BIOMECHANICAL CHANGES DURING THE 200 M BUTTERFLY EVENT: A COMPARISON AMONG ADULT AND INFANT SWIMMERS

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INTRODUCTION

Due to environmental specificity, swimming technique and biomechanics plays a determinant role in swimming performance. Once fatigue seem to be able to change technique, a rigorous evaluation of this effects must be of outstanding importance for practice. Nevertheless, only a few papers were published concerning changes, during a swimming event, on biomechanical parameters other than stroke length, stroke rate and swimming velocity (Troup, 1990; Alves & Madeira, 1995; Strass et al., 1995; Vilas-Boas & Cunha, 1995). Troup (1990) examined the 400 m freestyle event and the 200 m events of the three other strokes, but only comparing the 1st and penultimate lengths, using mainly parameters concerned with force production capacity of the hand. Alves & Madeira (1995) studied the fatigue effect on technique between the 1st and the last length, but considering the 400 m distance both for front crawl and for backstroke swimming. Parameters studied were pull length and depth, duration of pull phases and hip speed fluctuations. Strass et al. (1995) studied more parameters than Troup (1990), but the research was restricted to a 50 m treadmill freestyle performance, comparing the beginning and the end of the event. Meanwhile, Vilas-Boas & Cunha (1995) investigated the 200 m butterfly event, considering 13 kinematics parameters of the hand, hip and foot.

None of the available studies deal with differences of fatigue induced technical changes according to age and competitive experience.

The purpose of this study was to characterise and compare biomechanical changes of butterfly technique during a 200 m event among adult and infant swimmers.

METHODS

Ten well trained male swimmers (5 adults and 5 infants) were studied. Mean characteristics of the sample are presented in Table 1.

Table 1. Mean characteristics of the sample.

Subjects (n=10)	Age (years)	Height (cm)	Weight (kg)
Adult (n=5)	21.2 ±3.5	179.4 ±5.7	76.6 ±10.4
Infant (n=5)	12.0 ±0	159.4 ±5.3	45.8±3.8

Each swimmer performed a maximal 200 m butterfly test, videotaped both underwater and overwater with JVC-SVHS synchronised cameras. Both images were mixed using a Panasonic WJMX50 mixing table. In order to obtain a dual-media final image, only the bottom half image of the top camera, and the top half image of the bottom camera were considered. Both cameras provided images on the sagital plane, once they were fixed in the lateral wall of the pool, one 30 cm underwater and the other 30 cm over the water surface. The cameras were placed at a 5 m distance, with the optical axis perpendicular to the swimmers plane of displacement.

In each 200 m performance, the 2nd, 4th, 6th and 8th 25 m laps were evaluated using the Peak Performance 2D system using a sampling frequency of 50 Hz (Panasonic AG 7350 VT). The spatial model was composed of 10 digitised anatomical marks, allowing to represent the human body in 8 segments. One last point was digitised in order to define the water surface. center of mass (CM) calculations were based on Dempster (1955) model.

The parameters studied were: (i) swimming velocity (V); (ii) stroke length (SL); (iii) stroke rate (SR); (iv) maximum depth of the hand (HD); (v) total antero-posterior horizontal displacement of the hand (HA-PHD); (vi) index of horizontality of the hand path in the sagital plane ($IH = HA\text{-}PHD * HD^{-1}$); (vii) maximal vertical amplitude of the hip displacement during one stroke cycle (HiVDSP); (viii) CM maximal velocity, associated to the final of the upsweep or the "catching the wave" (Vmax); (ix) CM velocity during the entry of the hands (Vent); (x) CM velocity in the final of the insweep (Vin); (xi) CM velocity during the exit of the hands (Vex.); (xii) CM acceleration during the recovery of the arms (AA); (xiii) CM acceleration during the upsweep (AU); (xiv) "dropped elbow index" calculated through the vertical distance between the finger tip of the middle finger and the elbow (DE).

Statistics included means and standard deviations, ANOVA for repeated measures to test the significance of statistical differences within the groups studied, and one-factor ANOVA to test significance of statistical differences between the groups studied. Both ANOVA's used the PLSD Fisher test (a = 0.05).

RESULTS

Table 2 presents the results of parameters swimming velocity (V), stroke length (SL), and stroke rate (SR) for each of the studied groups.

Table 2. Mean and standard deviation values of velocity (V), stroke length (SL), and stroke rate (SR) for each of the studied groups.

	2nd 25m	4th 25m	6th 25m	8th 25m
V(m/s)				
infant	1.30±0.08	1.02±0.09 *	0.93±0.09*†	0.95±0.08*†
adult	1.57±0.05	1.38± 0.06*	1.32±0.10*	1.33±0.22*
	◊	◊	◊	◊
SL (m)				
infant	1.55±0.11	1.45±0.15	1.41±0.22	1.34± 0.08*
adult	1.81±0.23	1.82± 0.14	1.56±0.13*†	1.63±0.12*†
		◊		◊
SR(c/mn)				
infant	59.40±5.22	51.99±7.91	54.06±4.43	52.09±4.84
adult	49.54±7.27	48.90±6.38	51.28±7.83	49.73±5.83
	◊			

Significant differences ($p<0.05$) are market : * when compared to the 2nd 25m; † when compared to the 4th 25m; ◊ comparing the infant and adult group.

In accordance with literature (Nelson et al., 1980), our results pointed out a progressive decrease of V between successive laps of the 200 m Butterfly event, with the exception of the last one, where V was slightly increased relatively to the 3rd lap. Although V profile was similar for adult and infant swimmers, the adult group showed a higher homogeneity on this parameter. The increase of swimming velocity , namely in short courses, is usually related to the increase of SR and the decrease of SL. Nevertheless, for butterfly stroke, the increase of V seems to be related both to SR and SL increases (Craig et al., 1985). In this study, the variation of V also seems to be attributable to changes both in SL and SR, despite non significant difference was found. SL seems to distinguish the competitive level of different swimmers (Hay, 1987). Accordingly, our results showed that the higher swimming velocity of adult swimmers is related to higher SL values, when compared with the infant group. However, the substantially higher SR values of the infant swimmers, can also be partially explained through the scaling effect of body dimensions.

Tables 3 to 5 present the mean and standard deviation values obtained for the other parameters studied. Interestingly, only few statistical differences were found between laps for each group, and between groups.

Table 3. Mean and standard deviation values of maximum depth of the hand (HD), total antero-posterior horizontal displacement of the hand (HA-PHD), index of horizontality of the hand path in the sagital plane (IH = HA-PHD * HD^{-1}) and maximal vertical amplitude of the hip displacement during one stroke cycle (HiVDSP) for each of the studied groups.

	2nd 25m	4th 25m	6th 25m	8th 25m
HD(m)				
infant	0.53±0.31	0.61±0.19	0.67±0.12	0.58±0.08
adult	0.61±0.18	0.69±0.17	0.61±0.08	0.62±0.24
HA-PHD (m)				
infant	0.33±0.18	0.28±0.19	0.36±0.25	0.57±0.38
adult	0.37±0.11	0.24±0.17	0.31±0.22	0.31±0.22
IH				
infant	0.66±0.21	0.63±0.74	0.36±0.25	0.98±0.63
adult	0.71±0.43	0.24±0.17	0.31±0.22	0.77±1.12
HiVDSP (m)				
infant	0.12±0.07	0.14±0.03	0.12±0.08	0.10±0.06
adult	0.14±0.07	0.13±0.04	0.13±0.03	0.13±0.05

Table 4. Mean and standard deviation values of CM maximal velocity associated to the final of the upsweep or the "catching the wave" (Vmax), CM velocity during the entry of the hands (Vent), CM velocity in the final of the insweep (Vin), and CM velocity during the exit of the hands (Vex.) for the groups studied.

	2nd 25m	4th 25m	6th 25m	8th 25m
Vmax (m/s)				
infant	1.99±0.31	1.61±0.27	1.76±0.18	1.77±0.35
adult	1.90±0.25	2.07±0.31 ◊	1.77±0.19†	1.64±0.30†
Vent (m/s)				
infant	1.21±0.33	1.35±0.24	0.96±0.34	1.08±0.31
adult	1.60±0.39	1.37±0.25	1.37±0.15 ◊	1.39±0.12
VIn (m/s)				
infant	1.91±0.09	1.66±0.13*	1.56±0.14*	1.34±0.33*†
adult	1.60±0.36	1.51±0.27	1.42±0.31*	1.53±0.34*
Vex (m/s)				
infant	1.90±0.19	1.59±0.2	1.71±0.22	1.56±0.53
adult	1.80±0.22	1.59±0.30	1.67±0.25	1.49±0.20

Significant differences ($p<0.05$) are market : * when compared to the 2nd 25m; † when compared to the 4th 25m; ◊ comparing the infant and adult group.

Table 5. Mean and standard deviation values of CM acceleration during the recovery of the arms (AA), CM acceleration during the upsweep (AU), and the "dropped elbow index" (DE) for the groups studied.

	2nd 25m	4th 25m	6th 25m	8th 25m
AA (m/s^2)				
infant	-2.92±1.64	-0.97±0.64*	-2.74±0.94	-2.60±1.89
adult	-1.18±1.89	-3.22±3.12	-1.72±0.85	-1.00±1.33
AU (m/s^2)				
infant	-0.08±0.93	-0.42±1.20	0.77±1.02	1.20±4.51
adult	1.10±1.24	0.46±2.28	1.35±2.03	-0.23±1.14
DE (m)				
infant	0.40±11.40	0.40±7.02	0.39±12.27	0.34±11.08
adult	0.35±17.51	0.34±8.77	0.39±12.88	0.33±23.67

Significant differences ($p<0.05$) are market : * when compared to the 2nd 25m.

HD, HA-PHD and IH presented values and profiles of variation differents from those previously reported on literature (Vilas-Boas & Cunha, 1995), and didn't change significantly along the event and between groups. The same was also found for HiVDSP, for Vex, for AU and for DE. These findings were quite unexpected; specially those related to velocity and acceleration kinetics along the event. Similarities of velocity and acceleration values obtained for adult and infant swimmers may be partially explained through a particular effect of drag and propulsion combination on resultant impulses determination. Meanwhile, the observed inexistance of significant differences between groups on DE, seems to suggest that the infant swimmers studied has already solved one of the main and usual technical errors on butterfly swimming: the "dropped elbow" position.

CONCLUSION

The results of this study pointed out that: (i) a number of biomechanical parameters of swimming technique are changed along the 200 m butterfly event, both for adult and infant swimmers, probably related to fatigue; (ii) some of the significant differences were observed earlier for infant than for adult swimmers; (iii) differences in swimming velocity among infant and adults were probably a combined effect of multiple factors.

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