Summer Olympic Games (Rio de Janeiro, Brazil 2016). This is the first publication of this type to draw attention to deaf swimmers. This research brings a new perspective on the differences between deaf and hearing swimmers. While when comparing the average speed (and final time) of swimmers hearing OG_1 and deaf DL_1, there are always high values of statistically significant differences, statistically significant differences do not occur or have been much lower between the groups DL_1 and OG_2. Smaller values of differences between DL_1 swimmers and OG_2 group may result from the fact that almost 57% of OG_2 swimmers were representatives of countries in Africa (17.3%), Asia (18.3%) and countries in Central America (6.7%), Oceania (7.2%) and South America (7.7%), where financing of competitive sports is at a much lower level than in highly developed European countries, Japan or the USA. Based on information about the hypothetical position in the eliminations in individual swimming styles and distances during OG (Rio_H/N), it can be concluded that in almost all OG swimming competitions, 84.6% to 97.8% of hearing swimmers would be ahead of the DG gold medalist – Table 1 (except for Free_S_50 (55.3%)). In many cases, competitors OG from Africa and Oceania were also ranked higher. Various factors may influence the observed statistically significant differences. The lack of verbal communication makes it difficult to establish cooperation between deaf players and sports clubs, coaches and hearing players. Deaf players very often face marginalization and even social exclusion. This means that only the most talented deaf swimmers join hearing swimming clubs. The lack of natural verbal communication between the athlete and the coach and other swimmers may affect the level of technical training and, consequently, the results achieved. Another element contributing to poorer sports results achieved by deaf people is the fact that the lack of verbal communication adversely affects the development of the respiratory system, lungs, intercostal muscles and the diaphragm - responsible for breathing. These are aspects that correlate with each other, causing a deaf swimmer to overcome more barriers and limitations than a hearing swimmer, hence the distant positions of the DL gold medalists in the Rio_H/N classification. Hearing athletes, participants of the Olympic Games, have greater training opportunities, including a larger number of training camps, the availability of biological regeneration and supplementation at the highest level, a wide coaching staff, and the possibility of frequent participation in top-class sports competitions. More financial resources are allocated to competitive sports for hearing people, both from the state treasury and from sponsors.

Analyzing the results achieved by the best deaf swimmers, it can be assumed that:

• development of a breathing apparatus at an early stage of training,

• development of specialist films related to swimming on internet platforms,

• increase in financial subsidies for recreational and professional sports of the Deaf,

• increase in the level of sports training,

may bring tangible benefits increasing the level of sports training of the Deaf and their participation in the social (swimming) life of hearing people. To this end, swimming pools should be equipped with starting lights as standard, which would allow Deaf swimmers to start together with hearing swimmers.

Joint competition between hearing and deaf swimmers would improve the sports competences of Deaf people.

The international community of deaf athletes is largely hermetic and not used to cooperation with scientific institutions. This means that cooperation with the deaf community is limited and difficult, hence the lack of research on the deaf sports community, such as anthropometry, physiological factors, etc.

Further studies will focus on respiratory function tests, including spirometry, to determine the influence of physiological factors on sports results, as well as training/coaching, educational and social aspects and their inter-correlations in the group of deaf swimmers.

Separate studies should concern the Deaf national teams in individual countries and information on swimming sports in these countries.

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